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McGREGOR, W. H. D. AND P. J. KRAMER. 1963. Seasonal trends in rates of photosynthesis and respiration of loblolly pine and white pine seedlings. *Amer. J. Bot.*, **50**:760-765.

McWILLIAM, J. R. AND A. W. NAYLOR. 1967. Temperature and plant adaptation. I. Interaction of temperature and light in synthesis of chlorophyll in corn. *Plant Physiol.*, **42**:1711-1715.

MILLER, R. A. AND S. ZALEK. 1965. Effect of light quality, light intensity and temperature on pigment accumulation in barley seedlings. *Ibid.*, **40**:569-574.

NEISH, A. C. 1958. Seasonal changes in metabolism of spruce leaves. *Can. J. Bot.*, **36**:649-662.

POPOV, K. AND P. TSONEVA. 1966-1967. Sezonni i vorzrastovi izmeneniya v sodorzhanieto i sostoyanieto na pigmentite v listata na *Pinus silvestris* i *Taxus baccata*. *God. Sofiiskiya Univ. Biol. Fak. KN 2 Bot. Mikrobiol. Fiziol. Biokhim. Rast.*, **61**:147-164.

RUTTER, A. J. 1957. Studies in the growth of young plants of *Pinus sylvestris* L. I. The annual cycle of assimilation and growth. *Ann. Bot. (London)*, **21**:399-425.

SACHER, J. A. 1954. Structure and seasonal activity of the shoot apices of *Pinus lambertiana* and *P. ponderosa*. *Amer. J. Bot.*, **41**:749-759.

SHIROYA, T., G. R. LISTER, V. STANKIS, G. KROTKOV AND C. D. NELSON. 1966. Seasonal changes in respiration, photosynthesis and translocation of the ^{14}C labelled products of photosynthesis in young *Pinus strobus* L. plants. *Ann. Bot. (London)*, **30**:81-91.

TAYLOR, A. O. AND A. S. CRAIG. 1971. Plants under climatic stress II. Low temperature, high light effects on chloroplast ultrastructure. *Plant Physiol.*, **47**:719-725.

URSINO, D. J., C. D. NELSON AND G. KROTKOV. 1968. Seasonal changes in the distribution of photo-assimilated ^{14}C in young pine plants. *Ibid.*, **43**:845-852.

WILLSTÄTTER, R. AND A. STOLL. 1918. Untersuchungen über die Assimilation der Kohlensaüre. Springer-Verlag, Berlin. 448 p.

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ABSTRACT: *A study of the diel changes in the feeding activity of* Notropis spilopterus *(Cope) in the Huron River near Ann Arbor, Michigan, was based on samples taken at 3-hr intervals for 24 hrs. The food in the stomachs of 263 spotfin shiners was examined. Based on stomachs with food, Trichoptera larvae, represented mainly by hydropsychids, accounted for the greatest volume (33%). Diptera larvae, represented by simulids and chironomids, were most frequent (50%). Both of these food items occurred in a high percentage of stomachs (54%). The major peak in stomach fullness occurred at 9:00* PM *when 74% of all stomachs were over 50% full. Most stomachs from fish collected at midnight were empty (85%). Feeding activity increased by 6:00* AM, *but at a relatively low intensity. Fewer fish were feeding at noon than at 6:00* AM. *However, at noon the feeding intensity was somewhat greater. During the day, especially at noon, smaller fish were feeding more intensely than larger fish. Both Trichoptera and Diptera larvae constituted an important proportion of the food through most of the daylight hours. Trichoptera larvae were much less important at dusk than Diptera larvae.*

INTRODUCTION

Little is known of the 24-hr food habits and feeding activity of fishes, especially nongame species. Determinations of food habits and feeding activity based on fish collected at a single time do not realistically reflect the precise role of given fish species in the tropic structure of an aquatic ecosystem. The purpose of this investigation was to determine the diel changes in the food and feeding activity of the spotfin shiner, *Notropis spilopterus* (Cope). Although the food habits and feeding activity of this species have been investigated, apparently no study on the diel changes in food has been done.

METHODS

Specimens were collected on 25 and 26 July 1970 in the Huron River, 3 miles NW of Ann Arbor, Washtenaw Co., Mich. Beginning at noon, specimens were collected every 3 hr for 24 hr with a 15-ft, ¼-inch mesh common seine. A total of 263 spotfin shiners were taken. All specimens were allowed to suffocate for 20 min before being preserved in 10% formalin. Both air and water temperatures were taken.

The standard length of all fish was determined to the nearest mm. Sex was determined by examination of the gonads. Keys utilized in the identification of food organisms included Edmondson (1966), Pennak (1953) and Mason (1968). Stomach contents were examined at 10 to 30× under a binocular microscope. Per cent fullness of each stomach was estimated visually by comparing the volume of the stomach with the total volume of the food and was designated as: empty, 25% to 50%, 50% to 75% or 75% to full. After this, the contents of the stomachs were placed in the rectangular well (1 mm deep) of a depression slide, the bottom of which was divided into 1-mm squares. For each food item, its proportion of the total volume of food in each stomach was estimated, and its mean per cent volume for all stomachs was calculated. Counts of each food item were made on all stomachs with food. Per cent frequencies were calculated; the count of each food item was divided by the total count of all food items in stomachs with food. Per cent occurrence was the percentage of stomachs in which each food item occurred.

For the purpose of analysis, the data on the occurrence of some food items were combined. Hydropsychid larvae, hydroptilid larvae and unidentifiable Trichoptera larvae were combined as "Trichoptera larvae." "Other aquatic invertebrates" includes Collembola, which consisted of entomobryids and sminthurids; Plecoptera larvae; Acarina, which consisted entirely of *Hydracarina* sp.; other Arachnida; Neuroptera larvae, which consisted entirely of sialids; Ephemeroptera larvae, which consisted mainly of heptageniids, caenids and trichorythids (*Tricorythodes* sp.), and ostracods. These organisms all occurred in very small numbers and constituted less than 2% by frequency in each case. Hymenoptera larvae consisted entirely of formicids; Lepidoptera larvae consisted mainly of pyralidids and Coleoptera larvae consisted of curculionids. "Diptera larvae" included unidentified Diptera larvae, dolichopodids, simulids and chironomids. The chironomid larvae were represented by three subfamilies. Orthocladiinae occurred most frequently and consisted entirely of *Nanocladius* sp. The subfamily Chironomiinae, which consisted entirely of *Polypedilum* sp., also occurred in large numbers. Representatives of the subfamily Tanypodiinae occurred infrequently.

RESULTS AND DISCUSSION

Food habits.—The mean per cent volume, frequency and occurrence of each major food item over the entire 24-hr period are noted in Table 1. Unidentifiable animal material accounted for 43% of the total volume of food. This was

mainly digested matter and may have resulted from digestion during the suffocation period following capture. Most of the identifiable food items consisted of Trichoptera and Diptera larvae. Trichoptera larvae were mainly hydropsychids and Diptera larvae were mainly simulids and chironomids. Diptera larvae were taken most frequently (50%) while Trichoptera larvae constituted the greatest volume (33%). Both occurred in a high percentage of stomachs (54%).

Several authors have studied the food habits of *N. spilopterus* (Starrett, 1950; Stone, 1940; Forbes, 1883; Greeley, 1927; Sibley, 1929; Rimsky-Korsakoff, 1930; Sibley and Rimsky-Korsakoff, 1931). These authors generally agree that for most part the diet of this species consists of aquatic insects. However, Starrett (1950) in Boone Co., Iowa, and Stone (1940) in Tompkins Co., New York, noted that in the summer this species consumed relatively high volumes of terrestrial insects (18% and 58% total volume, respectively). Starrett (1950) found that Diptera larvae occurred at a low volume in this species, and he noted high volumes of plant material (24% total volume) and Ephemeroptera nymphs (14% total volume). In contrast, the present study indicates that these latter two food items and terrestrial insects were relatively unimportant, while Diptera larvae occurred at a relatively high volume.

Movement of food through stomachs.—A measurement of the rate of movement of food through the stomach must be made to determine whether or not food items in stomachs at one feeding period do, in fact, reflect different food items from those consumed during the previous feeding period (*i.e.,* 3 hr earlier). The rate of movement was determined for fish collected at 6:30 AM. Of 31 specimens taken, 10 were allowed to suffocate and were preserved at the time of capture. The remainder were kept alive in a bucket away from any source of food. Of these, 11 were preserved at 7:30 AM and the remaining 10 were preserved at 8:30 AM. For each of these groups the per cent fullness and number of empty stomachs were determined.

A progressive increase in the percentage of empty stomachs with time is clearly indicated; at 6:30 AM, 10%, at 7:30 AM, 55%, and at 8:30 AM, 80% of the stomachs were empty. Thus, it would appear that the food in the stomachs at any given time represents food consumed within the previous 2 hr and that the results of stomach analysis of fish collected at 3-hr intervals should reflect changes in feeding habits over the period considered. Further, the applicability of the 6:30 AM data to the movement of food through the stomach at other hours of the study appears quite reasonable. It is estimated that an increase of 10 C will double the rate of movement of food through the stomach (Karzinkin,

TABLE 1.—Mean per cent volume, frequency and occurrence of the major food items of *Notropis spilopterus* over the entire 24-hour period based on 134 fish with food and a total of 534 food items

Food items	Mean % volume	Mean % frequency	Mean % occurrence
Trichoptera larva	33	33	54
Simulid larva	6	17	17
Chironomid larva	8	28	39
Other Diptera larva	1	5	13
Total Diptera larva	14	50	54
Other aquatic invertebrates	2	3	12
Hymenoptera larva	5	9	13
Coleoptera larva	2	2	8
Lepidoptera larva	2	2	5
Unidentifiable animal	43	....	....

1935). The majority of the specimens collected at other hours were captured at water temperatures not more than 2.2 C higher than at 6:30 AM.

Diel changes in feeding activity.—All specimens were examined in order to determine the change in fullness of the stomachs and, hence, to obtain an estimate of feeding activity of the fish over the 24-hr period (Table 2). The major peak in stomach fullness occurred at 9:00 PM. Some 74% of the stomachs were over 50% full and no empty stomachs were observed. Feeding activity decreased very rapidly after this. At midnight 85% of the stomachs were empty and only two specimens of 54 were over 50% full. This low level was maintained at 3:00 AM. By 6:00 AM feeding activity increased but at a relatively low intensity. Although only 10% of the stomachs were empty, all stomachs were less than 50% full. Thereafter, feeding activity decreased slightly until early afternoon. At noon the percentage of empty stomachs increased to 37%, but of the

TABLE 2.—Diel changes in percentage of empty stomachs and per cent fullness of *Notropis spilopterus* with regard to size and sex

Hour	Size range in mm	No. of species	No. of empty stomachs	% with empty stomachs	Fullness of stomach: Less than 25%	25%-50%	Over 50%	Male	Female
9:00 AM	45-51	19	4	21	4	8	3	5	14
	61-72	11	3	27	5	2	1	7	4
	all sizes	30	7	23	9	10	4	12	18
Noon	44-55	17	3	18	1	7	6	5	12
	57-70	10	7	70	2	1	0	9	1
	all sizes	27	10	37	3	8	6	14	13
3:00 PM	47-57	16	2	13	4	8	2	3	13
	61-77	12	5	42	5	1	1	11	1
	all sizes	28	7	23	9	9	3	14	14
6:00 PM	46-54	20	1	5	5	4	10	2	18
	56-64	9	1	11	2	3	3	5	4
	all sizes	29	2	10	7	7	13	7	22
9:00 PM	47-54	9	0	0	0	1	8	0	9
	55-64	7	0	0	0	2	5	5	2
	all sizes	16	0	0	0	3	13	5	11
Midnight	44-58	23	20	87	0	3	0	5	18
	60-82	30	25	83	0	3	2	24	6
	all sizes	53	45	85	0	6	2	29	24
3:00 AM	44-58	25	19	76	3	1	2	7	18
	60-80	16	14	88	1	1	0	13	3
	all sizes	41	33	81	4	2	2	20	21
6:00 AM	48-53	10	1	10	4	5	0	0	10

27 stomachs examined six were at least 50% full. Thus, fewer fish were feeding at noon than at 6:00 AM. However, those which were feeding at noon were doing so at a somewhat greater intensity than those collected at 6:00 AM. Since sunrise was at approximately 5:20 AM and sunset at about 8:00 PM, the food in stomachs at 6:00 AM represents food taken just before or after dawn and the food in stomachs at 9:00 PM indicates food items taken just before or at dusk.

For two size groups the fullness of stomachs was compared for each hour of collecting (Table 2). During the day (9:00 AM to 6:00 PM) the smaller fish apparently feed more intensely than the larger fish. This is especially true at noon. For smaller specimens, six of 17 stomachs were more than 50% full, and only 18% of the stomachs were empty. For this same period no stomachs from the larger specimens were more than 50% full and 70% had empty stomachs. Similar trends with size, though not so pronounced, were noted with the 3:00 PM and 6:00 PM specimens. Most of the smaller fish were females (Table 2).

Starrett (1950) found that *N. spilopterus* is a diurnal feeder, with maximum feeding activity during the late afternoon or dusk. He also noted that feeding activity decreased after dark. In general the present study supports these conclusions but also indicates a dawn increase in feeding at lower intensities. Further, the present study indicates that the smaller fish (predominantly females) feed through the day.

Diel changes in food habits.—Volume, frequency and occurrence of the major food items of *N. spilopterus* with regard to time of day are noted in Table 3. Trichoptera larvae constituted an important proportion to the food through

TABLE 3.—Diel changes in the per cent volume, per cent frequency and per cent occurrence of the major food items of *Notropis spilopterus*[1]

Hour collected	Total no. fish	Total no. items	Trichoptera larva			Simulid larva			Chironomid larva			Unknown Diptera larva			Total Diptera larva		
			Vol.	Freq.	Occ.	Vol.	Freq.	Occ.	Vol.	Freq.	Occ.	Vol.	Freq.	Occ.	Vol.	Freq.	Occ.
6:00 PM	27	158	60	61	85	10	9	26	6	22	67	2	12	22	18	43	78
9:00 PM	19	92	5	5	21	1	3	11	6	23	26	2	19	58	9	45	68
Midnight	8	9	0	0	0	0	0	0	1	22	13	1	22	25	2	44	25
3:00 AM	8	15	16	47	25	0	0	0	13	7	13	0	0	0	13	7	13
6:00 AM	9	37	28	16	44	20	70	33	2	8	22	0	0	0	22	78	44
9:00 AM	23	48	52	60	65	t	6	9	11	25	22	1	2	4	12	33	30
Noon	17	56	28	23	59	2	13	12	11	52	59	0	0	0	13	64	65
3:00 PM	23	119	26	17	61	11	31	26	8	40	48	0	0	0	19	71	57

Hour collected	Total no. fish	Total no. items	Hymenoptera larva			Coleoptera larva			Lepidoptera larva			Other aquatic invertebrates			Miscellaneous		
			Vol.	Freq.	Occ.	Vol.	Freq.	Occ.	Vol.	Freq.	Occ.	Vol.	Freq.	Occ.	Vol.	Freq.	Occ.
6:00 PM	27	158	2	3	7	2	1	4	0	0	0	0	1	4	19	....	....
9:00 PM	19	92	23	40	63	2	3	16	0	0	0	1	7	26	60	....	....
Midnight	8	9	13	56	38	0	0	0	0	0	0	0	0	0	85	....	....
3:00 AM	8	15	13	27	13	0	0	0	0	0	0	5	20	25	54	....	....
6:00 AM	9	37	0	0	0	0	0	0	6	3	11	1	3	1	43	....	....
9:00 AM	23	48	0	0	0	t	2	4	0	0	0	4	4	9	32	....	....
Noon	17	56	0	0	0	2	11	24	1	2	6	0	0	0	55	....	....
3:00 PM	23	119	0	0	0	4	1	4	8	8	17	2	3	13	41	....	....

1 t—indicates the food items which constituted less than 1% of volume

most of the daylight hours except prior to and following sunset. The volume and frequency of this food item reached a maximum at 6:00 PM (60% and 61%, respectively), decreased drastically thereafter, and at midnight none were found in stomachs. By 9:00 AM the following morning, they had reached levels comparable to those observed at 6:00 PM. Diptera larvae constituted an important food item during all daylight hours including the period before and after sunset. The volume of Diptera larvae was a maximum by 6:00 PM. Simulids accounted for the majority of the Diptera larvae at this time, while chironomids accounted for the major share of this food item later in the day. The volumes and occurrence of Hymenoptera (ants) reached a maximum at 9:00 PM, but decreased until early morning when they were absent.

Thus, it appears that *N. spilopterus* fed on or near the bottom during most of the daylight hours. Hymenoptera constituted the major food item at night. Perhaps this species feeds at or near the surface at dusk. The diel change in occurrence of the two main dipterans (simulids and chironomids) may be explained by temporal changes in feeding location or availability of food items.

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REFERENCES

EDMONDSON, W. T. (ed.). 1966. Freshwater biology. John Wiley and Sons, Inc., New York. 1248 p.

FORBES, S. A. 1883. The food of the smaller freshwater fishes. *Bull. Ill. State Lab. Natur. Hist.,* **6**:65-94.

GREELEY, J. R. 1927. Fishes of the Genesee region with annotated list, p. 47-66. *In:* Suppl. 16th Annu. Rep. N.Y. State Conserv. Comm.

KARZINKIN, G. S. 1935. K Poznaniyu Rybnoy Produktiviosti Vodoyemov. Soodshchenie. II. Izuchenie Fiziologii Pitaniya Segoletok zer Kal'nogo Karpa. Trudy Limnologicheskoy standii v Kosine, **19**:21-66. Zur Kenntniss der Fischproductivitat Gewasser. II. Mitteilung. Erforschung der Physiologie der Ernahrung des spiegelkarpfens. *Kossino Limnol. Stat.,* **19**:21-66 (In Russian with German summary.)

MASON, W. T. 1968. An introduction to the identification of chironomid larvae. Division of Pollution Surveillance, Fed. Water Pollution Control Admin., U.S. Dep. of Interior, Cincinnati, Ohio. 89 p.

PENNAK, R. W. 1953. Freshwater invertebrates of the United States. The Ronald Press, New York. 769 p.

RIMSKY-KORSAKOFF, U. N. 1930. The food of certain fishes of the Lake Champlain watershed, p. 88-104. *In:* A biological survey of the Lake Champlain watershed. Suppl. 19th Annu. Rep. N. Y. State Conserv. Comm.

SIBLEY, C. K. 1929. The food of certain fishes of the Lake Erie drainage basin, p. 180-188. *In:* A biological survey of the Erie-Niagara system. Suppl. 18th Annu. Rep. N. Y. State Conserv. Comm.

——— AND U. N. RIMSKY-KORSAKOFF. 1931. Food of certain fishes in the watershed, p. 109-120. *In:* A biological survey of the St. Lawrence watershed. Suppl. 20th Annu. Rep. N.Y. State Conserv. Comm.

STARRETT, W. C. 1950. Food relationships of the minnows of the Des Moines River, Iowa. *Ecology,* **31**:216-233.

STONE, U. B. 1940. Studies on the biology of the satinfin minnows, *Notropis analostanus* and *Notropis spilopterus.* Unpubl. Ph.D. Thesis, Cornell Univ., Ithaca, New York.

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