THE ALGAL FOOD OF PIMEPHALES PROMELAS. (Fathead Minnow)*†

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INTRODUCTION.

In recent years increasing interest has been shown by icthyologists and those people concerned with fish culture regarding the food of our common fishes. The interest at the present time is centered in the study of the food of the possible species which may be used as forage fish for bass or other carnivorous pond fishes. *Pimephales promelas*, Rafinesque, the fathead minnow, is a species under such consideration. The purpose of this paper is to describe the food of the fathead with special emphasis on the algal food, but also with mention of such animal forms and other materials found in the alimentary canal. This work has been carried on for over a year at the Botany Department of the Ohio State University and at the Franz Theodore Stone Laboratory at Put-in-Bay, Ohio.

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METHODS OF COLLECTION AND STUDY.

The minnows were collected by means of a fine-meshed seine. They were placed immediately in a ten per cent formalin solution to preserve the contents of the stomach and intestine. Later a longitudinal slit was made in the ventral body wall and the alimentary canal was removed. Each alimentary

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canal was placed in a small shell vial filled with 6-3-1 preservative (6 parts water, 3 parts 95% alcohol, and 1 part formalin). When a detailed study was made of the contents of the alimentary canal small bits were removed and microscopic slides were prepared. Permanent glycerin mounts for future reference were made of the stomachic or intestinal contents of each fish observed. The slides were studied first under the medium and then the high powers of the compound microscope with the occasional use of the oil immersion. The content of many of the alimentary canals was spread out in flat dishes and was studied under the low power of the compound microscope.

Two hundred three fish were studied. The size ranged from 6 centimeters long, which is practically the maximum length of the fathead, to 2.7 centimeters. The measurements were taken from the point of the snout to the base of the caudal fin.

FEEDING HABITS.

Up to the present time there has been little work done on the feeding habits of *Pimephales promelas*. According to Forbes and Richardson (5): ". . . . . it belongs to the mud-eating group of minnows, and its alimentary structures correspond to this fact, the intestine being two to three times the length of the head and body, and the pharygeal teeth not hooked but with well developed grinding surface. Our only knowledge of its food is derived from a study of four specimens from muddy streams in northern and central Illinois. The intestines of these were largely filled with mud containing some algæ and a considerable number of insects, partly of terrestrial species and partly aquatic larvæ of Diptera."

Lord (13) in the discussion following his paper (p. 96) on *The Blackhead Minnow As a Forage Fish* given at the Meetings of the American Fisheries Society at Hartford, Connecticut, in August, 1927, says: ". . . . . the blackhead (= fathead) minnow, after it reaches a certain size, say forty millimeters, can be seen browsing along on the stems of aquatic plants, scraping off the diatom slime and small algæ. It is not a carnivorous fish so far as can be seen."

A study of the alimentary canals of *Pimephales promelas* certainly shows that it belongs to the mud-eating group of minnows. In practically every one of the fish studied which were taken from the streams or small rivers the alimentary

canals were filled, sometimes even gorged, with sand and silt. Mixed in with the silt were found the plant and animal remains. This would tend to indicate that the fathead also feeds near the bottom, taking in mud, plant and animal food, and organic remains. Specimens taken from regions along Lake Erie show a decided decrease in the amount of mud present, (in some cases it was entirely absent), but by far the greater number of fatheads is found in the muddy creeks or in small sluggish rivers; so it seems they can be considered as belonging to the mud-eating group. Judging from the predominance of fragments of Oscillatoria in the stomachic and intestinal contents, it would seem that the minnow nibbles, to a certain extent at least, on that filamentous blue-green. Broken filaments of Oedogonium and Spirogyra were observed frequently while it was not at all uncommon to find short or even quite long filaments of other filamentous greens. Whether these were nibbled directly from the plant mass or whether they entered the fish by accident as water was taken into the mouth during respiration cannot be said. The filamentous greens were found to be very much more abundant and the filaments themselves were much longer than were those observed by Tiffany (20) in his work on the algal food of the young gizzard shad.

ORGANISMS COMPRISING THE FOOD.

Only a few statements have been made by investigators concerning the food of the fathead. Reference has been made in the preceding paragraph to the report of Forbes and Richardson (5) on the food of *Pimephales promelas*.

Forbes (6) in another paper says: ". . . . about three-fourths of the intestine consisted of mud, the remainder being wholly insects. These were partly terrestrial species, occurring accidentally in the water, and partly aquatic larvæ of Diptera. The vegetable food of these specimens amounted to about one per cent, chiefly various unicellular Algæ."

Pearse (15) in giving a quantitative summary of the food of three specimens in per cent says, "Tanytarus gregarious larvæ, 79.3; mites, 1.6; amphipods, 0.3; Cyclops, 2.6; oligochaetes, 6; diatoms and other algæ, 1.3; and debris, 8.3."

Lord (13) found that "after a size of 25 to 30 mms. was reached the fish were observed feeding on algæ to a great extent. It is thus non-competitive with game-fish."

It seems that the habitat in which the fish are taken determines to a great extent what will be found in the alimentary canal. The fish which were investigated came, for the most part, from streams in southwestern Ohio. One lot of minnows was collected June 24, 1928, in White Oak Creek, Brown County, and also in the East Fork of the Miami River, Clermont County, when the waters were high and the streams were full of mud. These fish were found to be filled with mud or silt and plant and animal food proved to be rather scarce. The algal forms consisted almost entirely of Closteriums, Diatoms, and various species of Euglena along with filaments of Rhizoclonium and disintegrated Spirogyra. The Entomostraca were proportionately much more scarce than were the fragments of leaf tissue, tracheæ, and epidermal hairs which were found mixed in with the mud. In fact many of the fish showed practically no indication of having taken in animal food.

On the other hand a few fish were collected in Maumee Bay, at the mouth of the Maumee River, and also at the mouth of the Portage River which showed a varied diet of many small algal forms and Entomostraca. These fish were practically devoid of mud.

The remainder of the fish, taken from various streams of the Ohio River drainage system, showed a very large percentage of mud, but they also showed a larger percentage of algal species as well as a slightly larger percentage of animal forms.

Of the animal forms observed, the Entomostraca were by far the most abundant. The Cladocera were found most frequently with the Copepoda being second in importance. The Ostracoda were found to be much less abundant than were the other two orders. Other animal forms that were observed were Rotifers, Nematoda, and the remains of a few small insects. Setæ of the freshwater Oligochaeta and masses of pigment cells were frequently found. Very often the only evidence of animal food was an occasional appendage or perhaps a furcal ramus of a copepod.

Pimephales promelas is considered by some to be more of an animal than a plant feeder, but present observations do not indicate that such is the case. Further it does not appear to be nearly so much of an animal feeder as Kraatz (11) has shown *Pimephales notatus* to be.

The algal material found in the alimentary canal is probably the only plant material which is used for food to any great

extent. The blue-greens are very abundant as compared with the number found by Tiffany (20) in the gizzard shad. The different type of habitat of the fathead probably accounts for this increase. The number of species of the Protococales, (Chlorococcales) is much smaller, while the species lists of Desmids, Euglenoidia, and filamentous greens are much longer than those reported by Tiffany (20). Not only can differences in the habitats account for the variations in the algal forms found in the alimentary canals of the two fish, but also the types of gill rakers present in the fish can offer some explanation for these variations. The gill rakers of *Pimephales promelas* are much shorter and are much fewer in number than are those of the gizzard shad. This fact alone can probably account for the scarcity in the numbers of the Protococcales reported for the fathead.

ALGAL FOOD.

Table I shows the 128 species and varieties of algæ which were identified in the alimentary canals of the 203 fatheads investigated. The table is arranged to show the relative abundance of the species according to two general habitats: (a) bays and the mouths of several rivers in the western end of Lake Erie (indicated by "Erie"), and (b) streams and small rivers of the Ohio River drainage system (indicated by "O. R. D."). "R" in the table refers to rare or occasional, "C" to common, and "A" to abundant. When the letter x is found in two columns under the same general habitat, for a single species, it means that the abundance of the species is one or the other depending upon the locality in which the fish were collected.

TABLE I.

Algal Species or Variety	Erie			O. R. D.		
	R	C	A	R	C	A
Myxophyceæ.						
Aphanocapsa pulchra (Kuetz) Raben	x				x	
Chroococcus limneticus Lemm	x					
" " var. *distans* G. M. Smith	x					
" *turgidus* (Kuetz) Naeg				x		
" *varius* A. Braun				x		
Coelosphaerium kuetzingianum Naeg		x		x		
" *naegelianum* Unger	x			x		
Gloeocapsa dubia Wartmann	x					
" *gelatinosa* Kuetz	x					

TABLE I—Continued.

Algal Species or Variety	Erie			O. R. D.		
	R	C	A	R	C	A
Gomphosphaeria lacustris Chodat	x			x		
Merismopedia elegans A. Braun				x		
" *glauca* (Ehr) Naeg		x	x			x
" *punctata* Meyen		x		x		
" *tenuissima* Lemm		x		x		
Microcystis aeruginosa Kuetz	x			x		
" *flos-aqua* (Witt) Kirch		x		x		
" *incerta* Lemm	x	x				
" *pulvera* (Wood) Migula	x					
Lyngbya aestuarii (Mert) Lieb				x		
" *birgei* Smith				x		
" *? cryptovaginata* Schkorb				x		
" *kuetzingiana* Kirch				x		
" *? lutea* (Ag.) Gomont				x		
Oscillatoria amoena (Kuetz) Gomont				x		
" *brevis* Kuetz				x		
" *laetevirens* (Crouan) Gomont					x	
" *limosa* Agardh	x					x
" *princeps* Vauch				x	x	
" *sancta* Kuetz				x		
" *tenuis* Agardh		x				x
Phormidium ? molle (Kuetz) Gomont	x					
Anabaena lemmermanni P. Richter	x	x				
Anabaena spp?	x			x		
Nodularia paludosa Wolle				x		
Gleotrichia natans (Hedw.) Rab				x		
Chlorophyceæ.						
Eudorina elegans Ehr	x					
Sphaerocystis schroeteri Chodat				x		
Pediastrum boryanum (Turpin) Menegh		x		x		
" *clathratum* (Schroeter) Lemm. var. *microporum* Lemm				x		
" *duplex* Meyen	x					
Pediastrum duplex Meyan var. *clathratum* A. Braun	x					
" *simplex* (Meyen) Lemm						x
Dictyosphaerium ehrenbergianum Naeg	x					
" *puchellum* Wood	x					
Westella botryoides (W. West) de Wildeman	x					
Ankristrodesmus falcatus (Corda) Ralfs	x			x		
" *setigerus* forma *minor* (Schroder) G. S. West				x		
Schroederia judayi G. M. Smith	x					
Coelastrum microporum Naeg	x					
Kirchneriella obesa (W. West) Schmidle	x	x				
Oocystis borgei Snow	x	x				
" *elliptica* W. West forma *minor* W. West				x		
Actinastrum gracillimum G. M. Smith	x					
Scenedesmus abundans (Kirch) Chodat	x					
" *bijuga* (Turpin) Lager		x			x	
" *denticulatus* Lager	x					
" *dimorphus* (Turpin) Kuetz		x		x		
" *obliquus* (Turpin) Kuetz	x			x		
" *opoliensis* P. Richter	x				x	
" *quadricauda* (Turpin) de Bréb			x			x
" " var. *parvus* G. M. Smith	x			x		

TABLE I—Continued.

Algal Species or Variety	Erie			O. R. D.		
	R	C	A	R	C	A
Scenedesmus quadricauda var. *quadrispina* (Chodat) G. M. Smith	x			x		
Tetraedron minimum (A. Braun) Hansg	x					
" *tropicum* W. & G. S. West				x		
Stigeoclonium tenue (Ag.) Kuetz				x		
Geminella minor (Naeg) Heer				x	x	
Ulothrix tenerrima Kuetz	x					
Cladophora crispata (Roth) Kuetz				x		
" *glomerata* (L.) Kuetz				x	x	
Rhizoclonium hieroglyphicum (Ag.) Kuetz					x	
Bulbochaete spp?				x		
Oedogonium exospirale Tiffany				x		
Oedogonium spp?	x				x	
Spirogyra spp?						x
Closterium acerosum (Schrank) Ehr	x					x
" " (Schrank) Ehr. var. *elongatum* Bréb				x	x	
" " (Shrank) Ehr. var. *minus* Hantz				x		
" *lanceolatum* Kuetz	x				x	
" *lunula* (Mull) Nitz. var. *intermedium* Gutw				x		
" *moniliferum* (Bory) Ehr	x			x		
" *peracerosum* Gay var. *elegans* G. S. West				x		
" *leibleinii* Kuetz				x		
Closterium pronum Bréb				x		
" *ulna* Focke				x		
Cosmarium adoxum West & G. S. West				x		
" *angulossum* Bréb				x		
" *bireme* Nordst				x		
" *cytomatoplerum* Nordst				x		
" *didymochondrum* Nordst	x					
" *garrolense* Roy & Biss	x			x		
" *laeve* Rab		x		x		
" *logiense* Bis	x					
" *obtusatum* Schmidle				x		
" *pyramidatum* Bréb				x		
" *reniforme* (Ralfs) Arch				x		
" *speciosum* Lund. var. *simplex* Nordst	x			x	x	
" *undulatum* Corda var. minutum Tittr	x	x				
Hyalotheca dissiliens (Smith) Bréb				x		
Penium margaritaceum (Ehr) Bréb				x		
Pleurotaenium ehrenbergii (Bréb) De Bary				x		
Staurastrum paradoxum Meyen	x			x		
HETEROKONTEÆ.						
Tribonema bombycinum Agardh	x					
EUGLENINEÆ.						
Euglena acus Ehr					x	x
Euglena fusca (Klebs). Lemm				x		
" *pisciformis* Klebs				x		
" *spirogyra* Ehr	x					
" " Ehr. var. *laticlavius* (Huber) Lemm				x		
" " Ehr. var. *marchia* Lemm				x		
" *spiroides* Lemm	x				x	

TABLE I—Continued.

Algal Species or Variety	Erie			O. R. D.		
	R	C	A	R	C	A
Phacus longicauda (Ehr.) Duj	....	....	....	x	....	....
" *pleuronectes* (O. T. M.) Duj	....	....	....	x	....	....
" *triqueter* Ehr	....	....	....	x	....	....
PERIDINIEÆ.						
Peridinium aciculiferum Lemm	....	....	....	x	....	....
" *inconspicuum* Lemm	....	....	....	x	....	....
DIATOMEÆ (BACILLARIEÆ).						
Melosira distans (Ehr) Kuetz	....	x	....	....	....	....
" *varians* Agardh	x	....	....	x	....	....
Coscinodiscus lacustris Grunow	....	x	....	....	....	....
Tabellaria fenestra (Lyng) Kuetz	....	x	....	x	....	....
Meridion circulare Agardh	....	....	....	x	....	....
Synedra spp?	....	x	....	....	x	....
Cocconeis placentula Ehr	....	x	....	....	x	....
Cocconeis spp?	....	....	....	....	....	x
Rhoicosphenia curvata (Kuetz) Grunow	....	....	....	x	....	....
Navicula spp?	....	....	x	....	....	x
Pinnularia divergens W. Smith	....	....	....	x	....	....
Pinnularia spp?	....	x	....	....	x	....
Gyrosigma kuetzingii Grunow	x	....	....	....	....	x
" *scalproides* Rab	x	....	....	....	x	....
" *spenceri* W. Smith	....	....	....	x	....	....
Gomphonema acuminatum Ehr	....	....	....	x	....	....
Amphora ovalis Kuetz	....	....	....	....	x	....
Epithemia argus Ehr	....	....	....	x	....	....
Nitzschia sigmoides (Nitz) W. Smith	....	....	....	x	....	....
" *vermicularis* (Kuetz) Hantz	....	....	....	x	x	....
Cymatopleura solea Bréb	x	....	....	....	....	x
Surirella biseriata (Ehr) Bréb	....	....	....	x	....	....

SUMMARY OF THE DISTRIBUTION OF SPECIES AMONG THE ALGAL GROUPS.

Table II is a summary of all the algal forms found, giving numbers of the genera, families, orders, and divisions.

TABLE II.

MYXOPHYCEÆ, 34.	
CHROOCOCCALES	18
Chroococcaceæ	18
Aphanocapsa	1
Chroococcus	4
Coelosphaerium	2
Gloeocapsa	2
Gomphosphaeria	1
Merismopedia	4
Microcystis	4
HORMOGONEALES	16
Oscillatoriaceæ	13
Lyngyba	5
Oscillatoria	7
Phormidium	1
Nostocaceæ	2
Anabaena	1
Nodularia	1
Rivulariaceæ	1
Rivularia	1
CHLOROPHYCEÆ, 63.	
Isokontæ, 35.	
VOLVOCALES	2
Volvocaceæ	1
Eudorina	1
Palmellaceæ	1
Sphaerocystis	1
PROTOCOCCALES	27
Hydrodictyaceæ	5
Pediastrum	5
Dictyosphaeriaceæ	3
Dictyosphaerium	2
Westella	1
Autosporaceæ	19
Ankistrodesmus	2
Schroederia	1
Coelastrum	1
Kirchneriella	1
Oocystis	2
Actinastrum	1
Scenedesmus	9
Tetraedron	2
CHAETOPHORALES	1
Chaetophoraceæ	1
Stigeoclonium	1
ULOTRICHALES	2
Ulotrichaceæ	2
Geminella	1
Ulothrix	1
SIPHONOCLADIALES	3
Cladophoraceæ	3
Cladophora	2
Rhizoclonium	1
Stephanokontæ, 1.	
OEDOGONIALES	1
Oedogoniaceæ	1
Bulbochaete	
Oedogonium	1
Akontæ, 27.	
ZYGNEMALES	
Zygnemaceæ	
Spirogyra	
Desmidiaceæ	27
Closterium	10
Cosmarium	13
Hyalatheca	1
Penium	1
Pleurotaenium	1
Staurastrum	1
HETEROKONTEÆ, 1.	
HETEROTRICHALES	1
Tribonemaceæ	1
Tribonema	1
EUGLENINEÆ, 10.	
Euglenaceæ	10
Euglena	7
Phacus	3
PERIDINIEÆ, 2.	
Peridiniaceæ	2
Peridinium	2
DIATOMEÆ (BACILLARIEÆ), 18.	
CENTRICÆ	3
Melosiraceæ	2
Melosira	2
Coscinodiscaceæ	1
Coscinodiscus	1
PENNATÆ	15
Tabellariaceæ	1
Tabellaria	1
Meridionaceæ	1
Meridion	1
Fragilariaceæ	
Synedra	
Achnanthaceæ	2
Cocconeis	1
Rhoicosphenia	1
Naviculaceæ	4
Navicula	
Pinnularia	1
Gyrosigma	3
Gomphonemaceæ	1
Gomphonema	1
Cymbellaceæ	2
Amphora	1
Epithemia	1
Nitzschioideæ	2
Nitzschia	2
Surirellaceæ	2
Cymatopleura	1
Surirella	1
TOTAL NUMBER OF FORMS RECORDED	128

NOTES ON SOME ALGAL FORMS.

Pediastrum simplex (Meyen) Lemm.

This species was found to be by far the most abundant of all the species of Pediastrum. It can be recognized easily by the single process of the marginal cells of the coenobium and by the compact plate. The species as observed was found to be quite variable both as to the size of the coenobium and as to the length of the marginal process.

Cosmarium cymatopleurum Nordst.

Several specimens were observed each having the following dimensions: length 58μ; breadth 46μ; isthmus 15μ. West (24) gives for the dimensions of the species length 82–97μ; breadth 60–70μ; isthmus 25–30μ. The specimens observed fit the descriptions and diagram in West (24) except for the much smaller dimensions.

Cosmarium undulatum Corda var. **minutum** Wittr.

The specimens observed had the following dimensions; length 27μ; breadth 27μ; isthmus 6μ; while West (24) records the dimensions as being length 21–28μ; breadth 18–21μ; isthmus 8.5–10μ.

Cosmarium logiense Bissett.

The dimensions of the few specimens found were length 42μ; breadth 30.8μ; isthmus 11.5μ, while West's (24) dimensions are length 61–65μ; breadth 48–50μ; isthmus 16–18μ. The granules in the wall were too small and were entirely too numerous to consider the specimens as a variety of *Cosmarium reniforme* (Ralfs) Arch. They seemed to be closest to *Cosmarium logiense*.

Closterium pronum Bréb.

A single specimen was found and this seemed to be nearer to *Closterium pronum* than any of the related species, although it was somewhat larger. The species observed was 500μ in length, 11μ in breadth, with the apices measuring 3.65μ. *Closterium pronum* is recorded in West (24) as having a length of 313–423μ and a breadth of 5.7–9μ. This together with the variations noted under *Cosmarium pronum* is perhaps a distinct variety, but since only a single plant was observed, the complete diagnosis awaits further data.

Euglena spiroides Lemm.

Of the fairly large number of specimens observed several were noted which may be a larger variety of the species. *Euglena spiroides* (14) (23) is recorded as being 60–170μ long and 16μ in diameter, while these few specimens were from 219–269μ in length and were 23.4μ in diameter.

Oedogonium exospirale Tiffany.

This species was identified by a single isolated oospore. The oospore of *Oedogonium exospirale* can be recognized easily by the spiral ribs of the outer wall which unite at the poles of the spore.

Although filaments of Oedogonium were found many times, none of them contained fruiting cells so they could not be identified. Filaments showing the basal holdfast were noticed occasionally.

Bulbochaete spp.?

Bulbochaete occurred several times in the fish collected from southwestern Ohio, but the alga was never found in the fruiting condition.

Spirogyra spp?

Disintegrated Spirogyra was found many times, but the filaments were never seen conjugating. The lengths of the filaments varied considerably, some being but several cells in length, while others were very long.

Oscillatoria spp.?

The species list for Oscillatoria is shorter than it should be because fragmentation made absolute identification of the end cell extremely difficult. *Oscillatoria tenuis* was by far the most abundant of any of the algal species recorded.

Lyngbya ? cryptovaginata Schkorb.
Lyngbya ? lutea (Ag.) Gomont.

These species fit the descriptions in Pascher (8) except for the habitats.

The Lyngbyas as a whole were difficult to identify because of the fragmentation and isolation of the filaments. The species list is perhaps much longer than shown in Table I.

Phormidium ? molle (Kuetz) Gomont.

The species could not be identified absolutely from the single filament observed.

Diatoms.

The diatoms were extremely abundant, but only a few were identified. The genus Navicula, as would be expected, was the most common genus represented.

SUMMARY.

1. *Pimephales promelas* may well be considered as belonging to the mud-eating group of minnows. It is a bottom-feeder, taking in plant and animal food and organic remains along with large quantities of mud.

2. Although previous records tend to indicate that the fathead takes in more animal than plant food, present observations show that animal food is proportionately less abundant than is the plant food.

3. Two hundred three fish were examined and a total number of one hundred twenty-eight species and varieties of algæ were identified.

4. The 128 species and varieties are distributed among the classes of algæ as follows: Myxophyceæ 34, Chlorophyceæ 63, Heterokonteæ 1, Euglenineæ 10, Peridineæ 2, Diatomeæ 18.

5. The algal species found in the alimentary canal of the fathead depend upon the habitat in which the fish is taken; yet the number and size of the gill rakers of the fish determine to a great extent what forms are retained in the alimentary canal.

6. Since *Pimephales promelas* takes in but a small amount of animal food, it is not much in competition with the carnivorous fish. If the fatheads can be obtained in large enough numbers, therefore, they should be found desirable as a forage fish.

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