THE FOOD OF THE SMALLER FRESH-WATER FISHES.

By S. A. FORBES.

In a paper on the food of fishes, published in 1880,* I characterized the food of all the Illinois Acanthopteri, with the exception of the Aphredoderidæ; and in the present article, which is to be regarded as a continuation of that just mentioned, I propose to summarize my observations on all the smaller fishes occurring in the waters of the State, with the exception of the darters (Etheostomatinæ), which were treated in the preceding paper.

The purposes and methods of the investigation upon which the following discussion is based, are so similar to those already described, that they will not need any especial present explanation.

The data for it have been obtained by a minute and careful study of the contents of the alimentary canals of 319 specimens, belonging to twenty-five species, representing twenty-two genera and seven families, namely: Aphredoderidæ, Cottidæ, Gasterosteidæ, Atherinidæ, Cyprinodontidæ, Umbridæ, and Cyprinidæ.

An additional feature is the description of the structures subsidiary to alimentation, given, in this paper, for each genus, in order to furnish a basis for a more exact discussion of the relations of structure to food-habits than I attempted formerly. Under this head I have included the length and complication of the alimentary canal, the character of the pharyngeal structures, the number and development of the gill-rakers, and the presence of any peculiar prehensile apparatus about the mouth.

First giving for each species a brief account of its numbers and distribution throughout the State, I shall add for each genus a description of these alimentary structures, following this by a detailed statement of the observations made upon its food, and closing with a summary of such observations, and a discussion of the correlations of structure to food characters, given sometimes

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under the genus and sometimes under the special group to which the genus is assigned.

FAMILY APHREDODERIDÆ.

This family is represented by a single peculiar species (Aphredoderus sayanus), resembling the sun-fishes in most of its characters, but remarkably distinguished by the fact that the vent, although occupying the normal position in the young, opens in the adult far forward under the head, moving gradually to the front with increasing size. This fish is not over three inches in length. It occurs in rivers and smaller streams, as well as in lakes and ponds throughout the State. We have collected it from the Illinois River and various tributaries, as well as from the lakes connected with that stream, and from ponds and creeks throughout Southern Illinois. It has also been taken in the Calumet River near Chicago, and from lakes in that vicinity, but is not known to occur in Lake Michigan. It is said to be nocturnal in its habits, by Dr. C. C. Abbott, who kept specimens in an aquarium for some time.* The same author reports that in confinement it feeds voraciously upon small fishes, especially immature Cyprinidæ; and for this reason he bestowed upon it the name of pirate perch, by which it has become generally known among ichthyologists. The observations presently to be detailed will show, however, that his specimens were doubtless forced to feed so largely upon fishes for want of food more natural to them, since in their native haunts fishes make but a small percentage of their ordinary food.

The intestine of this species is short and simple, less than the length of the head and body without the tail, and distinguished only by the character previously mentioned. The gill apparatus is ineffective, the rakers being very short, thick, blunt, and few, and covered with short spinules. The pharyngeal jaws consist of small plates, covered with short, sharp spinulose teeth, similar to those of the sun-fishes. The mouth is large, but not remarkably protractile.

The specimens dissected number nineteen, representing seven different dates and localities, throughout Central and Southern Illinois. Some were taken from small temporary ponds left by

*Proc. Phil. Acad. Nat. Sci., 1861, p. 95.

the retreating overflow of streams, others from permanent lakes, and still others from creeks and rivers. The food from the different localities varies but little, on the whole, and it is scarcely worth while to discuss the separate collections. That of these nineteen specimens was almost purely animal, traces of a minute flowering plant (Wolffia), and small quantities of filamentous Algæ only being taken by two of the specimens. Fishes were eaten by but two, and were reckoned at two per cent. of the food of the whole. One of these found was recognizable as a Cyprinoid, but the other could not be determined. Insects amounted to more than ninety per cent., all of them aquatic, with the exception of a few gnats (Culicidæ) taken by eight of the fishes. Nearly half of the food consisted of larvæ of Chironomus and Corethra. Aquatic coleopterous larvæ were reckoned at eleven per cent., and specimens of Corixa, taken by three of the fishes, at two. A single fish had also eaten Galgulus. A fourth of the food consisted of neuropterous larvæ (Ephemeridæ and Libellulidæ). Crustaceans, though captured by more than half the fishes, made but four per cent. of the food. As far as recognized, this element consisted chiefly of the amphipod, Allorchestes dentata, and the common isopod, Asellus. A few specimens of Cyprididæ were noticed in two of the fishes, and Cyclops and other Copepoda were taken by five. One fish had eaten a Lumbriculus, a species closely allied to the common earthworm.

A careful comparison was made of the food of specimens of various ages — those, consequently, in which the situation of the vent was widely different — but no differences of food whatever were distinguishable. It is highly probable, consequently, that the explanation of this peculiar character must be sought elsewhere than in the food. With respect to the other relations of food to structure, we have at present only to note the coïncidence of fishes and aquatic insects as the principal elements of the food with the large mouth and inferior development of the gill and pharyngeal apparatus, and short and simple intestine.

FAMILY COTTIDÆ.

This curious family, chiefly marine, is represented in the State by several species from Lake Michigan, mostly from its deeper waters, and by a single one recently discovered in our streams.

POTAMOCOTTUS MERIDIONALIS, Gill. GOBLIN, BLOB.

Although this fish has not hitherto been recorded from the State, we have found it abundant in small streams in Southern Illinois, and a single specimen has been sent us from McHenry County, near our northern limits. The first of these situations is in a limestone region, where small caves are not infrequent; but the second is in an area deeply covered by drift, with rock nowhere exposed.

The general appearance of this fish is not unlike that of a catfish, the head being broad and flat, the mouth very large, and the skin smooth. The gill-rakers are few, short and thick, and of insignificant character; the pharyngeals are similar to those of Aphredoderus, but form thicker and larger plates; the intestine is short and simple, its entire length being less than that of the head and body.

Six specimens of this species, taken in Southern Illinois, had eaten only animal food, about one-fourth of which consisted of fishes, one of which was furnished with ctenoid scales. Undetermined aquatic larvæ (thirty-six per cent.) and other insects, were estimated at forty-four per cent. of the food. Crustacea, all belonging to the genus Asellus, eaten by two of the fishes, composed the remaining twenty-nine per cent. The general resemblance of the food of this species to that of Aphredoderus seemingly corresponds to the similar character of their alimentary structures.

FAMILY GASTEROSTEIDÆ.

Of the interesting little stickle-backs, two species were studied, only one of which is common in the State.

EUCALIA INCONSTANS, Kirt. BLACK STICKLEBACK.

This fish is abundant in streams and lakes in the northern part of Illinois, but has not been taken by us south of Rock River.

Its mouth is small; the gill-rakers are long and slender (about half as long as the corresponding filaments), but are not unusually numerous; the pharyngeal apparatus is insignificant or wanting; and the intestine is short and simple, not longer than the head and body together.

Four specimens from Rock River, and one from Cedar Lake, in Lake County, had divided their food about equally between plant and animal substances: the former, consisting wholly of filamentous Algæ, taken by four of the specimens in quantities to make it certain that they were ingested purposely. The animal food was about equally insects and crustaceans, the former nearly all aquatic larvæ of Diptera (Chironomus being the commonest form), and the latter chiefly Entomostraca, of which Cladocera were the most abundant. One of the specimens had eaten Cypris—some of them *Cypris vidua*. Cyclops was also noticed in three of the fishes, and amounted to three per cent. of the food.

The herbivorous character of this fish seems not to be related to any structural facts; but the occurrence of the large ratio of Entomostraca is at once accounted for by the well-developed gillrakers, these serving as a straining apparatus by means of which the fishes possessed of it are able to appropriate minuter organisms than would otherwise be available for their food.

PYGOSTEUS PUNGITIUS, Lac. MANY-SPINED STICKLEBACK.

This species has hitherto been found by us only in Lake Michigan, and in Calumet River near its mouth.

But two specimens were dissected; and these had fed wholly on larvæ of Chironomus and Simulium (sixty per cent.), and on Chydorus and other Cladocera (forty per cent.).

With so small an amount of material to illustrate the food of the family, we can only say that it evidently consists chiefly of aquatic larvæ and Entomostraca, together with a considerable percentage of vegetable substances. In the absence of any apparatus for mastication, the latter will doubtless be found to consist of Algæ, as in the cases examined.

FAMILY ATHERINIDÆ.

LABIDESTHES SICCULUS, Cope. SILVERSIDES.

This elegant little fish, the only fresh-water representative of its family, is generally abundant throughout the State, and has been collected by us in a great variety of situations, from the northern lakes to the Wabash River.

It is long and slender, the mouth small and well furnished with

teeth, while the throat is destitute of special pharyngeal apparatus. The gill-rakers are unusually well developed, being numerous, slender, finely toothed, and longer than the corresponding filaments of the gills. Taking into account the small size of the fish, and the consequently small diameter of the apertures of the mouth and gills, it will be seen that it is provided with an especially effective straining apparatus. The intestine is unusually short, the entire alimentary canal measuring considerably less than the length of the body without the head.

The following account of its food is derived from the dissection of twenty-five specimens, obtained from Crystal Lake, Fox River, and Calumet River in Northern Illinois, from Peoria and Mackinaw Creek in the central part of the State, and from Little Fox River in the Wabash Valley. The food of these specimens was purely animal, a little over half consisting of insects, and a little less than half of crustaceans. The larvæ of Chironomus were among the most important elements of the food, standing at thirty per cent. of the whole. The crustaceans were all Entomostraca, and represented a great variety of both Copepoda and Cladocera, although none of the specimens examined happened to have eaten Among the Cladocera recognized were Daphnia Ostracoda. pulex, retrocurva and hyalina, Simocephalus americanus, Bosmina, Chydorus, Pleuroxus, Alona, and Eurycercus; and among the Copepoda were Cyclops thomasi, Canthocamptus, Diaptomus, Limnocalanus, and Epischura lacustris. Spiders and terrestrial insects, accidentally washed or fallen into the water (the latter including Chalcididæ, various Diptera, plant-lice, Tettigonidæ, Thrips, and Podura), amounted to twelve per cent. of the food. The only peculiarities of food corresponding to differences of locality were found among the group from the northern lakes, in which the Chironomus larvæ were present in diminished ratios, while the Cladocera were more abundant.

FAMILY CYPRINODONTIDÆ.

This family consists, in Illinois, of four species, one of Fundulus and three of Zygonectes.* The family is divided into two sections, *carnivorous* and *herbivorous*, by Dr. Günther in his "In-

*I do not consider Fundulus menona, Jor. and Cope., as distinct.

troduction to the Study of Fishes." Although our genera both belong to the carnivorous section, it will be seen that they are not by any means strictly confined to animal food, vegetation making about one-fifth of their usual nutriment.

FUNDULUS DIAPHANUS, LeS. BARRED KILLIFISH.

This species is very abundant in the northern part of the State, especially in lakes or in clear and sandy streams, but we have not taken it anywhere in Central or Southern Illinois. Most of our collections were made in the lakes of Lake and McHenry Counties.

The intestine is shorter than the body, the gill-rakers are short, obtuse, and few in number, the pharyngeal jaws are of the pavement type, set with fine, sharp teeth, and the mouth is small, but extraordinarily protractile.

Eight specimens were studied, from Crystal and Cedar Lakes. About four-fifths of the food consisted of animal substances, the remaining fifth of vegetation. Except a few filamentous Algæ taken by one of the specimens, the latter consisted wholly of seeds of various plants fallen into the water. Eighty per cent. of the food of two of the specimens, and twenty per cent. of that of a third consisted of such seeds; ratios evidently too large to have been taken accidentally. Two of the specimens had eaten Planorbis, and all had eaten insects, which made about forty per cent. of the food; terrestrial species, including spiders, making twelve per cent. Among the aquatic forms were Chironomus larvæ, Hydrophilidæ, and larvæ of Ephemeridæ, the latter eleven per cent. Crustacea were a fifth of the food, chiefly the abundant amphipod, Allorchestes dentata. Cypris and Candona were likewise noticed in considerable quantity (seven per cent.), and a few specimens of various Cladocera occurred.

ZYGONECTES NOTATUS, Raf. TOP MINNOW.

This species ranges in ponds and sluggish streams throughout the State, but is most abundant southwards. Here it may commonly be seen swimming slowly about in stagnant pools, with the head at the surface of the water, as if interested in the phenomena of the weather, or possibly watching for the appearance of terrestrial insects. The alimentary structures are in all respects similar to those of Fundulus, except that the intestine is possibly a little longer, being about equal to the head and body. The only striking peculiarity is the depressed head, with the mouth placed at the upper angle and opening obliquely upward. This, with the surfaceswimming habit of the fish, has given rise to the supposition that it feeds largely upon surface insects; but I did not find this to be the case, as the seventeen specimens studied contain no example of an insect of this character.

These specimens were taken from a considerable variety of situations throughout Central and Southern Illinois, and at various times of the year. The animal food amounted to about ninety per cent. of the whole. Vegetation, almost wholly filamentous Algæ, was taken by ten of the specimens, but in such quantities by various individuals as to make it certain that its presence was not accidental. In one, for example, the intestine was packed with these Algæ to the exclusion of all other food, and in three others this made more than half the whole. One specimen had also eaten Wolffia. Mollusks (Physa) had been eaten by three, and insects amounted to seventy-three per cent. Spiders and various terrestrial insects made fully a fourth of the food. Philhydrus, taken by three of the specimens, was reckoned at eight per cent. Corixa and other aquatic Hemiptera amounted to eleven per cent., and larvæ of Agrion to three. Crustacea were estimated at only six per cent. They included Crangonyx gracilis, and various Cladocera, Ostracoda and Copepoda. Among the Entomostraca recognized were Daphnia, Chydorus, Pleuroxus, Acroperus, Cypris, and Cyclops. Chironomus larvæ were about one per cent., taken by only two of the specimens.

ZYGONECTES INURUS, Jor. and Gilb. BLACK-EYED TOP MINNOW.

ZYGONECTES DISPAR, Ag. STRIPED TOP MINNOW.

The first of these species is peculiar in this State, as far as known, to Southern Illinois, not having been taken by us north of White County. The second ranges throughout.

Six specimens of the first and two of the second were studied. The food characters presented do not differ sufficiently from those of *Zygonectes notatus* to make it worth while to treat them separately, and a summary for the genus will be given instead.

Four-fifths of the food of the genus consisted of animal matter, nearly one-quarter being Mollusca, including Physa, Planorbis, and Valvata sincera. Insects make less than half, and nearly half of these were of terrestrial origin. Chironomus larvæ, usually so abundant in the food of insectivorous minnows, occurred here in only trivial quantity. Specimens of Philhydrus were eaten by three of the fishes. Corixa alternata amounted to five per cent. of their food, Agrion larvæ and case worms (Leptoceridæ) to two per cent. Crustaceans were only four per cent. of the whole, partly Amphipoda, but chiefly Entomostraca. The vegetable food (sixteen per cent.) was chiefly Wolffia, taken by five of the specimens from southern lakes. Ten individuals had, however, eaten filamentous Algæ.

Summary.

The only essential difference between these two genera exhibited by the specimens studied, is the much larger ratios of terrestrial insects captured by Zygonectes, this genus eating nearly twice as many as the other. This fact is possibly related to the surface-swimming habit already mentioned, but is more likely due to the smaller bodies of water in which the top minnows occur. Concerning the food of the family as a whole, the salient characters are the presence of a considerable quantity of vegetable food, (about twenty per cent.) the occurrence of fifteen per cent. of Mollusca, the insignificant quantity of Crustacea eaten (four per cent.), and the importance of terrestrial insects as a source of support.

FAMILY UMBRIDÆ.

UMBRA LIMI, Kirt. MUD MINNOW.

This species, the only one of its family in Illinois, is very abundant in muddy ponds and ditches, and has been collected by us from Lake to Union Counties.

The intestine is short, less than the body in length; the gillrakers are thick and rather long, about one-half the length of the filaments, and the pharyngeal apparatus is wholly insignificant.

Ten specimens were studied, from six localities, all from Southern Illinois but one, which was taken in Calumet River. Vegetable food amounted to forty per cent., chiefly Wolffia, eaten by seven of the specimens from Southern Illinois lakes. A considerable quantity of unicellular Algæ was also taken by one. Mollusks, eaten by two, were reckoned at five per cent., all Physa. Insects drop to fourteen per cent., chiefly undetermined larvæ. No terrestrial forms were recognized. Corresponding to the greater development of the gill-rakers, we find the Entomostraca assuming greater importance in the food. These were reckoned at ten per cent.; three per cent. additional consisting of *Crangonyx gracilis*.

FAMILY CYPRINIDÆ.

This family includes all the fishes properly known as "minnows," embracing, in fact, by far the larger part of the smaller fishes of the State. Both in number and in variety of species it is much the most important family of fresh-water fishes. It includes, in Illinois, about forty species, nearly or quite one-fourth of the whole number known to occur in our territory. They occur in all waters from the Mississippi River and Lake Michigan to the smallest streams and ponds; but are much the most abundant in creeks and rivulets. The species differ greatly with respect to their favorite haunts, some affecting the principal lakes and larger rivers, others occurring most commonly in clear and rapid brooks, while still others are most frequent in the sluggish and muddy streams of prairie regions. The principal economic interest of the fishes of this family is due to the well-known fact that they furnish an important part of the food supply of larger species.

But little has hitherto been done upon their food in the United States. In fact, I have seen nothing more accurate or comprehensive than the following general statement made by Prof. Cope, in his paper on the Cyprinidæ of Pennsylvania:*

"These differences of habit are associated with peculiarities of food and of the structure of the digestive system. Few families of vertebrates embrace as great a variety in these respects as the present one. There are carnivorous, insectivorous, and graminivorous genera, which are distinguished as among mammalia, the former by the abbreviation, the last by the elongation of the ali-

*Trans. Amer. Philosophical Society, Vol. 13, New Series, page 353.

mentary canal, in the former the teeth are usually sharp-edged or hooked, in the latter truncate, hammer, or spoon-shaped."

"In the American genera, as far as included in the scope of this essay, the peculiarities of the intestines correspond with the food. In the Alburnellus rubrifrons,1 they are but four-fifths the length of head and body (excluding caudal fin). In Hypsilepis kentukiensis,² Photogenis leucops, Argyreus atronasus³ and nasutus,³ Ericymba buccata, and Exoglossum maxillingua, about seven-ninths; the food of the last five species is insects and crustaceans, the last depending largely on mollusca. In the species of Ceratichthys, Semotilus, and Hybopsis, with Hypsilepis cornutus,⁴ fifteen-sixteenths to equal the length; the habits insectivorous. The genera with longer intestines are, first, Stilbe⁵ one and two-fifths to one and three-fourths the length; Chrosomus, Hyborhynchus, and Pimephales two and two-fifths to two and two-thirds, and Hybognathus four times. The intestines in these are generally filled with a soft, dark-colored slime, without remains of insects, but of vegetable origin. In the remarkable genus Campostoma the canal extends to between eight and nine times the length, and, like that of other vegetable feeders, is usually found occupied by the ingesta for a considerable part of its length."

This statement is in the main correct as far as it goes, but it will be seen from the following data, and from the discussion of the food of the family, that it is far from the truth with respect to the genus Campostoma and its allies.

If we examine the alimentary structures of the Cyprinidæ, to which reference has been made in describing the food of the preceding families, we shall find these fishes easily divided into at least four tolerably distinct groups, defined by characters drawn from the gill-rakers, the pharyngeal teeth and the intestines. In all but two of the genera of this paper* the gill-rakers are short and insignificant. The pharyngeal teeth may be either hooked or plain, and with or without grinding surface, while the intestine varies in length from less than that of the body without the head

¹Minnilus or Notropis. ²Photogenis analostanus. ³Rhinichthys. ⁴Luxilus cornutus. ⁵Notemigonus.

^{*}I have used here, for convenience' sake, the nomenclature of the Catalogue of the Fishes of Illinois, published in our third bulletin.

to seven or eight times the length of the head and body together. For convenience' sake I have grouped the genera as follows:

Group I.—Intestine long. Pharyngeal teeth not or slightly hooked, with grinding surface.

Campostoma, Pimephales, Hyborhynchus, Hybognathus.

Group II.—Intestine rather long. Teeth hooked, with grinding surface.

Notemigonus, Chrosomus.

Group III.—Intestine short. Teeth hooked, with grinding surface.

Hybopsis, Luxilus, Lythrurus, Hemitremia, Platygobio.

Group IV.—Intestine short. Teeth hooked, without grinding surface.

Minnilus, Photogenis, Ericymba, Phenacobius, Semotilus, Ceratichthys, Rhinichthys.

The second group, consisting of Notemigonus and Chrosomus, may be again divided according to the development of the gillrakers, which are numerous, long, and slender in Notemigonus; few, short, and insignificant in Chrosomus.

FOOD OF THE YOUNG.

The genera and species of Cyprinidæ are not easily recognized, even in the adult, the characters upon which they are based being often either trivial or extremely variable; and when one has to do with individuals small enough to show the earliest food of the family, it is commonly quite impossible to identify even the genus. In the few specimens which I have studied, I have not attempted such determination, although I have reason to believe that most of those examined belong to some species of Minnilus.

Their food was so far peculiar, as compared with the young of other families, that I will describe in detail that found by dissecting six specimens under an inch in length. The first of these, three-eighths of an inch long, taken in Fox River on the 8th of July, had eaten only a small Chironomus larva, and a single example of Bosmina. Two specimens, six-tenths of an inch long, captured in August in a creek in Central Illinois, had derived their food from quite different sources. Filaments of Spirogyra and other filamentous Algæ, cells of Cosmarium and Closterium,

and Cymatopleura and other diatoms, and spores of Ustilago, were the vegetable elements, while the head of a Chironomus larva and great numbers of the ciliate infusorian Euglena viridis, and a few specimens of Euglena acus, represented the animal kingdom. Full half the contents of these intestines consisted of the Protozoa mentioned. A third specimen of the same length, taken from the Illinois River in June, had derived about eight-tenths of its food from Bosmina, the remainder consisting of a small Chironomus larva and a minute larval hydrachnid. In a specimen seventenths of an inch long, taken in Mackinaw Creek in August, Euglena viridis was the most abundant object, making about sixtenths of the food; and Euglena acus and a species of Phacus also occurred. Various filamentous Algæ, specimens of Closterium and Cosmarium, and numbers of diatoms were the remaining elements. In another specimen, taken at the same time and place, about three-fourths of an inch in length, fungi and fungus spores amounted to more than half the food, although the same forms of Algæ occurred as before, together with a few examples of Euglena viridis and Difflugia. A Chironomus larva, a plantlouse, and some other insect not determined, had also been eaten.

From the above we may conclude that the young Cyprinidæ draw almost indiscriminately, for their food supply, upon Protozoa, Algæ, and Entomostraca, differing in this respect from the young of all the other families which I have studied, with the exception of the Catostomidæ. It is worthy of note, as a suggestive coïncidence at least, that the other families just mentioned which were found to take Entomostraca and Chironomus larvæ as their earliest food, were all possessed of raptatorial teeth on the jaws when very young; whereas in young suckers and Cyprinidæ, the mouth is unarmed at all ages.

GROUP I.

Intestine long. Pharyngeal teeth not hooked, with grinding surface. CAMPOSTOMA ANOMALUM, Raf. STONE LUGGER.

This very peculiar fish is exceedingly abundant everywhere except in the great lakes. I have taken it in streams of all magnitudes, from the Illinois River to the smallest creeks, but have not yet encountered it in Lake Michigan or in stagnant pools. It is commonest, however, in swift creeks of medium size.

It is distinguished from all other species by the great length of the intestine, which is from six to nine times the length of the body, and is spirally coiled about the air bladder. The gill-rakers are numerous, about twenty in number to each gill, but are very short, scarcely projecting beyond the anterior margin of the arch. They are evidently almost totally inefficient as a straining apparatus.

Of the great number of specimens available for dissection, only nine were studied, since the contents of the intestines were found so uniform in character that it was not deemed worth while to These were from both extremes and also multiply instances. from the center of the State, but were all taken in July, August and September. The intestine was invariably filled from end to end with a black and slimy matter, which, when examined under the microscope, was found to consist almost wholly of fine mud. When the intestine was emptied and the contents stirred up in alcohol and repeatedly decanted so as to separate the coarser fragments, the organic matter was easily distinguished. It made on an average, only about one-fourth of the contents of the intestine, the remainder consisting of the finest particles of sand and clay. Not far from one-fifth of the whole amount was of vegetable origin, consisting chiefly of filamentous Algæ, mingled with a few diatoms, but comprising occasionally minute fragments of other kinds of vegetation also. The only animal objects noted were occasional Chironomus larvæ and Difflugia. Sometimes the intestine was wholly filled with almost pure mud, in which no organic structures whatever could be detected. Date and locality seemed to make no material difference in the food of this fish, which should evidently be classed as limophagous. The ratios of animal to vegetable food were scarcely different from what one would expect to find in the intestine of a fish which had the habit of swallowing mud rich in organic matter, the greater ratios of vegetation being apparently due to the fact that plants are more abundant in the water than animals.

PIMEPHALES PROMELAS, Raf. BLACK HEAD.

This species is generally distributed throughout Central and Northern Illinois, but is not very abundant. We have taken it only in rivers and larger creeks, but have not found it south of Jersey County.

The alimentary canal is two or three times the length of the body, and the gill-rakers are fifteen in number and somewhat more prominent than usual, those on the posterior part of the first arch being about one-third the length of the corresponding filaments.

Only four specimens were studied, one from the Pecatonica River at Freeport, and three from Otter Creek in Jersey County. With this fish as with the preceding, about three-fourths of the contents of the intestine consisted of mud, the remainder being almost 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 only to about one per cent., chiefly various unicellular Algæ.

HYBORHYNCHUS NOTATUS, Raf. BLUNT-NOSED MINNOW.

This extremely abundant minnow occurs in streams and rivers throughout the State, but has not been found by us in ponds. Specimens were taken, however, in the small lakes of Northern Illinois.

The intestine is about two and one-half times the length of the head and body. The gill-rakers are few, short and thick, being about one-fifth of the length of the corresponding filaments.

Nine specimens were studied from all parts of the State, when their food proved to be so uniform in character that further observations were deemed unnecessary. Mud made about eighty per cent. of the contents of the alimentary canal, the remainder consisting of unrecognizable vegetable debris, with a few filaments of Algae. Undeterminable insects occurred in one, and a single specimen of Cypris in another.

Hybognathus nuchalis, Ag. Blunt-Jawed Minnow.

This species is likewise generally distributed in rivers, creeks and ponds, occurring in our collections from Galena to Cairo, and at a great number of points intermediate.

The alimentary canal in this genus is elongate, being about four times the length of the body. The gill-rakers are few and rather short, triangular in form, and about one-fourth to one-fifth the length of their corresponding filaments.

Eight specimens of this species were dissected, with results in

all respects similar to those given for the other members of this group. Filamentous Algæ, diatoms, and a few accidental fungus spores, were the only objects found imbedded in the quantities of mud which filled each intestine.

SUMMARY OF THE GROUP.

If we average the results of the four species studied, belonging to this first group, we shall find that about three-fourths of the contents of the stomach and intestine consist of soft, black mud, the remaining fourth being derived from both animal and vegetable substances, about three times as much from the latter as from the former. The animal food is chiefly insects, both terrestrial and aquatic, and the vegetation is divided about equally between Algæ and miscellaneous fragments of higher plants. This group, with long intestine and grinding pharyngeals, is consequently to be considered as essentially limophagous. We find this peculiar form of pharyngeal teeth associated only with intestines of this type.

GROUP II.

Intestines moderately long; pharyngeal teeth hooked, with grinding surface.

CHROSOMUS ERYTHROGASTER, Raf. RED-BELLIED DACE.

This species is locally abundant, although not generally common. It occurs in clear streams in the northern part of the State, but has not been taken by us in Central or Southern Illinois.

The length of the fish is contained one and two-thirds times in the length of the intestine; the gill-rakers are few and rather short, triangular, acute, and about one-fifth the length of the corresponding filaments.

I examined carefully but three specimens of this species, derived from two localities. These were alike in the presence of great quantities of mud, which amounted to about eighty-seven per cent. of the contents of the intestine. The animal food was confined to a trace of Cladocera. The vegetation amounted to thirteen per cent., partly tissues of aquatic plants, with traces of fungi, but chiefly Algæ of various forms, including a little Oscillatoria.

NOTEMIGONUS CHRYSOLEUCUS, Mitch. SHINER.

This extremely abundant minnow, commonly called the shiner, occurs in all waters throughout the State, from the largest rivers to the smallest creeks, and from Lake Michigan to small stagnant ponds.

The intestine is shorter than in any of the preceding species, although still rather long, the head and body being contained one and one-third times in its length. The gill-rakers are long, fine, and numerous, about twenty in number on the anterior arch, and fully one-third the length of the corresponding filaments, making, therefore, an effective apparatus for the separation of the Entomostraca from the water. As this fish presents a peculiar combination of alimentary structures, and as its food was found unusually various, a larger number of specimens were studied than of any of the species already discussed.

Twenty-five fishes were dissected, from a great variety of situations in all parts of the State, and representing various dates from May to September inclusive. As the food differed widely according to situation, that of specimens from certain localities being more widely different than the food of different species has usually been found, it will be best to mention the most conspicuous differences depending upon situation.

Specimens taken from the Pecatonica River at Freeport, an extraordinarily muddy stream, noted for the abundance of its mollusks, had eaten no other food than univalve Mollusca, chiefly Valvata tricarinata and Planorbis deflectus. Another, from the Illinois River at Pekin, had also eaten largely of mollusks, while three taken in Otter Creek in Jersey County, in almost stagnant reaches of the stream, extremely muddy, and green with Algæ, had filled their intestines with mud, like Campostoma; and still others from ponds near Normal had eaten only Entomostraca, about equally Cladocera and Copepoda. Another specimen from the Illinois River had taken similar food, all Daphnias. One specimen from Nippersink Lake, in the northern part of the State, was full of wild rice (Zizania). Taking all these groups together, and considering the species as a whole, besides the mud already mentioned, about fourteen per cent. of the food consisted of mollusks, and only six per cent. of insects, nearly all of which were of

terrestrial species. Crustaceans amounted to fifteen per cent., all Entomostraca. Vegetation stands at fifty per cent., more than half of it accidental vegetable debris, partly from aquatic and partly from terrestrial plants. About one-fifth of the food consisted of Algæ, half of which was filamentous in character, and the remainder desmids, including Closterium, and various diatoms.

The peculiar character of the alimentary structures of this species are very clearly reflected in this summary of its food, the elongate intestine corresponding to the presence of mud, and the well developed gill-rakers to the occurrence of Entomostraca. I have not yet noticed any structural peculiarity of the Cyprinidæ related to the habit of feeding upon mollusks.

SUMMARY FOR THE GROUP.

The two species foregoing agree only in their mud-eating propensity, — probably habitual in one and occasional in the other, the first having the longer intestine, and the second the longer gill-rakers. To this last difference we doubtless must trace the different relations of these fishes to Entomostraca.

I find nothing whatever, by comparison of the food of these specimens with those of the preceding group, to show the meaning of the hooked form of the pharyngeal teeth.

GROUP III.

Intestine short, teeth hooked, with grinding surface.

This group includes Hybopsis, Luxilus, Lythrurus, Hemitremia, and Platygobio. My studies were limited to three genera: Hybopsis, Luxilus and Hemitremia.

Hybopsis hudsonius. Clint. Spawn-eater.

This fine minnow is common everywhere to the northward, especially in Lake Michigan and the other lakes of Northern Illinois, but not abundant south of the central part of the State, although it has been taken to its extreme southern limit. It has never occurred in our collections in the smaller streams, but is confined to the lakes, rivers, and creeks of some magnitude.

The gill-rakers of this minnow are short and few.

Seventeen specimens were studied, from Lake Michigan,

Nippersink Lake and the Illinois River. Mud was found in noticeable quantities only in a single specimen, and there in small amount. About seventy per cent. of the food consisted of animal substances, three per cent. being fishes, taken by two of the minnows. One had also eaten a small bivalve mollusk. Insects made half the food, about one-third of them of terrestrial species (Rhynchophora), the remainder being chiefly larvæ of ephemerids. A few Chironomus larvæ and an aquatic hemipter, were the only other kinds determined. Crustacea amounted to thirteen per cent., nearly all Ostracoda (*Cypris vidua*) taken by two of the specimens from Chicago. Vegetable food stands at thirty-one per cent., eaten by ten of the specimens. One-third of this consisted of Algæ, chiefly of the filamentous forms, the remainder being miscellaneous fragments of exogenous plants, chiefly evidently aquatic.

Local and individual peculiarities .- The general summaries of the food of so many individuals from so great a variety of situations often disguise interesting and important facts relating to the food resources of the species, since an element taken in large quantity by one or two specimens may figure in the general average in such an insignificant ratio as to lead to the inference that its occurrence is merely accidental. In other words, general averages for a variety of situations will not necessarily indicate all the food resources open to the species. These can only be demonstrated by exhibiting the *peculiarities* of the record as well as its general average characters. For example, the fact that only eleven per cent. of the food of this species consisted of Algæ has a somewhat different aspect when we learn that one of the specimens had eaten nothing else, and that they made three-fourths of the food of another. Three specimens had eaten only insects, and these made ninety per cent. or more of the food of three others. Two had eaten nothing but Entomostraca, all the Cypris vidua previously mentioned. Vegetable structures made the entire food of four, and ninety per cent. or more of the food of three other specimens. Three out of four individuals taken at Nippersink Lake in May, had derived from ninety to one hundred per cent. of their food from terrestrial beetles of a single family (Rhynchophora), while ephemerid larvæ occurred in the food of three others in ratios exceeding seventy-five per cent.

HYBOPSIS STRAMINEUS, COPE. STRAW-COLORED MINNOW.

This insignificant species has been found by us in rivers and small streams throughout the State.

The gill-rakers were few and short.

Only five specimens were studied, all from rivers in Central Illinois. About three-fourths of their food consisted of animal matter, nearly all neuropterous larvæ (fifty-eight per cent.), Ephemeridæ standing at forty-eight per cent., and case-worms at ten. Crustacea were ten per cent., all Cyclops except a trace of Canthocamptus. About one-fourth of the food was vegetation, chiefly seeds of grasses, occurring, of course, only accidentally in the water. Two had derived from ninety to one hundred per cent. of their food from ephemerid larvæ, and four of the five had eaten vegetation amounting to as much as eighty per cent.

LUXILUS CORNUTUS, Raf. SHINER.

This large and fine minnow is probably the commonest fish in Illinois, occurring in lakes and streams of all sizes everywhere throughout our limits.

The gill-rakers are short and few, and of insignificant development, and the intestine is shorter than the head and body.

Twenty-one specimens were studied, from all parts of the State and at various seasons of the year. Animal food amounted to two-thirds of the whole, fourteen per cent. being fishes, eaten, however, by only one of the specimens. Insects, eaten by nineteen, were reckoned at forty-five per cent., only one-fourth of them terrestrial. Gyrinid larvæ, Corixa, and larvæ of Palingenia bilineata were among the forms recognized. The crustacean ratio was insignificant, standing at only three per cent., all the abundant amphipod, Allorchestes dentata, with the exception of traces of a considerable variety of Entomostraca, including Chydorus, Acroperus leucocephalus, and Cypris. One of the water-worms (Lumbriculus) was noticed in a single specimen. Vegetable food was reckoned at thirty-eight per cent., only about one-third of it consisting of Algæ, and the rest of accidental fragments, including the seeds, anthers, and pollen of plants, with a little Potamogeton and various forms of fungus spores. One of the commonest of the Algæ was Cladophora glomerata,* taken

*Kindly determined for me by Rev. Francis Wolle, Bethlehem, Pa.

by those from Effingham. The fact has already been noted that one of the specimens had eaten only fishes. Five had confined themselves to an insect diet, while twelve had derived more than half their food from the vegetable kingdom, one of them eating ninety-five per cent. and another one hundred.

HEMITREMIA HETERODON, Cope. NORTHERN HEMITREMIA.

This species, extremely abundant in Northern Illinois, has not been taken by us south of the central part of the State. North of Rock River it has been generally found in streams and lakes of all descriptions, from Lake Michigan down.

The gill-rakers are few in number, but thick, triangular, and rather long, those on the posterior part of the arch being from a fourth to a third the length of the filaments. The intestine is contained one and one-fourth times in the length of the head and body.

Eighteen specimens were studied, suitably distributed as to time and place. A little mud was found in the stomach of one. Only about one-tenth of the food consisted of vegetation, chiefly flowers and seeds. Traces of filamentous Algæ occurred in two of the specimens. Univalve Mollusca were noticed in one, and insects in twelve, amounting to more than a fourth of the entire food. These were chiefly larvæ of Chironomus (twenty per cent.), ephemerid larvæ occurring in but one. Crustacea were reckoned at fifty-eight per cent., all Entomostraca, with the exception of a single *Allorchestes dentata*. About two-thirds of these were Cladocera, the remainder being Ostracoda and Copepoda. Rotifers and Protozoa also rarely occurred, the latter including Centropyxis and Difflugia. Five of the specimens had eaten Entomostraca only, and two others ninety per cent. or more. Only two had derived more than half their food from vegetable sources.

It will be seen that the peculiar fact with respect to this species was the large per cent. of Entomostraca appropriated. I find nothing in the structure of the fish to explain this circumstance, other than the somewhat unusual development of the gill-rakers and the small size of the species. The latter probably had more to do with it than anything else. It should be noted, however, that nearly half the specimens were derived from places where Entomostraca were excessively abundant at the time of their capture.

SUMMARY OF THE GROUP.

Taking now this group as a whole, we remark, first, the absence of mud mingled with their food, as related to the greatly diminished length of the alimentary canal. We have now also a decided predominance of animal food, which is about three-fourths of the entire amount, and note likewise the first occurrence of fishes. Although Mollusca occur in this group, it is in quantity too small to appear in the ratios. Insects make about half the food of all, nine per cent. being terrestrial forms. The larvæ of Neuroptera are by far the most important insect species, and stand at twenty-five per cent. Entomostraca make a fifth of the whole food, distributed among all the orders. The vegetation eaten was largely of a purely miscellaneous and incidental character, only about a third of it being derived from aquatic plants.

GROUP IV.

Intestine short; teeth hooked, without grinding surface.

This group, organized more strictly for predatory purposes than any of the preceding, contains also the largest number of genera, embracing nine of those occurring in Illinois. It was not thought necessary to study all of these, and my dissections were confined to five of them, namely: to Minnilus, Photogenis, Phenacobius, Semotilus and Ceratichthys.

MINNILUS ATHERINOIDES, Raf. EMERALD MINNOW.

This species is everywhere abundant in streams and lakes, but does not occur in ponds. It is most common northward, swarming in summer along the shores of Lake Michigan.

The gill-rakers are short, triangular, and about one-fourth the length of the filaments; and the intestine is less than the length of the head and body.

Eighteen specimens were studied, all from the northern half of the State. The food was almost strictly animal, but five per cent. consisting of vegetation, and this chiefly of accidental character, occurring in trivial ratios. Only a single specimen had taken about forty per cent. of its food from filamentous Algæ. A minute fish had been eaten by one of these minnows. Insects

made two-thirds of the food, nearly two-thirds of them being terrestrial. Neuropterous larvæ were the principal aquatic forms, chiefly case-worms and larvæ of ephemerids. The Crustacea (twenty-two per cent.) were all Entomostraca, about two-thirds of them Cladocera, the remainder Copepoda. Among the former Bosmina and Chydorus were recognized, and Diaptomus among the latter.

Six of this species had eaten only insects, and these made ninety per cent. of the food of two others. One had filled itself with the larvæ of *Bibio albipennis*, a terrestrial grub abundant in early spring. Three from Peoria Lake, captured in October, had eaten Cladocera only, nearly all a single species, *Bosmina longirostris*.

PHOTOGENIS ANALOSTANUS, Grd. SILVER FIN.

Excessively abundant in streams of all sizes.

The gill-rakers are short, triangular, about one-fourth of the length of the filaments. The intestine is shorter than the head and body.

Thirty-three specimens of this species were examined. Twothirds of the food was insects, seven per cent. fishes, taken by three individuals, and one per cent. spiders, bringing the ratio of animal food up to seventy-one per cent. Besides these, a Limnæa was eaten by one, and traces of Cladocera and Copepoda occur in three. Nearly half the insects were terrestrial, Corixa and neuropterous larvæ being the most important aquatic forms. The vegetable food (twenty-nine per cent.) was nearly all of terrestrial origin, about one-third consisting of Algæ, both filamentous and unicellular, including Spirogyra and Glœocystis. Seeds, anthers and pollen of plants, and fragments of grass-like vegetation were noticed.

Eight of the specimens had taken only insects, and in two others these amounted to ninety-five per cent. Two had fed upon terrestrial species only. Corixa made ninety-five per cent. of the food of one. One had fed solely upon filamentous Algæ, and ninety per cent. or more of the food of three others consisted of vegetable structures in general.

PHENACOBIUS SCOPIFERUS, Cope.

This species occurs not very abundantly throughout the State, from Galena to extreme Southern Illinois. It has been taken by us almost invariably in swift and shallow streams.

The mouth is small and inferior, provided with fleshy lips somewhat resembling a sucker's in form. The gill-rakers and pharyngeal teeth are as usual in this group and the intestine is contained once and a half in the length of the head and body.

The nine specimens studied were from five localities, distributed from Galena to Union county. The food was almost purely insects, only two per cent. being unrecognized vegetation. Seventy-six per cent. consisted solely of Chironomus larvæ, and six per cent. of case-worms. Adult chironomids, taken by two of the specimens, amounted to two per cent. A few Cyclops found in a single specimen were the only Crustacea eaten by these fishes.

The peculiar character of this food, almost precisely that of a darter, is evidently related to the habitat of the fish.*

SEMOTILUS CORPORALIS, Mitch. CHUB.

This is a widely distributed and very abundant fish, perhaps the commonest species in the small creeks; but is less abundant in lakes and ponds.

The head and mouth are unusually large for a minnow; the intestine is six-sevenths the length of the head and body; and the gill-rakers are of the usual form.

Twenty-two specimens, from widely separated localities, give a ratio of seventy-six per cent. of animal food, four per cent. being fishes (partly Cyprinidæ), thirteen per cent. vegetation, and three per cent. worms. Insects make a little over half the whole, about one-half of them terrestrial. No Chironomus larvæ were found in the food of these fishes. Of neuropterous larvæ only a trace occurred, aquatic Coleoptera were noted in two, and Corixa in one. Grasshoppers (Acrididæ) made ten per cent. of the whole and were eaten by three of the specimens. Five had taken crawfishes, which made twelve per cent. of the entire food. No Entomostraca were noted, with the exception of one per cent. of Cyclops

*For a discussion of this matter, see Bulletin 3 of this series, p. 25.

occurring in two of the specimens. Numerous examples of Gordius were found in two, and were reckoned at three per cent. of the food.* The vegetable food (twenty-four per cent.) was half Algæ, the remainder miscellaneous vegetable debris.

Eight had eaten only insects, two having filled themselves with grasshoppers. Three from a prairie stream near Normal had taken only crawfishes, while of four specimens captured in McLean County in July, filamentous Algæ composed ninety-four per cent. of the food.

CERATICHTHYS BIGUTTATUS, Kirt. HORNED CHUB.

This species is everywhere abundant northward, chiefly, like Semotilus, in the smaller streams, but preferring swifter waters. We have not taken it, however, south of the center of the State.

It differs from the preceding members of the group by the greater length of its alimentary canal, which considerably exceeds the head and body, the latter being contained in the intestine about one and one-fourth times. The gill-rakers are not peculiar.

Thirteen specimens from Northern and Central Illinois had derived less than half their food from the animal kingdom. Only about one-fourth of it consisted of insects, largely case-worms and other neuropterous larvæ, another fourth being Crustaceans (crawfishes), eaten, however, by only two of the specimens. The vegetable food (fifty-four per cent.) was about equally divided between filamentous Algæ and seeds of Setaria and other grasslike plants.

Notwithstanding the small ratio of insects figured out, it is worthy of note that two specimens out of four captured in a creek in September had eaten only insects, chiefly case-worms, while these composed ninety-five per cent. of the food of another. As the intestines of these fishes contained a considerable quantity of gravel, it is evident that they had fed upon the bottom in rather swift water. On the other hand, two specimens had derived all their food from vegetable sources, and three others had eaten eighty per cent. or more of vegetation. The extraordinary amount of vegetation in the food of this fish is possibly related to the increased length of the alimentary canal.

^{*}These were not from the same specimens as those containing the grasshoppers.

SUMMARY FOR THE GROUP.

Ninety-five specimens of Group IV examined, representing five genera, had derived about three-fourths of their food from the animal kingdom, three per cent. of it being fishes, sixty-one per cent. insects, one per cent. Arachnida, and eleven per cent. Crustacea. One-third of the insects and spiders belong to terrestrial species. Chironomus larvæ are among the most important aquatic elements, amounting to sixteen per cent.; neuropterous larvæ coming next (eleven per cent.). About two-thirds of the crustaceans were crawfishes, the remainder being Cladocera and Copepoda. The vegetation (nearly one-fourth of the entire food) was chiefly of miscellaneous origin, nine per cent. only being recognizable as of aquatic forms. This was almost entirely filamentous Algæ.

Concerning this fourth group it may consequently be said, roughly, that the food consists of insects, crustaceans, and vegetable debris, about two-thirds of it the first, one-fourth of it the last, and one tenth, the other.

Summary for the Family.

If we regard the two hundred and fourteen specimens of fourteen genera which I have studied, as fairly representative of the family Cyprinidæ, and strike a separate balance of their food, we shall find that about thirty per cent. of the contents of the alimentary canal consists of mud; that one-half of it, or a little less, is animal matter, and that vegetation amounts to about one-fourth. Insects make one-third of the entire food, about ten per cent. being terrestrial species, eight per cent. Chironomus larvæ, and an equal number larvæ of Neuroptera. Of aquatic Coleoptera we have only a trace, and of aquatic Hemiptera (Corixa), but one per cent. Crustacea stand at ten per cent., nearly half of them Cladocera, Entomostraca as a whole amounting to about threefourths of the crustacean ratio. Fishes are only two per cent., and mollusks less than one. Nearly half the vegetable food consists of Algæ (chiefly filamentous forms), the remainder being miscellaneous structures, derived from a great variety of plants, mostly terrestrial.

Summing up, in a word, the characteristics of the food of the family as thus indicated, we may say that about one-half of it consists of animal substances, one-third being insects, and one-third of these of terrestrial species, and ten per cent. being crustaceans; that one-fourth consisted of vegetation, about equally aquatic and terrestrial, and that the remainder is mud, probably containing more or less fluid organic matter.

COMPARISON OF THE GROUPS.

It will be remembered that the groups were based upon differences in the structures relating to the appropriation and mastication of food. It is consequently from a comparison of the ratios of these groups that we shall derive the most interesting facts relating to the correspondence of food and structure. The most conspicuous result is the great preponderance of mud in the intestines of the fishes of the first group, characterized by an extraordinarily elongate intestine, and by pharyngeal teeth destitute of hooks and provided with a broad grinding surface. Here, as already noted, mud, sand, and gravel amounted to about threefourths of the matter ingested, while in the third and fourth groups only trivial and accidental quantities occurred. In the second group, on the other hand, with intestines intermediate in length, mud was still abundant, but much less so than in the first, averaging less than half the whole. If we exclude this indigestible matter, however, we shall find the first group still further distinguished by the predominance of vegetation as compared with animal matter, the latter being only about one-third the former, while in Groups III and IV, on the other hand, vegetation amounts to about one-third the animal food. The groups last mentioned, distinguished from each other as they are, only by the presence of a masticatory surface on the pharyngeal teeth in the first, and its absence in the second, differ scarcely at all in their general food characters, and this structural feature seems therefore to be of little significance. In both the animal ratio amounts to seventy-five per cent., and vegetation stands in each at twentyfive; while insects are respectively fifty and sixty-one. It is true that we find neuropterous larvæ greatly predominant in the first group, making one-fourth of their food, and Chironomus larvæ in the second amounting to sixteen per cent. The second of

these facts we find upon analysis to be evidently due to Phenacobius, by which genus nearly all the Chironomus larvæ were taken; and this, as already shown, is explained not by any structural feature, but by its peculiar habitat; and when we note that aquatic larvæ together amount in Group III to twenty-five per cent., and in Group IV to twenty-seven, we see that the significance of the difference mentioned disappears. A similar explanation is found of the difference in the ratios of Entomostraca, that of the first group amounting to twenty per cent. and that of the second only to four. An examination of the tables shows that this predominance in the group first mentioned is nearly all traceable to Hemitremia, a very small fish with rather elongate gill-rakers.

The importance of these gill structures is still more clearly indicated, as already noticed, by the difference between Notemigonus and Chrosomus of the second group, and clearly far outweighs the structure of the teeth as an indication of the food habits of the fish.

The general conclusions reached may be thus briefly stated: An extraordinarily elongate intestine indicates the limophagous habit, rather than an especial preference for vegetable food. The length or number of the gill-rakers has much to do with the abundance of Entomostraca and other minute animal forms in the food of the fish, while the presence or absence of the terminal hook or the masticatory surface to the pharyngeal teeth is not thus far shown to have any sensible influence upon the general average of the food. Finally, a species may depart widely in food characters from those more nearly allied to it in structure, if its favorite haunts are peculiar.

	A phredoderus sayanus.	Potamocottus meridionalis.	Gasterosteidæ.	Labidesthes sicculus.	Fundulus diaphanus.	Zygonectes notatus.	Zygonectes inurus.	Zygonectes dispar.	Summary of Cyprinodontidæ.	Umbra limi.			
No. of Specimens Examined	19	6	7	25	8	17	6	2	33	9			
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
ANIMAL FOOD.	.99	1.00	.75	1.00	.81	.90	.63	1.00	.70	.59			
FISHES	.02	.27		.01		*			*				
I. MOLLUSCA				.01	.02	.03	.42	*	.15	.05			
Univalves					.02	.03	.42	*	.15	.05			
Bivalves				.01									
II. INSECTS	.91	.44	.44	.54	.37	.73	.18	*	.43	.14			
Aquatic larvæ	.08	.36											
. Hymenoptera				.01	.04	.08	.02		.05				
2. Diptera	.45	.01	.43	.46	.14	.21	.07	*	.14	*			
Cerrestrial				.30	.01	.02			.01				
Brachycera.				.04		.01			.01				
Chironomidæ				.25	.01	.01			+				
Aquatic (larvæ)	.43		.31	.05	.02	¥			.01				
Cullcldæ	+					T			*				
Chivenemus	.01		117		····	****			· · · · ·				
Cimulium	.50		.11	.05	.0.2				.01				
Onlantena *	11				06	17			08				
Porroctrial	11				.00	.11			.00				
Aquatic larve					03	08			04				
Avdronhilidæ						.08			03				
Philhydrus					.03	.04			.02				
Hemintera.	.02			.01	.02	.17	.08	*	.09	.03			
Cerrestrial.				.01	.02	.05	.05		.04				
Aquatic						.11	.01	*	.04				
Čorixa	.02					.10		*	.03				
. Neuroptera (larvæ)	.25			.06	.11	.03	.01		.05				
Ephemeridæ	.14				.11				.04				
Palingenia	.07												
Odonata				.06		.03	1.0.0.0		.01				
Agrion.				.01		.03		****	.01				
Libellulidæ.	.11									****			
Leptoceridæ							.01		Т				
V ADACHNIDA			01	T 03	00	02			02	***			
Porpostrial			.01	.03	.02	.03			.02				
Hydrachnidæ			.01	+	+	.00			+	*			
V CRUSTACEA	04	.29	30	40	.21	.06	.03	*	.10	.13			
Amphinoda	.03		1.50		.13	*	.02		.05	.03			
Isopoda (Asellus)	.01	.29											
3. Cladocera			.28	.24	.01	.02	+	*	.01	.06			
Daphniidæ			.14	.23		.01							
Lynceidæ.			.14	.01	.01	+		*					
. Ostracoda	+		.01		.07	.02			.03	.04			
. Copepoda	+		.01	.16		.02	.01		.01				
VI. VERMES (Chætopoda)	.02					****			1911				
VII. Protozoa.							Tor		T				
VEGETABLE FOOD	.01		.25		.19	.10	.51		.11	.41			
Seeds	· · · · ·				.18	.01			.05				
La La na la	TOT		95		01		.04		.03	.00			
A 600	.01					.00	.00.		.00	.00			

TABLE OF FOOD: APHREDODERIDÆ TO UMBRIDÆ.

TABLE OF FOOD OF CYPRINIDÆ.

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	Campostoma anomalum.	Pimephales promelas.	Hyborhynchus notatus.	Hybognathus nuchalis.	Summary of Group I.	Notemigonus chrysoleucus.	Chrosomus erythrogaster.	Summary of Group II.	Hybopsis hudsonius.	Hybopsis stramineus.	Luxilus cornutus.	Hemitremia heterodon.	Summary of Group III.	Minnilus atherinoides.	Photogenis analostanus.	Phenacobius scopiferus.	Semotilus corporalis.	Ceratichthys biguttatus.	Summary of Group IV.	Summary of Cyprinidae.
No. of Specimens	9	4	9	8	30	25	3	28	17	5	21	18	61	18	33	9	22	13	95	
KINDS OF FOOD.	NUM	BER	OF	SPEC	IMEN	NS A	ND I	RATIO	OS IN	WE	псн	EAG	и в	LEM	ENT	OF 1	FOOD	WA	S FO	UND,
ANIMAL FOOD		.27	***		.07	.35	+	.18	.69	.76	.62	.87	.73	95	.71	.98	.76	.46	.77	.48
II. MOLLUSCA				222		.14		.07	.03		.14	+	+	.00	+		.04			-02
Univalves.						.14		.07				+	1		+	00			• • • •	
III. INSECTS	+	.25	÷		.06	.06		.03	.51	.66	.45	.29	.48	.67	.63	.98	.56	.24	.61	.84
Terrestrial	11.55		••••			1.1.1.1		***			.03	+	.01	.02	.01		.12	.03	.01	.10
1. Hymenoptera	+ + + + +			***			1.1.1.1 1.1.1.1		****	1.1.1.1	.02		.01	.05	.04	1.4.4.4	10		.04	1000
2. Lepidoptera 3. Diptera	+	.15			.04	.03		.01	.03	.05	.04	.24	.09	.01	.05	.78	.01	.03	.02	1000 F
Terrestrial									÷•••	* * * *		.01	+	.11	.18	02	+		.06	-
Aquatic (larvæ)	+				+	+	2222	+	.03			.20	.06	.02	06	.76		.01	.17	
Chironomus	1				+	+		+	.03		****	.20	.06	02	.03	.76		.01	.16	.08
4. Coleoptera						.02		.01	.18		.06		.06	.13	.02		.10	01	.05	1.00
Terrestrial			distant.		1.7.4	.02	1.1.1	.01	.18	****	.05		.06	.13	.01	1	.05	.01	.04	11.11
Aquatic	****				5.5.5. (5.5.5.6)						.01	++++	+		* * * *		.03		.01	+
Haliplus	* * * *		****				• • • •	•••					····· +	****	****		.02	****	.01	+ + + + + +
Hydrophilidæ																	.01		+	122-214
5. Hemiptera	1111	1111				.01		.01	.01		.02		+	.11	.10		.03	• • • • •	.05	
Aquatic						.01		01	.01		.01		.01	.05	.08		.03		.03	.01
6. Orthoptera	1.000	100100	****				107.0				.01	***			.08	****	.03	1.2.4.7	.02	1.000
7. Neuroptera		++++							.28	.58	.10	.03	.25	.17	.10	.14		.16	.11	.08
Larvæ						****			••••	111	.04			****	.03	.00		.05	.02	* * * * * * * * * *
Ephemeridæ				• • • •					.28	.48	.06	.03	.21	.10	.01			.01	.02	
IV. ARACHNIDA						+					+	+	+	.02	.01	.00			.01	* A S B
V. CRUSTACEA			+		+	.15	+	.08	.13	.10	.03	.58	.21	.22	+	+	.13	.22	.11	.10
2. Amphipoda					****	1.1.1					.03	.01	.01							
3. Cladocera						.10	+	.05	.01		+	.36	.09	.15	+	····			.03	.04
Daphniidæ						.10		.05				+	+	.12	+				.02	
A Ostracoda	6 40 4 5	* * *	+		+	*	+ + + +	*	.01		+	.35	.09	Ť	+			• • • •	+	.01
5. Copepoda					1	.05		.03		.10		17	.07	.07	+	+	.01		.01	.02
VI. VERMES		.02		• • • •	.01	· · · · ·					† +	+	1			****	.03		.01	****
Naidæ		.02			.01							• • • •								
Rotifera,	****	****	****									+	+	1			.05			
VII. PROTOZOA	+				+					94		+	+							
Miscellaneous	.20	.01	.15	. 20	.09	.30	.13	.11	.10	.01	.05	.03	.05	.01	.06	.02	.10	.02	.04	
1. Fungi				7.95	+	. 10	+	+		• • • •	19		+ 05	··		****	19			10
MUD AND GRAVEL	.18	.72	.80	.75	.75	.15	.87	.51	· +			.02	.01			+			+	.29

ERRATA.

Page 6, line 12 from bottom; page 8, line 15; page 11, line 2; for *Cydnidæ*, read *Pentatomidæ*.

Page 17, line 9, before Vireo, omit and.

Page 23, above ARACHNIDA, for Cydnidæ, read Pentatomidæ.

Pages 25 and 27, above Orthoptera, for Cydnidæ, read Pentatomidæ.

Page 28, lines 2 and 8, for *Graphorhinus vadosus*, read *Epicaerus imbricatus*.

Page 64, under *Hemiptera*, for *Siphonophora granariæ*, read *Aphis maidis*.

Page 69, line 5 from bottom, for *fresh-water*, read *local*.

Page 78, line 1, after all, insert the.

Page 82, line 7, for character, read characters.

Page 91, line 5, for consisted, read consists.

Page 92, line 2 from bottom, for more, read most.

Page 97, line 11, for fory-six, read forty-six.

Page 99, line 2, for with, read with.

Page 101, lines 12 and 13 from bottom, for *structure*, read *structures*.

Page 105, line 23, for aération, read aëration.