STUDY OF THE FOOD OF THE BLUNT-NOSED MINNOW, PIMEPHALES NOTATUS.

WALTER C. KRAATZ,
Department of Biology, University of Akron.

INTRODUCTION.

Study of the food of minnows is now recognized as very important by ichthyologists. The public knows the importance of minnows as suitable, natural food for game fishes and other larger food fishes, but still fails to appreciate often the basic need of adequate food for the minnows.

Food of minnows has been studied by a number of investigators, practically beginning in this country with the widespread fish work of Forbes about 1880, as recorded in many papers. An example of recent work on food of several minnow species is that of Breder and Crawford, (1922). Many minnow species have been examined in general surveys, but few in large series of specimens. Studies referring to Pimephales notatus will be cited below.

Most of the specimens used in this study were seined in the Portage Lakes, near Akron, Ohio, a chain of lakes very popular for fishing and resort purposes, and rather typical of the few lakes of such sort in Ohio. (Osburn 1921).

General interest in the fish conditions of these lakes warrants investigation of their minnow food. Mr. E. L. Wickliff, of the Ohio Division of Fish and Game, suggested to the writer study of such species as would be abundant and good food for the game fishes, and likewise which would more likely be to a considerable extent vegetarian, so that they would be in little competition with the young game fishes. Such minnow species might then be suitable for propagation in fish hatcheries and fish ponds. Pimephales notatus (Rafinesque), the blunt-nosed minnow, was for practical reasons selected as best for this initial detailed study of food.

The writer wishes to express his indebtedness to Mr. E. L. Wickliff for suggestions, for some southern Ohio specimens, and for the collecting equipment furnished by the Ohio Division

of Fish and Game, and also his indebtedness to a number of interested students, who at various times in the summer of 1926 helped in the collections, namely Messrs. A. Dobkin, L. Sheinin, H. Cassidy, C. Krill, and also Mr. R. Rice, who helped in 1927.

Distribution and Frequency of the Species.

Pimephales notatus, recorded as the most abundant minnow in Ohio, (Osburn 1921), was the most abundant species of Cyprinidæ in every one of the Portage Lakes seined during the period of the collections, indeed nearly five times as common on an average as the next most abundant species, Opsopoeodus emiliæ, which was followed closely by Abramis.

This is somewhat contrary to its distribution in Illinois, where statistical data (Forbes and Richardson, 1908, p. 99) showed it scarce in lakes and far commoner in creeks and small rivers, and in fact less fequent in lakes than 16 other minnow species.

The species lives chiefly over mud bottom, less frequently over sand bottom but also on stony shoals, where they breed, according to Reighard (1925, p. 226), who studied this species in a typical lake. The collections upon which this work is based certainly showed it to be an ideal small lake species.

Previous Study of Pimephales Food.

Forbes, (1878, p. 79) found three specimens "full of dirt with fragments of endogenous vegetation, confervoid algæ, and many diatoms."

Forbes, (1883, p. 73) found nine specimens from various parts of Illinois in which: "Mud made about eighty percent of the contents of the alimentary canal, the remainder consisting of unrecognizable vegetable debris, with a few filaments of algæ. Undeterminable insects occurred in one, and a single specimen of Cypris in another."

Hankinson, (1908, p. 204) says: "The food of this species varies very much, but consists chiefly of small organisms taken from the bottom, from water plants, and from the water. Individuals were frequently seen feeding on the eggs of the black bass, Johnny darter, miller's thumb and sunfish of three species." He noted that some of their own fry were eaten, and that in the spring "midges in various stages of development

formed the chief food." He also found some algæ and Entomostraca and in one case a beetle.

Forbes and Richardson, (1908, p. 120) state: "It is one of the mud-eating group, the alimentary canal being commonly packed from end to end with mud containing filamentous algæ and miscellaneous vegetable debris." Occasionally they found insect fragments and Entomostraca.

Reighard, (1915, p. 226) says: "the muddy bottom of protected bays affords it food, for it is a 'mud-eater.'" He also (p. 242) found a variable diet, indicating similarity to that given by Hankinson.

Pearse (1918, p. 271) in a study of this and many other species in Wisconsin Lakes, in commenting upon 60 specimens for which he studied the food in detail, said: "The blunt-nosed minnow eats a good deal of silt, bottom debris, and plants, though entomostracans and insects constitute more than half its food. Certain individuals had taken foods as follows: Chironomous lobiferus pupæ, 100; Bosmina longirostris cornuta, 100; oligochaetes, 98; filamentous algæ, 90; silt and debris, 100. These figures show that the minnow is a versatile feeder. The food in the stomach has always been chewed into fine pieces."

Pearse, (1921, p. 46) found in five specimens from Lake Pepin, rather equal quantities of midge larvæ, midge pupæ, Daphnia, fine debris, and unknown materials.

Thus considerable examination of food has been made in this common species. But a new survey here of over 300 specimens should give a better view of the variability of its diet, and give data from Ohio waters from which no such examination has been made before.

Methods.

Food was examined in all cases from formaldehyde preserved specimens which had been collected near shore with a 15 foot, eighth inch mesh seine. The method of food study was the customary one, described by Forbes (1878), Pearse (1915, 18, 20), and used by others, as by the writer on Campostoma (Kraatz 1923). This is the method of estimation of volume of each class or type of food, expressed in percentage of the whole food contents of each fish. No quantitative work was done. This qualitative method gives by mere inspection and

judgment, obviously only approximations of correct percentages. But with care and use of many specimens the approximations become as reasonably accurate as can be expected, and it is the only simple, feasible method available. The worst difficulties are in cases where masses of commingled inorganic and finely divided organic debris must be differentiated for estimates, and where percentages are judged on some large mass, say of a larva of some thickness, over against numerous tiny diatoms or algæ scattered over a wide area. Food items occurring in large quantities were expressed commonly in multiples of tens or fives. But relatively rare items were often apparently correctly expressed as one per cent or two per cent. It must be understood that the numerous fractional percentages, expressed to one decimal point, occurring in the tables, were secured only after averaging groups of individual specimens.

Altogether 315 specimens of the species were carefully examined. In each the entire alimentary canal in the abdominal cavity was taken, measured, cut into pieces and the entire contents squeezed out upon a large glass plate. The mass was evenly spread over the plate in a film of water, and examined with binocular first under X 29, and then X 46, which was adequate to show up most foods and estimate the contents in general, and then examined under low power of compound microscope, usually no more than X 75, which was required to recognize the groups of smaller organisms such as diatoms, and other unicellulars. Although some greater magnifications were used for some minute organisms, it was not necessary for the work presented in this paper.

Explanation of Tables.

The detailed findings of food items of all 315 individuals of the species are not given in tables in this paper; they would fill at least 15 pages of tables. In grouping specimens, and averaging foods of a common kind together for all fishes of a group, it was so arranged that in each group (or each entry in the table) there would be fishes from only one lake and one collection, and also of only a small range of lengths. Much space is saved, though countless, detailed diet differences are partly obscured.

In one table (No. 4) a few individuals are selected showing particularly contrasting individual diets.

In reading food percentage figures, there may come inevitably the impression of relative quantities of foods. Naturally this is incorrect. To assist in a corrected idea there should be noted in this connection the figures expressing to what degree the intestine was filled. In all individual specimen data, the writer has intestine length as well as "degree filled" to correlate with length of fish. "Degree filled" is an estimation; if "1" is used, it means the intestine was packed from end to end; if "½," that it was about ½ full, no matter how distributed. In grouping the fishes the fractions can tell no more than, when for instance the figures ¼—¾ occur for 10 fishes, that some of the ten had as little as ¼ and other as much as ¾ of the intestine filled.

ABBREVIATIONS USED IN THE TABLES.

New (New Reservoir); Nesm. (Nesmith Lake); Long (Long Lake); West (West Reservoir); East (East Reservoir); Turk. (Turkeyfoot Lake); Rex (Rex Lake); S. O. (Southern Ohio, from the Ohio River drainage, but with exact localities for specimens examined unknown. This group was sent to the writer by Mr. Wickliff). In one place in Table 2, an entry of two lines is recorded as "East S." This stands for East Reservoir, Sandy Beach. The latter, a sandy bathing beach, was just one particular collecting place very readily worked, among others on the lake. But it happened that specimens were kept separated from those of other localities on the lake, and incidentally showed some interesting differences in detail of food from most of the fish from other collections.

TABLE I.

Alimentary Canal Contents of *Pimephales notatus*.

Date of Collection	Locality Collected	Fish Length, mm.	Number of Specimens	Degree Filled	Inorganic	Unrecognizable Organic Debris	Coccogoneales	Hormogoneales	Diatoms	Protococcales	Desmids	Filamentous Green Algae	Higher Plant Remains	Protozoa	Rotifers	Setae, Annelida	Statoblasts, Bryozoa	Copepoda	Cladocera	Ostracoda	Amphipoda	Water Mites	Eggs (unknown)	Caddis Larvae and Cases	Midge Larvae	Insect Remains	Unrecognizable Animal Remains
6-24-26	New	40-55	7	1/2-3/4	11.0	6.7	2.3	8.0	.7	1.7		9.3							38.9	1.4					11.4	5.7	
6-29-26	"	37-49	2	1/2-3/4	15.0	15.0	2.5		2.5	2.0		1.0	2.5	1.0					3.5						15.0	40.0	
"	"	50-58	7	1/3-3/4	23.7	18.0	2.3		5.7	4.1	.4	6.7	.7	.3		.3	.1	.4	6.6	.1					10.8	19.8	
7-15-26	"	21-29	10	1/10-1/2	5.3	6.3	.5		5.0	3.5	.1	1.8		.3		1.4		7.0	13.3	4.3					50.5		.7
"	"	42-49	4	2/3-3/4	17.5	12.5	.5		13.5	21.2	2.5	13.3	1.2						1.5						16.3		
"	"	50-55	6	1/3-1	17.0	9.0	2.0	.8	10.2	14.5	.8	1.3	1.7					.5	17.2	15.0					8.3		1.7
7-29-26	"	28-35	10	1/4-2/3	15.3	22.0	.4	.6	4.8	6.3	1.4	2.0		.4			2.5	5.0	10.0	17.5			.6		6.2	4.0	1.0
"	"	50-54	5	1/2-9/10	17.0	25.0		.2	13.8	18.0	2.2	.4	4.0	.4					12.0	5.0			1.0		1.0		
"	"	60-63	5	0-9/10	7.5	8.7	.7	.5	4.0	12.3	.3	1.7		.3	.3			8.7	32.5	22.5							
7- 2-27	"	35-46	3	1/3	1.3	10.0	.7		3.3	.7		.7						1.6	65.0	5.0					11.7		
7- 6-26	Nesm.	41-47	2	1/5-1/4	42.5	15.0			.5							.5											1.5
"	"	51-60	3	1/2-1/3	23.3	25.3		1.0	3.7	.3		2.0	1.0						41.7	1.7							
7-29-26	Long	36-43	7	1/10-1/5	8.9	14.4	.3		.1				4.3			.1		10.0	2.1	50.7					2.9	5.7	.7
"	"	44-49	10	1/5-3/4	13.2	14.5	.8	.6	.6	3.	.2	1.3	5.3			.5		.2	6.0	27.5					3.0	25.5	.5
"	"	50-56	10	1/10-1/3	13.7	13.3	2.4	.9	3.7			2.0	16.7			.2	.5	1.0	9.0	9.0	5.0		1.0		12.5	8.0	1.0
"	"	61-64	3	1/5-1/3	15.0	20.0	5.7	1.3	7.0			3.3	24.3						13.4	3.3						6.7	

TABLE II.

Alimentary Canal Contents of *Pimephales notatus*.

Date of Collection	Locality Collected	Fish Length, mm.	Number of Specimens	Degree Filled	Inorganic	Unrecognizable Organic Debris	Coccogoneales	Hormogoneales	Diatoms	Protococcales	Desmids	Filamentous Green Algae	Higher Plant Remains	Protozoa	Rotifers	Setae, Annelida	Statoblasts, Bryozoa	Copepoda	Cladocera	Ostracoda	Amphipoda	Water Mites	Eggs (unknown)	Caddis Larvae and Cases	Midge Larvae	Insect Remains	Unrecognizable Animal Remains
7-20-26	West	24-29	10	1/3–3/4	12.5	11.5	16.6	1.2	4.9	5.0	1.3	4.7	.3	.3	1.0	4.3		1.0	7.6	27.0			.3				.5
8- 5-26	"	33-48	6	1/4–3/4	15.8	16.5	9.2	1.7	7.6	.3	2.3	3.8	2.5	.2				5.0	17.5	13.4			.8		.8	1.7	.8
"	"	50-56	10	1/3–4/5	19.6	23.6	8.3	2.2	6.8	.5	2.0	6.0	4.4	.1	.1	1.0		.5	4.0	17.4					2.0	1.0	.5
"	"	58-61	4	2/3–4/5	15.0	19.5	1.5	.5	2.2		1.8	3.8	3.8					1.2	3.2	30.0					13.7	3.8	
6-26-26	East	49-66	5	1/2–2/3	17.0	11.6	.4	.4	15.0	.2		.8	2.0						3.8	.4	4.0		1.0		12.4	28.0	3.0
7- 3-26	"	42-54	6	1/2–3/4	20.8	14.2	6.1	7.3	23.8	1.5	.3	3.1	1.6	.3			.5	2.6	17.5								
7-17-26	"	44-49	5	1/2–9/10	15.0	7.0	6.2	23.4	21.0	.4	2.0	2.0	1.2		.4			.4	8.8	10.0			.2			2.0	
"	"	50-58	12	1/2–4/5	14.3	6.5	10.5	10.5	34.2	2.5	5.5	8.0	.4		.2			.3	4.7	.8					.4	8.	.4
"	"	62-63	3	3/4–9/10	15.0	4.3	6.3	12.7	25.0	1.3	1.3	9.0	2.7	.7					5.0					16.6			
7-17-26	East S.	48-58	10	1/3–4/5	13.8	4.7	1.8	4.0	6.5	.3	.4	2.5							65.5								.5
"	"	61-71	10	1/2–4/5	15.8	4.0	2.2	13.1	4.3	1.1	.5	2.9					.3	.3	53.0	1.2							1.3
7-31-26	East	25-36	12	1/2–2/3	16.3	17.5	4.4	2.1	4.3	.1	1.3	4.8	9.3			.3		3.8	17.1	15.8		.7	.3		.7	.8	.4
"	"	40-48	8	1/2–3/4	20.3	14.4	7.3	2.5	2.3		.8	1.8	6.2						3.5	40.6							
"	"	50-58	6	1/3–1/2	16.7	20.8	1.2	3.3	3.3	.2	.5	.2	16.7						5.0	23.3					.8	6.7	1.3
"	"	60-69	4	1/2–3/4	18.2	20.5	2.0		5.8				7.0		.5			1.0	18.8	1.3					6.2	17.5	1.2
8- 5-27	East	24-36	10	1/5–1/2	1.1	15.2	3.3	.3	2.5	.1		.3	.9			.7		13.5	31.5	9.5					11.0	8.5	1.6

TABLE III.

Alimentary Canal Contents of *Pimephales notatus*.

Date of Collection	Locality Collected	Fish Length, mm.	Number of Specimens	Degree Filled	Inorganic	Unrecognizable Organic Debris	Coccogoneales	Hormogoneales	Diatoms	Protococcales	Desmids	Filamentous Green Algae	Higher Plant Remains	Protozoa	Rotifers	Setae, Annelida	Statoblasts, Bryozoa	Copepoda	Cladocera	Ostracoda	Amphipoda	Water Mites	Eggs (unknown)	Caddis Larvae and Cases	Midge Larvae	Insect Remains	Unrecognizable Animal Remains
7-10-26	Turk.	42-49	8	0–¾	12.1	17.1	6.9	6.6	5.6	1.7	.4	6.6	.7		.2	.4		1.6	24.0	10.4						4.3	1.4
"	"	50-58	10	⅛–⅔	15.3	13.8	4.3	2.2	.8	.6	.1	3.5	13.5	.2				9.0	16.9	5.5	.5	.2	.6		3.5	9.0	.5
"	"	61,62	2	0–¼	15.0	10.0	10.0	5.0												20.0						40.0	
7-24-26	"	40-49	9	⅛–⅔	15.6	22.2	15.8		3.1	1.1	.6	10.0	5.5						19.3						3.9	2.8	
"	"	50-57	6	½–⅚	24.2	21.7	7.8	2.0	3.0	.8	.3	10.0	8.3		.2			.8	5.8	5.0					3.4	6.7	
"	"	60-65	5	½–⅔	19.0	17.0	6.6	.6	4.8	1.2	3.4	39.0	2.6		.2			1.0	4.6								
8- 7-26	"	34-38	5	¼–½	11.0	18.0	23.6		1.2			2.6						1.0	17.0	9.0					9.0	3.0	4.6
"	"	47-57	5	¼–⅘	26.0	41.0	8.0	.6	10.0	.6	.4	2.0	2.4						3.0	2.0					3.0	1.0	
7-24-26	Rex	30-35	5	¼–⅔	11.0	18.0	6.2		8.4	5.2	6.4	15.0	1.6		2.0	.2		3.0	6.0						15.0	2.0	
"	"	44-49	5	¼–9/10	15.0	23.0	8.0	.4	15.0	2.6	5.0	6.0	3.0	.2		.2		1.0	15.6	2.0					3.0		
?	S. O.	21-27	7	⅓–⅘	46.4	25.7	1.1	.9	6.0		5.7	1.2	.7	.2				.7	11.4								
?	"	30-39	10	¾–1	66.5	25.0		1.4	3.6		1.6	1.3	.3	.2	.1												
?	"	40-48	8	⅔–1	57.5	11.4	1.5	16.1	8.6		.5	3.6	.5	.3													
?	"	50-59	9	⅓–1	59.7	10.6	1.4	14.8	4.0		.7	5.0	2.1					.1	.1							.5	
?	"	60-71	6	⅓–1	55.8	16.7	.5	4.2	3.7	.2	.3	8.2	1.2		.2	.2			3.3						1.6	.6	3.3

TABLE IV.

Alimentary Canal Contents of *Pimephales notatus*.

Specimens Selected to Show Contrasting Diets.

Date of Collection	Locality Collected	Fish Length, mm.	Intestine Length mm.	Degree Filled	Inorganic	Unrecognizable Organic Debris	Coccogoneales	Hormogoneales	Diatoms	Protococcales	Desmids	Filamentous Green Algae	Higher Plant Remains	Protozoa	Rotifers	Setae, Annelida	Statoblasts, Bryozoa	Copepoda	Cladocera	Ostracoda	Amphipoda	Water Mites	Eggs (unknown)	Caddis Larvae and Cases	Midge Larvae	Insect Remains	Unrecognizable Animal Remains
6-24-26	New	46	64	2/3	2	12				1									85								
7-15-26	"	21	20	1/3	3				5	2								5	20	5					60		
"	"	50	79	3/4	15	15			5	5			10												50		
7-29-26	"	30		1/3	5	5			2	2										80			6				
8- 5-26	West	55	68	2/3	8	5	1	1												85							
7-20-26	"	27	26	1/2	25	20	30	1	1		1	2	3						7	10							
6-26-26	East	66	105	1/2	15	5			5										5				5		15	50	
7- 3-26	"	52	62	3/4	15	10	3	30	30	1		10					1										
7-17-26	"	54	85	4/5	10	5	10	1	60	2	8	1						1	1	1							
"	"	56	70	2/3	6	5	5	65	15	2	1	1															
"	"	51	71	3/4	2		1	1	1										95								
"	"	53	70	1/2	10	3	1	4	2										80		•						
7-29-26	Long	36	45	1/5	10	9	1											70	5	5							
"	"	50	67	1/3									90					5		5							
?	S. O.	37	76	4/5	70	20		7	3																		
?	"	53	92	1	90	2	1	2	5																		

Discussion of the Food.

As seen in the tables, inorganic material was found in large amounts in canal contents. Rarely was there a fish without at least a small percentage. On the other hand it was not exceptionally high, averaging from 10 to 30 percent in Portage Lakes fishes. That much might be expected of any fish feeding in shallow water, over muddy bottom, and inclined to a somewhat bottom feeding habit, without its being properly characterized a "mud-eater." In the series of specimens sent by Mr. Wickliff from southern Ohio, (from some parts of the Ohio River drainage) there was a considerable contrast, for inorganic matter was present to a greater amount than 50% on an average. The smallest percentage, 15% to 20% was found in only a few of forty fishes, and several had as much as 90% inorganic matter.

Unfortunately the "unrecognizable organic debris," was often of large percentage. None of this so listed could be distinguished with any certainty whatever. Sometimes it was even hard to separate from inorganic matter, but on close examination showed clear differences from mud particles or crystals, appearing usually as flocculent, irregular bits, finely broken down material, sometimes of greenish color, suggesting that it was often of plant origin. Animal material would most likely be more quickly and fully digested if once sufficiently mechanically broken down, and thus escape discovery.

There were many different plant types. "Higher plants" means that in various specimens pieces of leaf, etc., of seed plants presumably, were found. They may have been small pieces when ingested. In several series of specimens, where there is a rather large percentage, as from East Reservoir, July 31, 1926, and Long Lake, July 29, 1926, it was almost entirely due to the presence of Wolffia in large numbers.

Coccogoneales (unicellular blue-green algæ) and Hormogoneales, (filamentous blue-green algæ), as well as diatoms and Protococcales, (unicellular green algæ and some colonies) were usually easily recognizable by group, and not much digested, that is when recognizable at all. Filamentous green algæ usually occurred in fragments.

In many specimens the total plant food percentage was large, but in almost as many other specimens, the animal food was in excess. In the literature there has been somewhat more reference to its preference for plant food, possibly giving rise

to the idea (together with its possession of a rather long intestine), that it must be vegetarian. Some writers however show its very general diet. The present study does not allow its classification as vegetarian, for the following reasons: the large percentage of animal food frequent, and the unusual prevalence of algæ which it had to draw upon for food.

In explanation of the latter point, it should be noted that during the time of the collections, particularly in the latter half of the summer, of both years, there were found present, particularly in East, West, and New Reservoirs, and also Turkeyfoot lake, tremendous quantities of minute algæ in the plankton, giving to the water a prominent greenish color. This was found to be due to blue-green algæ, of both filamentous types, and tiny floating colonies of cells, like Coelosphaerium and Microcystis. Much collecting was done with tow net, and in the time of greenish water, every drop contained many of these blue-green algæ. All other types, both plant and animal, were relatively rare in this plankton. A real vegetarian fish like the gizzard shad, (Tiffany 1920, 21), would have found this a bounteous feast, and would have been filled with these algæ. It should be noted that in shallow water these algæ were equally prevalent throughout, surface to bottom, where a foot or up to three feet deep, in the very water where the blunt-nosed minnows were collected, which, (except in few individual cases) had eaten relatively much less of the algæ then were present in the water. Pimephales seems to be partly a bottom feeder, though not so much as is Campostoma, (Kraatz 1923).

Animal food was found to be of many types. Unrecognizable animal remains were noted in only a few specimens. But certain kinds of much broken down animal remains may be so readily digested so as to escape listing.

The vast majority of animal organisms were very small. The record for Protozoa and rotifers is probably incomplete.

Entomostraca formed the outstanding animal type of food. Cladocera were most abundant in the largest number of specimens, and seemed to be eaten in large numbers whenever common. In possibly half of the cases they were quite intact, but the rest could be recognized only from antennæ, pieces of shell, or the ephippium. A number of specimens had 80% and more, and one 95% Cladocera. Ostracoda were nearly as common, though in somewhat fewer fish. In some they formed a large percentage, including several with 80% and one nearly

90%. They were usually much broken up. Copepoda occurred in a few fishes, much broken up. In the rare cases where Amphipoda were listed, Hyalella was found broken up considerably.

The largest recognizable animal types were the insects, though Hyalella, mentioned above, was as large as most insects, since on the whole only smaller insects were eaten. In a few cases where adult insects were found they were much disintegrated. Midge larvæ were far in excess of all other insects. In many instances they were quite intact, and practically in all cases recognizable as midge larvæ. Often the entire chitin covering was found. The larvæ were all very small, and only twice was one over 5 mm. found in the food.

No recognizable fish remains were found. As for eggs eaten, in a number of specimens some eggs were found, all grouped in the tables as "eggs (unknown)." Some of these were insect eggs. One fish only had eaten fish eggs (likewise recorded in same column), forming 5% of its food. Unless there were many fish eggs well digested, Pimephales has a good record on that score, offering a contrast to the findings of Hankinson (1908). On the whole there was less food disintegration than one was led to expect from findings of Pearse (1918).

Conclusions

In view of the striking prevalence of algæ in the waters, with a lesser ingestion of these algæ than a real vegetarian would show, and in view of the large proportion of Entomostraca taken, it seems that Pimephales is as much an animal feeder as plant feeder, if not more so. It is impossible to say that the species has any food preferences, and also impossible to show that the blue-green algæ were for any reason somehow repellent, or that other algæ would be taken in preference to blue-greens, if present.

Pimephales is best regarded as a general feeder, preferring all small food organisms, and as a fish versatile in a high degree, as has been shown more or less also in previous studies, principally by Pearse (1918). It is not characteristically vegeterian, nor carnivorous, nor specifically a plankton feeder, but a general feeder upon all small organisms and debris taken about equally from plankton and from the bottom of its habitats.

Since Pimephales notatus is by far the most abundant minnow, at least in the Portage Lakes, and very generally common in Ohio, it is one of the most outstanding food for the

game fishes of the region. Also, this natural food species, since it thrives so well, will undoubtedly increase somewhat more under general regulation of minnow seining. This increase comes without extra cost. While this minnow is not a vegetarian, as indeed very few species are, it is not much in competition with game fishes for food, except in the very young stages of the game fish life. It certainly is not harmful because not carnivorous on such young. Pimephales should therefore be one of the minnows most favored, and should be found desirable for various fish ponds and lakes.

BIBLIOGRAPHY.

BREDER, C. M. JR., AND CRAWFORD, D. R.
1922. The food of certain minnows; a study of the seasonal dietary cycle of six cyprinoids, with special reference to fish culture. Zoologica, Vol. II, No. 14, pp. 287-327.

FORBES, S. A.
1878. The food of Illinois fishes. Bul. Ill. State Lab. Nat. Hist. Vol. I, No. 2, pp. 71-86.

FORBES, S. A.
1883. The food of the smaller fresh-water fishes. Bul. Ill. State Lab. Nat. Hist., Vol. I, No. 6, pp. 61-86.

FORBES, S. A., AND RICHARDSON, R. E.
1908. The fishes of Illinois. Illinois State Nat. Hist. Survey Div. (2nd ed. 1920), pp. cxxv. and 357.

HANKINSON, T. L.
1908. A biological survey of Walnut Lake, Michigan. Geol. Survey Mich., 1907, pp. 157-288.

KRAATZ, W. C.
1923. A study of the food of the minnow Campostoma anomalum. Ohio Jour. Sci., Vol. XXIII, pp. 265-283.

KRAATZ, W. C.
1924. The intestine of the minnow Campostoma anomalum (Rafinesque), with special reference to the development of its coiling. Ohio Jour. Sci., Vol. XXIV, pp. 265-298.

OSBURN, R. C.
1901. The fishes of Ohio. Ohio State Acad. Sci. Sp. Paper 4, pp. 104.

OSBURN, R. C.
1921. Report on fish conditions in the Portage Lakes. Div. of Fish and Game, Ohio Dept. Agri., Sportsmen's Bul. No. 1, pp. 14.

PEARSE, A. S.
1915. On the food of the small shore fishes in the waters near Madison, Wisconsin. Bull. Wis. Nat. Hist. Soc., Vol. XIII, No. 1, pp. 7-22.

PEARSE, A. S.
1918. The food of the shore fishes of certain Wisconsin Lakes. Bul. U. S. Bur. Fisheries, Vol. XXXV, (for 1915-16), pp. 245-292.

PEARSE, A. S.
1921. The distribution and food of the fishes of three Wisconsin lakes in summer. Univ. Wis., Studies in Sci., No. 3, pp. 1-61.

REIGHARD, J.
1915. An ecological reconnoissance of the fishes of Douglas Lake, Cheboygan County, Michigan. Bul. U. S. Bur. of Fisheries, Vol. XXXIII, (for 1913), pp. 215-249.

TIFFANY, L. H.
1920. The gizzard shad in relation to plants and game fishes. Trans. Amer. Fish. Soc., 1921, pp. 382-386.

TIFFANY, L. H.
1921. Algal food of the young gizzard shad. Ohio Jour. Sci., Vol. XXI, pp. 113-122.