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ARTICLE VII.—STUDIES OF THE FOOD OF FRESH-WATER
FISHES.

BY S. A. FORBES.

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ARTICLE VII. — *Studies of the Food of Fresh-Water Fishes.**

By S. A. FORBES.

FAMILY GADIDÆ.

LOTA MACULOSA, Pennant. BURBOT; LAWYER.

The cod family is represented in Illinois by only a single species, the burbot (*Lota maculosa*), occurring in the interior of Lake Michigan, and making its way at irregular intervals to the shallow waters within the reach of ordinary fishing operations. Since the opening of canals between the Great Lakes and the river systems of the State, occasional specimens have been taken in the Illinois and Mississippi.†

Its predaceous character is too well known to make special description of its alimentary structures necessary. It is reported by Mr. G. Brown Goode‡ to feed upon various small fishes and Crustacea which frequent the bottom, devouring more particularly fishes with habits like its own. It is extremely

* This article is to be considered as a continuation of the studies reported in Volume I. of the Bulletin of the Illinois State Laboratory of Natural History, Nos. 3 and 6, the first published in 1880, and the second in 1883.

The data here presented relate to the fishes of the State of Illinois, and most of them to the lower families of the series. They are derived from collections made by my assistants and myself in various parts of the State at intervals from 1876 to 1887, for the special purpose of ascertaining the principal characters of the food, and the feeding habits of the fishes of our native fauna.

†I have seen a specimen taken from the Mississippi at Canton, Mo., in 1887, and sent to Mr. S. P. Bartlett, one of the State Fish Commissioners of Illinois. One occurred some years ago at Naples, on the Illinois River, and in a letter dated April 10, 1886, Prof. J. Lindahl, of Augustana College, Rock Island, says that three specimens have been taken from the Mississippi River within his knowledge, all small, the largest hardly a foot in length.

‡"The Fishery Industries of the United States," p. 239.

voracious, with a wonderfully distensible stomach; and not only captures the most active fishes, such as the pike, but will eat carrion, and may even swallow stones. It is reported to be nocturnal in habit, and often to secure its prey by stealth.

It is illustrated in our collection by ten examples; five taken in spring and five in November. All but one had eaten fishes, these making eighty-three per cent. of the food of the entire group. One of the spring specimens had taken crayfishes only—*Cambarus propinquus*, the species commonest in the lake. Two others of this lot had likewise eaten crayfishes, fifty per cent. of the food of one and fifteen per cent. that of the other consisting of this same species. The fishes taken, with the exception of one young white-fish (*Coregonus clupeiformis*) and a small unrecognizable residue, were the common perch of the lakes, *Perca lutea*.

FAMILY ESOCIDÆ.

This family is represented within our limits by the European species, *Esox lucius* (the so-called common "pickerel" of the streams and smaller lakes of Illinois), by the noble muskallunge, *Esox nobilior* of Lake Michigan, and by the small grass pickerel, *Esox umbrosus*. No fishes of our waters, unless it be the gars, have become so strictly adapted to a predaceous life, —an adaptation which probably limits them, *nolens volens*, to a living prey.

ESOX LUCIUS, Linn. PIKE; PICKEREL.

Our specimens of this species, thirty-seven in number, of nine different lots, were from various parts of the Illinois River, except a single one from Fourth Lake in northern Illinois.

One had eaten larvæ of dragon flies (twenty per cent.), but the entire food of the remainder consisted only of fishes, these making, consequently, ninety-nine per cent. of the whole. Nine per cent. were not otherwise recognizable. Twenty-one per cent. were sunfishes and black bass—one of the latter the small-mouthed species—and nine per cent. were croppie (Po-

moxys),—eaten however by only one of the specimens. Twenty of the thirty-seven pike had taken gizzard shad (*Dorosoma*), which made forty-six per cent. of the entire food of the species. Cyprinidæ (chiefly *Notropis hudsonius*) were found in two, and three had eaten buffalo fish (*Ictiobus cyprinellus* and *I. bubalus*).

ESOX VERMICULATUS, LeS. BROOK PICKEREL.

This fish—so far as its food structures are concerned a miniature of the preceding—is abundant throughout the State in ponds and lakes and along the borders of streams, especially by the weedy margins of rivers. I have studied the food of eighteen examples, and found it to differ from that of the larger species only as was to be expected from the smaller size of this pickerel, (which rarely reaches a foot in length), and from the character of its favorite haunts.

The specimens selected for examination were from various localities in northern, central, and southern Illinois; represented lakes, rivers, and smaller ponds; and were collected in June, July, and October of different years.

Two had eaten the tadpoles of frogs, and eight had captured fishes,—which made about half of the food of the entire group. Only three of these were recognizable; one a cyprinoid, one a sunfish, and the other (*Gambusia patruelis*) a common top minnow of the southern part of the State.

Aquatic insects formed the next most important element of the food, reaching thirty-five per cent., and eaten by nine of the specimens. The greater part of these were larvæ of Agrion and larger Odonata, only four per cent. being Hexagenia larvæ. One specimen had taken an isopod (*Asellus*), but no other crustaceans occurred.

The food of this group may consequently be generalized as consisting of the larger aquatic insect larvæ and the smaller fishes in nearly equal ratio, with occasional larvæ of Batrachia.*

*Five additional specimens of this species, too large to be reckoned examples of the young and yet too small to class as adults had eaten, like the full-grown examples, chiefly fishes and neuropterous larvæ. A specimen only an inch and a half in length had swallowed a fish: one three and a fourth inches long had likewise taken only a

FAMILY SALMONIDÆ.

The common lake trout, the white-fish, and the lake herring, are the representatives of this great family in the waters of Illinois, and occur there only in Lake Michigan. None of the smaller lakes of the State contain the herring, or so-called "cisco," as do some of those of Indiana and Wisconsin.

The food of the trout and adult white-fish having been already studied by the assistants of the United States Fish Commissioner,* I have given them no special attention.†

COREGONUS ARTEDI, LeS. LAKE HERRING.

Gills long, deeply arched; gill chamber consequently capacious but narrow. Gill-rakers rather long and slender, allowing considerable separation of the gills. Only one row on the anterior arch, about thirty-eight in number, projecting almost directly forward, at least equal in length to the corresponding filaments of the gill. The anterior row on the second gill are as stout as those of the first, but only half as long; the second row represented by about ten triangular rudiments at the lower end of the arch. Anterior row gradually shorter on succeeding gills, posterior row longer; the second row on the fourth gill opposing a similar series on the pharyngeal arch. Each filament with a double row of fine teeth along the inner edge. No pharyngeal teeth; pharynx with numerous fine longitudinal ridges which are covered with minute recurved spines. Intestine short and straight, anterior part provided with an immense number of small cæca. Alimentary canal a little shorter than the head and body without the tail.

My specimens of this species available for a study of their food were only five in number, obtained at South Chicago in

small fish; and a third, five inches in length, had eaten a young centrarchid. The two others, respectively two and three fourths and four inches long, had filled themselves with larvæ of *Agrion* and small libellulid larvæ. One had taken, in addition, a minute larval *Corixa* and a small univalve mollusk.

* See "The Fishery Industries of the United States," pp. 490, 513.

† For a discussion of the first food of the common white-fish, see Bulletin Ill. St. Lab., Nat. Hist., Vol. I., No. 6, pp. 95-109.

October, 1881, and at Chicago in 1885. Numbers of others were examined, but without result, as they had been kept until the food was all digested.

These five specimens had taken only animal food, one of them only Entomostraca—ninety per cent. of these being the common *Daphnia* of the lakes (*D. hyalina*), and the remainder consisting of a few specimens of *Bosmina*, *Chydorus sphericus*, and *Cyclops*. The food of the remaining four was altogether insects of terrestrial origin. In one were recognized great quantities of winged ants (*Myrmicidæ*), another had eaten only *Lepidoptera*, and still another winged tipulids (crane-flies). In the food of one, numerous specimens of the common squash beetle (*Diabrotica vittata*) were recognized, and a large quantity of undetermined Homoptera. An example of the homopterous insect *Diedrocephala mollipes* was detected in another.

Two small specimens of this species, hardly to be classed as young, respectively two and six inches long, had fed, like most of the adults examined, chiefly upon terrestrial insects, the shortest specimen upon small *Diptera* (ninety per cent.) and the homopterous insect *Typhlocyba*. The other example was taken from the stomach of a lake catfish (*Ictalurus lacustris*) from Lake Michigan. It had eaten a variety of terrestrial species, including an ant, several minute Homoptera, *Coriscus fesus*, a species of *Amnestus*, and examples of the families *Staphylinidæ* and *Anthicidæ*.

FAMILY DOROSOMATIDÆ.

DOROSOMA CEPEDIANUM, LeS. GIZZARD SHAD; HICKORY SHAD;
MUD SHAD; THREAD HERRING.

This remarkable fish occurs everywhere in the larger streams and in the ponds connected with them, but not in isolated lakes. It is marine in origin, swarming in the coast waters from Delaware to Mexico.

The mouth is toothless except in youth.* The gills are remarkably disposed within a rather small gill chamber. The

* For its juvenile characters and an account of the food of the young, see Bulletin Ill. St. Lab. Nat. Hist., Vol. I., No. 3, pp. 68-70.

dorsal portion of each gill projects far forward in the palatal region, and then turns abruptly backward, forming an acute angle in the roof of the mouth. This course of the arches is necessitated by the large accessory organ upon the fourth branchial arch.* The arches are all provided with numerous short rakers projecting horizontally upon either side, and forming an unusually effective straining apparatus. The intestine is very long and slender and much convoluted, the oesophagus small and long, and the stomach very short and muscular, like the gizzard of a granivorous bird. The small intestine is beset with a multitude of slender cœca, and its mucous surface is everywhere remarkably villose.

The species was represented in our collections by many specimens, but the food was so uniform in character that a prolonged study of it seemed unnecessary, especially as the critical analysis of such large quantities of material, minutely divided and thoroughly intermingled, was a very tedious and time-consuming process.

The adult specimens examined were eleven in number; ten from the Illinois river between Havana and Ottawa, and one from the Pecatonica, in northern Illinois. Eight dates and five localities are represented by them, the former ranging from April to October.

The species has, in general, the habit of swallowing quantities of fine mud, containing, on an average, about twenty per cent. of vegetable *débris*. Occasionally, in the vicinity of distilleries, it feeds, like the buffalo fish, on distillery slops, and sometimes a greater percentage of vegetation occurs mingled with the mud. Traces of animal food were common; but the ratio in most of my specimens was insignificant, averaging only four per cent. of the whole; although in one shad taken in spring in northern Illinois one fourth of the food consisted of Entomostraca (Cypris). Univalve mollusks occurred in one, fragments of Coleoptera in another, and young Corixa in still another; and spiders and water mites were also noted. Five specimens, in all, had taken Entomostraca—four of them

* This accessory organ is correlated by Sagemehl with the limphagous habit of the fishes in which it occurs.—*Morphologisches Jahrbuch*, XII., p. 318.

Cypris, one Cyclops, and two Alona. The vegetable food of the group amounted to thirty-two per cent., eaten by all the specimens. Beside the distillery slops already mentioned, Lemna, Wolffia, various diatoms and other unicellular plants, and occasionally filamentous Algæ, were noted in the food. It is probable that in some situations and at some seasons of the year, Entomostraca would be found a more important element; otherwise one can hardly see the advantage of the excellent branchial strainer borne by this species. The great length of the intestine and the unusual development of the mucous surface are seemingly correlated here, as among the cyprinoids, with the limophagous habit.

In five specimens, two and a half inches in length, the food was intermediate in character between that of the adult and that of the young, about sixty per cent. of it being Algæ, mixed with an abundance of dirt, and the remainder Cladocera (twenty-two per cent.) and insect larvæ—about half of them Chironomus.

A single specimen, five and a fourth inches long, had fed principally on Entomostraca (Bosmina, Daphnia, and Cyclops), with a very few Chironomus larvæ.

FAMILY CLUPEIDÆ.

Only a single species of the herring family occurs in this State—the golden shad, *Clupea chrysochloris*, Raf.—and this not by any means commonly with us. It seems to be strictly predaceous, the three specimens taken by me at Pekin and Peoria in September and October of three different years having eaten only fishes—two of them the gizzard shad (*Dorosoma*) and the third some undetermined kind. A single small specimen, two and a fourth inches long, had fed wholly upon terrestrial insects, among which were noticed *Triphleps insidiosus*, a species of Typhlocyba, a chalcid (*Eurytoma*), small Diptera (including Culicidæ and Muscidæ), and some small spiders.

FAMILY HYODONTIDÆ.

HYODON TERGISUS, LeS. MOON EYE; TOOTHED HERRING.

This species, not common in our collections, is represented in these studies by only five specimens, obtained from the Illinois River at Peoria and Havana, on four dates in August and October of two different years (1878 and 1887). Their food consisted wholly of insects (two thirds of them terrestrial) with the exception of a trace of univalve Mollusca. A single one, two and seven eighths inches long, had derived its food about equally from terrestrial and aquatic insects, including Orthoptera, Chironomus larvæ, and *Corixa tumida*.

FAMILY CATOSTOMATIDÆ.

One of the most striking characteristics of the fish fauna of Illinois, and indeed of the Mississippi Valley, is the prominence of the sucker family, which includes within our limits six genera and fifteen recognized species. Several of these are among the most abundant of our larger fishes, and most are very generally distributed.

With reference to the essential characteristics of their food, I find them dividing into three tolerably distinct groups. The first includes the cylindrical suckers (*Moxostoma*, *Catostomus*, and the like), in which the pharyngeal bones are heavy, the lower teeth thick and strong, usually with a well-developed grinding surface, and the gill-rakers short, thick, and few. In the second are the deep-bodied suckers, in which the pharyngeal jaws and teeth are well developed, although not as strong as in the cylindrical group, while the gill-rakers are of moderate length and number. The third contains the still deeper-bodied and thinner species, with light pharyngeal jaws and teeth, and long, slender, and more numerous gill-rakers. To this group belong the species commonly placed in the genus *Carpiodes*. Or, if we arrange the genera in a series, with reference to their food structures, we shall find *Placopharynx* at one extreme and *Carpiodes* at the other, the change consisting in a gradual increase in number, length, and effectiveness

of the gill-rakers, correlated with an increase in length of the pharyngeal bones and in the number of their teeth, and a converse diminution in the size and strength of these structures. The intestine also becomes longer and smaller as one passes from the cylindrical suckers to the deep-bodied buffalo and carp.

The data concerning the food of this family here presented are drawn from a study of the alimentary contents of one hundred and nine specimens, collected chiefly from the Illinois and Mississippi Rivers and their immediate tributaries. They indicate, in general, that about one tenth of the food consists of vegetation, taken chiefly by the buffalo fishes (*Ictiobus*), and in them largely composed of distillery slops. Mollusks and insects appear in nearly equal ratio in the food of the family at large, the former taken much the more generally by the cylindrical suckers, with heavy pharyngeal jaws and solid teeth, and the latter about equally by all, with the single exception of the stone roller (*Hypentelium*), whose peculiar haunts and feeding habits explain its departure from the average. On the other hand, the ten per cent. of Entomostraca were eaten chiefly by the deeper-bodied species.

PLACOPHARYNX CARINATUS, Cope.

This species has the general appearance of one of the red horse (*Moxostoma*), and has possibly been commonly overlooked in our collections, as we have noted it very rarely.

Its branchial apparatus is not noticeably different from that of the following genus, the gill-rakers being short and few, and effective only on the upper part of the arch, the lower arm being, like that of *Moxostoma*, covered by a ridged pad.

The fish is very remarkably distinguished, however, by the heavy pharyngeal jaws and the thick and strong pharyngeal teeth with conspicuous grinding surface. The latter number about thirty on each pharyngeal, the upper ones minute and useless rudiments, the lower ten very large, occupying about two thirds the length of the arch,—the lower six, in fact, one half of it. It is altogether likely that this apparatus is related to a preference for molluscan food, but the number of specimens available for my examination was too small to verify this supposition.

Two large examples taken from the Illinois at Havana in October, 1887, were found to have eaten similar food. In one, sixty per cent. consisted of small univalve Mollusca (*Valvata carinata* and *Amnicola*), the remainder being almost wholly insects—chiefly larvæ of water beetles (*Hydrophilidæ*) and larval *Ephemeridæ* (largely *Cænis*). About five per cent. of *Lemna* occurred in this fish,—probably taken by accident, as the river was covered with a film of duckweed at the time. A few *Chironomus* larvæ and an *Allorchestes* were also noted. In the other specimen only five per cent. of the food consisted of mollusks (the same species as before, together with a small *Sphærium*). Larval *Hydrophilidæ* made eighty per cent. of the contents of the intestine, and *Ephemeridæ* (*Cænis*) more than ten per cent. *Chironomus* and other dipterous larvæ, *Plumatella*, and a little *Wolffia*, were likewise recorded.

In a third example, only five and a half inches long, the locality of which is not known, the food was chiefly *Plumatella*, the only other elements being small case-flies (*Phryganeidæ*), a minute univalve shell (*Strepomatidæ*), and a few small *Chironomus* larvæ.

**MOXOSTOMA MACROLEPIDOTUM, LeS. COMMON RED HORSE;
WHITE SUCKER.**

The genus *Moxostoma*, the commonest and most typical of the cylindrical suckers, is represented in Illinois by three species, two of which, *aureolum* and *macrolepidotum*, occur everywhere in lakes, rivers, and smaller streams. We have encountered *M. carpio* but rarely, and my studies relate only to the two former species.

In *macrolepidotum* the gill-rakers of the anterior row are twenty-five to twenty-seven in number, the upper twenty to twenty-two being elongate, triangular, stout, and crenate within, about three fourths as long as the filaments of the gill; while the lower five or six of this series, all of the second series of the anterior arch, and all of the other rakers of the gills, including the row upon the pharyngeals, have the form of transverse leaf-like plates with crenate edges, projecting in triangular outline a little beyond the margin of the thick gill arch. The gills seem but slightly separable, and the branchial apparatus is coarse and ineffective.

Pharyngeals moderately heavy, the teeth about forty-five on each side, the lower ten thickened and broadened, with smooth terminal edges, but alternately higher and lower in the specimen examined. The other teeth are hooked at the anterior angle, and irregularly crenate on the cutting edge. The intestine is small, one and a fourth times the length of the head and body.

The salient features of the food of *Moxostoma macrolepidotum*, as exhibited by twelve specimens examined, are the abundance of univalve Mollusca and the bivalve *Sphærium*, the insignificance of the vegetable element, and the absence of Crustacea and the larger and more active insect larvæ. The insect food consisted almost wholly of larvæ of *Chironomus* and other small mud-inhabiting species.

The molluscan food, taken by eleven of the twelve specimens, amounted to more than half the total, the principal forms represented being *Vivipara* and *Melantho* (twenty-two per cent.), *Somatogyrus* and *Amnicola* (six per cent.), and the following pulmonates,—*Limnea*, *Physa*, and *Planorbis*. Three of the specimens had eaten *Sphærium*, but the *Unionidæ* were only doubtfully represented. The insects—about one third the food—were practically all aquatic, and nearly all dipterous larvæ. Two specimens, however, had taken a small quantity of hydrophilid larvæ, one an *Agrion* larva, and two others larvæ of *Ephemeridæ*. The Entomostraca recognized belonged to *Alona* and *Cyclops*. The vegetable food consisted of distillery slops, eaten by one of the specimens, with a little *Wolffia*, *Chara*, filamentous Algæ, and some miscellaneous matter.

This group of specimens was taken from the Illinois River at Henry, Peoria, Pekin, and Havana, and from Crystal Lake in northern Illinois, at dates ranging from May to November of four different years.

Five additional examples of this genus, the species of which was not determined but which almost certainly belonged to *macrolepidotum*, had eaten a still larger ratio of Mollusca than the preceding group, these making now three fourths of their food,—the greater part *Sphærium*. *Melantho*, and *Amnicola* also occurred, the former making one fourth of the food of the five.

MOXOSTOMA AUREOLUM, LeS. RED HORSE.

This species, less abundant in central Illinois than the preceding, takes almost identical food, so far as one may judge from the six specimens examined by me from Pekin, Peoria, and Crystal Lake in northern Illinois. The food was practically all animal, about one half of it Mollusca — largely Vivipara and Sphærium. The insects were, as before, mostly Chironomus larvæ and pupæ, the only other form worthy of note being smooth, slender, distinctly segmented, footless larvæ with elongate brown heads — very common in the food of fishes, but not yet identified.*

MINYTREMA MELANOPS, Raf. STRIPED SUCKER ; SPOTTED MULLET.

In this species, not uncommon throughout the State in suitable streams, the alimentary structures are not essentially different from those of Moxostoma, the pharyngeal teeth being, however, more numerous and more closely set,—about fifty-five in the series, the lower five to ten enlarged, but less so than in Moxostoma, and with the grinding surface less distinctly defined, most of even these largest teeth still presenting a somewhat crenate margin.

So far as indicated by the four specimens examined, the food of this species is similar to that of the preceding, being nearly all Mollusca,—differing, however, in the fact that the thin-shelled bivalve Sphærium had been taken in preference to the thick-shelled univalves. A Cyclops and a larger percentage of Cypris represented the Entomostraca. The small ratio of insects noticed were all Chironomus larvæ.

CATOSTOMUS TERES, Mitch. COMMON SUCKER ; WHITE SUCKER ; BROOK SUCKER ; FINE-SCALED SUCKER.

Abundant northward, occurring rarely in the Illinois as far south as Peoria, and still more rarely in the extreme southern part of the State. Wherever abundant, it inhabits nearly all waters, both lakes and flowing streams. It is common in Lake Michigan.

* This larva has the superficial characters of the Mycetophilidæ, and was doubtfully assigned to that group by Dr. Williston, in a recent letter to me.

Pharyngeal jaws strong, thick, nearly twice as wide as high ; teeth about thirty-five in number, the lower four or five much thickened, occupying about one fourth the length of the jaw. The crown is expanded transversely to the axis of the jaw, rounded, not crenate or hooked. The crowns of the teeth above the sixth or seventh are hooked and slightly crenate, but less so than in *Moxostoma*. Compared with that genus, both teeth and jaws constitute a more effective crushing and grinding apparatus.

The system of gill-rakers is similar to that of *Moxostoma*, but is less effective as a strainer, the anterior row of the first gill being less numerous, shorter, and thicker. These divide into two sets of about equal length, the upper series projecting forward, rather short, triangular, about one third the length of the corresponding filaments, fifteen or sixteen in number, the lower series, five or six, in the form of low lamellar ridges. Rakers of the other gills thick, lamellar, with tubercles on the free edges ; corresponding lamellæ on anterior margin of the pharyngeal jaw.

Alimentary canal about two and a half times the length of the head and body. The alimentary structures in general indicate better adaptation to molluscan food than those of the stone roller, and inferior adaptation to Entomostraca.

The number of specimens examined was too small to make it worth while to report their food, especially as they were evidently under size. The branchial and pharyngeal structures and known habits of the species indicate that its food is not especially different from that of *Moxostoma*, just discussed, and it will probably be found to consist chiefly of Mollusca and insect larvæ, the former in larger ratio than in *Moxostoma*, and in smaller ratio than in the species next to follow.

HYPENTELIUM NIGRICANS, LeS. STONE ROLLER ; HAMMER-
HEAD.

This curious fish, distinguished both in form and habit from its allies of the family, occurs usually in rapid shallows of clear streams, commonest to the northward. It is taken rarely in lakes.

The square, strong head of this species is related to its mode of life, but the cylindrical body, the large rounded pectoral fin, and relatively high coloration, give the fish the aspect of a darter among the suckers; and its habit of searching for its food among the stones in swift and shallow waters is another point of affinity with that interesting group. Curiously different as are the food and feeding habits of this species when compared with its nearest ally, *Catostomus teres*, the alimentary structures are not remarkably unlike. The pharyngeals are somewhat lighter, the pharyngeal teeth more slender and more prominently cuspidate, and the gill-rakers somewhat stouter, possibly affording a better apparatus for the separation of the relatively large insect larvæ upon which this species chiefly feeds. Its alimentary structures are extremely different, however, from those of the *Etheostomatidæ*, whose food, haunts, and habits it copies so closely. It is, in short, a molluscan feeder, which has become especially adapted to the search for insect larvæ occurring in rapid water under stones.

The pharyngeals bear about forty teeth on each side, which are unusually high, thin, and acute, all the upper ones with an uncommonly prominent hook or cusp at the internal angle. The six lower teeth are cultrate, without hook or distinct grinding surface, but only two or three are noticeably thickened.

The anterior gill-rakers are short and stout, twenty-five in number, six of them on the horizontal part of the arch. Those of the upper series are thin plates with the base about half the length, and are one third to one half as long as the corresponding filaments. The lower rakers of the series, more prominent than those of *C. teres*, are much like the upper, but shorter, the height scarcely equal to the base. There are five or six tubercles on the upper edge of each. The remaining gill-rakers, similar to those just mentioned, interlock by their tips, which are much more prominent and more tuberculate than those of *Moxostoma*. The stouter filaments of the strainer are probably related to the larger and more active insect larvæ on which this species feeds.

The intestine is small, considerably convoluted, and about twice the length of the head and body.

The food of six specimens taken in the Fox River and Mackinaw Creek contained no vegetation and but a small ratio of mollusks (*Sphærium*), but was nearly all aquatic insect larvæ (ninety-two per cent.). The great majority of these were Ephemeridæ, more than half the food consisting of a single form, abundant under stones, belonging to the genus *Cænis*. A few *Chironomus* larvæ, taken by all the specimens, some larvæ of Coleoptera, and traces of terrestrial insects were the only other elements.

ERIMYZON SUCETTA, Lac. CREEK FISH; CHUB SUCKER.

Everywhere abundant in streams and lakes, ascending creeks in spring. Occurs in our collections from McHenry to Union county. Rarely taken by us, however, and not represented in the material used for these studies.

Pharyngeal jaws moderately heavy, short for the size of the fish, bearing about sixty teeth, the lower ten filling the lower third of the arch, these moderately enlarged, with inconspicuous grinding surface, the terminal edges being irregularly rounded. The remaining teeth are hooked, the upper ones of the series crenate on the cutting edge.

Anterior gill-rakers thirty-four in number, upper twenty-one short and thick, about one third the length of the gill filaments; tips of the lower members of the series laterally flattened to a paddle shape. About eight of the lower gill-rakers of the anterior series fuse to form a thick ridged pad. Rakers of the remaining arches similar to those of *Moxostoma*, but more prominent, the tips of the transverse plates projecting further beyond the surface of the arch.

This species presents an ovoid thickening of the palatal region upon either side, which fills the greater part of the branchial chamber, but is less conspicuous than in *Ictiobus*.

Two young specimens, one and three fourths and three inches respectively, differed but little, in food, from those mentioned on page seventy-two of Bulletin 3 (Vol. I.) of the Illinois State Laboratory of Natural History. The larger one had eaten chiefly the smallest of our Entomostraca (*Canthocamptus*), with a trace of *Chironomus* larvæ. The smaller had taken a moderate ratio of Entomostraca (*Cypris*, *Cyclops*, and undeter-

mined Lynceidæ), a much larger proportion of Protozoa (especially *Diffugia* and *Arcella*), a few *Squamella* and other rotifers, and unicellular Algæ, including *Protococcus*, *Chroöcoccus*, *Closterium*, and *Cosmarium*.

GENUS ICTIOBUS. BUFFALO AND RIVER CARP.

In this genus are included only the deeper-bodied suckers with light pharyngeal jaws and relatively long gill-rakers. The species differ, however, in these particulars, and may be arranged in a series exhibiting a progressive lengthening of the gill structures, a lightening of the pharyngeal jaws, and an increase in number and a decrease in size of the pharyngeal teeth. Related to these differences of structure are the inferior importance of mollusks in the food (especially of the thick-shelled univalves), the greater number of insects, the appearance of *Entomostraca* as an important element, and the considerable percentage of vegetation taken. The insects eaten are well distributed instead of being essentially limited, as in *Moxostoma*, to dipterous larvæ. In short, correlatively with the greater number and smaller size of the pharyngeal teeth, the weaker jaws, and the greater development of the straining apparatus, in *Ictiobus* we find the food generalized, and drawn from numerous sources; while in *Moxostoma* the food and the food prehensile structures are specialized in the direction of a rather close dependence on the smaller mollusks.

The feeding habits of these fishes, like those of all species inhabiting the muddy waters of central Illinois, are very difficult of determination, but several fishermen, and others with unusual opportunities for observation, have reported to me that one or more species of this genus have the peculiar habit of whirling around in shallow water or plowing steadily along, with their heads buried in the mud, and their tails occasionally showing above the surface. These operations have nothing to do with spawning, and it is likely that fishes thus engaged are burrowing for small mollusks and for mud-inhabiting larvæ.

ICTIOBUS BUBALUS, Raf. QUILL-BACK; SMALL-MOUTHED BUFFALO.

This is a very abundant fish in the larger streams and in the lakes and river bottoms, being one of the three species most

commonly shipped from the Illinois and Mississippi under the name of buffalo fish. They all sell as "coarse fish," but from their abundance and their fair character as food, are, on the whole, the most important commercial fishes in our streams.

The gills of this species are very compactly disposed in a rather small branchial chamber, the upper ends of the arches being decurved and the lower elevated so that each gill forms about three fourths of a circle. Ten of the lower rakers of the anterior series are reduced to thickened ridges which extend obliquely across the horizontal portion of the arch. The remainder of this series, thirty-five in number, are flattened, minutely toothed, the central ones about as long as the corresponding filaments of the gill, the others regularly shortened above and below. The other rakers are similar to those of *Moxostoma*, having the form of toothed triangular plates, with their apices slightly projecting beyond the opposed surfaces of the arches. The interlocking tips are a little more prominent than in *Moxostoma*, and the whole apparatus is somewhat better developed.

The pharyngeal bones are moderately heavy, triangular in section, about as thick as high; and the teeth, about one hundred and thirty upon each jaw, project directly backwards and act, as in *Moxostoma*, against a semi-circular rim of cartilage. They are compressed, and more or less crenate on the cutting margin, the upper ones minute, the others gradually thickening downwards so that the lower twelve occupy about one fourth of the length of the arch. The edges of these lower teeth are rounded, not acute.

Seventeen specimens of this species, distributed in seven lots, collected from the central course of the Illinois River and from the Mississippi at Quincy in the years 1880, 1882, and 1887, and in various months from April to October, give the following general view of the food.

In decided contrast to the preceding members of the family, about one fifth of the food consisted of vegetation—taken by sixteen of the fishes—nearly all aquatic, but with an occasional admixture of terrestrial rubbish. The principal vegetable element was a small duckweed (*Wolffia*) especially abundant in fishes taken from the Illinois during the autumn of 1887,

when it made in some cases as high as ninety-five per cent. The larger duckweed (*Lemna*), fragments of *Ceratophyllum*, diatoms, and other unicellular Algæ, are also worthy of mention.

The animal food (eighty per cent.) was fairly well divided between Mollusca, insects, and Crustacea, respectively thirty, twenty-nine, and twenty per cent. Only occasional traces of univalves were noticed (*Vivipara* and *Planorbis*); but the thin-shelled bivalve *Sphærium* was a very important element, taken by seven of the fishes, and reckoned at thirty per cent. of the food of the group. Several individuals had eaten nothing else.

Insect larvæ were very generally taken, and, in fact, occurred in the food of every specimen examined. Chironomus larvæ were reckoned at nearly a fifth of the food, and were found in fourteen out of the seventeen fishes. Neuroptera larvæ, on the other hand, occurred in relatively insignificant number, most of them Ephemeridæ; although a small number of case-worms (*Leptocerus*) and of dragon-fly larvæ (*Agrion*) were also noticed. Hydrachnida occurred in the food of one, and Crustacea were eaten by thirteen specimens,—all Entomostraca with the exception of a single small crayfish and an amphipod.

Curiously, the entomostracan eaten most freely by these large fishes was the smallest of the Copepoda — *Canthocamptus*. In the food of ten specimens taken at Peoria April 16, 1880, and October 6, 1887, this made nineteen per cent. of the food of the entire group. Specimens of *Cyclops*, *Cypris*, *Pleuroxus*, *Iliocryptus*, *Bosmina*, and *Simocephalus* occurred in numbers too small to figure in the ratios. Fresh-water Vermes were almost wholly wanting, only a few *Anguillulidæ* occurring in the food of one. Eight had eaten Polyzoa, including both *Plumatella* and *Pectinatella*. The latter was recognized by its statoblasts only, detected in seven specimens collected in October, 1887, in situations where the gigantic colonies formed by this polyzoan had been earlier very abundant. It is probable, consequently, that these statoblasts, widely dispersed with the death and decay of the translucent mass in which they are developed, had been picked up by accident with the other food.*

* Some notes on the young of this genus, published in the Bulletin of this Laboratory, Vol. I, No. 3, page 73, show that specimens varying

ICTIOBUS CYPRINELLUS, C. & V. RED-MOUTH BUFFALO.

The statements made concerning the abundance, distribution, and commercial value of the preceding species will apply equally well to this. The fishermen report, however, that the quill-back frequents deeper water than the red-mouth. The structures of food prehension differ from those of *bubalus* in the lighter pharyngeal jaws, the greater number and smaller size of the teeth, and the more efficient branchial apparatus. The pharyngeal jaws are relatively thin, the thickness being about one fourth the height. The teeth are about seventy-five in number on each jaw, minute above, gradually but not greatly thickened below, the ten lowest occupying nearly one fifth the length of the jaw. These largest teeth have the cutting edges obtuse, and are slightly hooked within. The remaining teeth are more or less crenate on the cutting edge, each with conspicuous hook or cusp at the inner angle. The posterior edges are also acute.

The gill-rakers are similar to those of the quill-back, but more efficient as a straining apparatus. The longer rakers of the anterior row (seventy-five in number) are fully equal in length to the corresponding filaments, and are armed within with a double row of clusters of minute teeth. Eight or ten of the lower rakers are fused in the form of thick oblique ridges, The tips of the rakers of the other rows project beyond the borders of the arches a distance about equal to the line of attachment to the arch. The pharyngeal enlargements are very conspicuous and thick, nearly filling the pharyngeal cavity.

in length from seven eighths of an inch to two inches, fed largely upon unicellular Algæ and rotifers, the remainder of their food being chiefly the smallest Entomostraca. I add here the details from two additional specimens, taken in June, from the Illinois River, at Pekin, one three fourths of an inch in length and the other eight tenths. The greater part of the food of these consisted of rotifers, Protozoa, and gelatinous and other unicellular Algæ, a single *Bosmina* in each being the only entomostracan form determined. The rotifers included *Brachionus* and *Anurea*; and among the Protozoa were *Actinosphærium*, *Arcella vulgaris*, and *A. discoidea*. *Closterium* was noticed among the Algæ, with numerous gelatinous Algæ related to *Protococcus*, and a filament of *Oscillatoria*. Spores of fungi were found in both, and a fragment of vegetation penetrated by a fungus mycelium occurred in one.

This species seems to differ in food from the preceding, especially in the inferior amount of mollusks and the larger ratio of vegetation. The animal food of seventeen specimens collected in seven lots from the Illinois and Mississippi Rivers and the northern lakes in various months from April to October of five different years, was about two thirds the whole, the remaining third consisting largely of Algæ, unicellular and filamentous, and otherwise chiefly of distillery slops (taken by Illinois River specimens) and miscellaneous vegetation of terrestrial origin. This last was occasionally found in quantities sufficient to show that it had been intentionally swallowed, making in one instance the greater part of the food. The molluscan food of these specimens amounted to only three per cent., nearly all *Sphærium*; the insect food to thirty-three per cent., practically all aquatic, and very largely larvæ of *Chironomus* (twenty per cent.). The Neuroptera were chiefly *Hexagenia* larvæ (nine per cent.). Except a single *Crangonyx*, the Crustacea were all Entomostraca. These occurred in much greater variety than in *cyprinellus*, among them being representatives of *Daphnella*, *Simocephalus*, *Bosmina*, *Chydorus*, *Pleuroxus*, *Alona*, *Cypris*, *Cyclops*, and *Canthocamptus*. Fragments of *Plumatella* were noticed in a single specimen, *Difflugia* in two.

ICTIOBUS URUS, Ag. BLACK BUFFALO; MONGREL BUFFALO;
BIG-MOUTHED BUFFALO; CHUCKLE-HEAD.

This species occurs commonly with the preceding, but less abundantly. Said by fishermen to frequent shallower water.

With respect to food, it closely resembles *cyprinellus*, our seventeen specimens, well distributed as to date and place, having taken almost identical ratios of animal and vegetable food—sixty-seven per cent. and thirty-three per cent. respectively. Twelve per cent. were mollusks,—nearly all *Sphærium*, as before. The large ratio of insect food (about forty-two per cent.) was more than half *Chironomus* larvæ, most of the remainder being *Hexagenia* larvæ, taken, however, by only one of the specimens. The Crustacea (thirteen per cent.) were practically all Entomostraca, fragments of a young crayfish appearing in only a single specimen.

Among the vegetable elements, distillery slops (eaten by three of the specimens) were the most important (twenty-one per cent.). The rather insignificant amount of aquatic vegetation (six per cent.) was distributed as usual among a number of the lower plants, chiefly duckweeds and the unicellular Algæ.

ICTIOBUS CYPRINUS, LeS. RIVER CARP; CARP SUCKER.

Under this specific head I include, for the purposes of this paper, all the so-called species of river carp sometimes separated under the genus *Carpoides*, and hitherto described under some eight specific names. This form is abundant in the great rivers of the State and in their larger tributaries, and also in Lake Michigan and the smaller lakes of northern Illinois. It is extremely common in the lakes and ponds of the river bottoms, but occurs in running water in smaller numbers than the other species of its genus.

In its structures of food prehension it exhibits an extreme development and a correlative degradation of branchial apparatus and pharyngeal structures respectively. The gills are remarkably compacted, the upper and lower ends nearly meeting when the mouth is closed. The pharyngeal protuberances are enormous, almost filling the branchial cavity. Anterior gill-rakers in two series, as usual, the upper about sixty-seven in number on three fourths of the arch, the longest a little longer than the corresponding filaments. The lower part of the gill with about ten thick, papillar, coherent ridges extending downward a distance equal to the length of the filaments of the same vicinity. The longer rakers have each two closely alternating rows of tubercles on the inner edge, roughened with extremely minute denticles. Inner surface of the arch with transverse tuberculate ridges springing from the bases of the rakers of the gill, and terminating inwardly in slight projections representing the posterior row of rakers. The other arches are similarly tuberculate and ridged, and the whole apparatus closely embraces the pharyngeal thickenings. Pharyngeal bones very thin and brittle, less than a millimeter thick in a fish ten inches long, the thickness one seventh the height to the base of the teeth. The latter about two hundred, minute above, gradually increasing downwards, but not much thick-

ened or elongate, about thirty on the lower fourth of the arch. Crowns emarginate or doubly emarginate, with the inner angle similarly produced, forming a hook or cusp. Intestine very slender, four times as long as head and body in the specimen examined.

Nineteen examples of the species, representing thirteen dates and localities, from April to October, and from 1877 to 1887, collected from Crystal Lake in northern Illinois, from the lakes of the Ohio near Cairo, and from the Illinois River at Ottawa, Peoria, and Havana, show that the native carp differs from the other species of *Ictiobus* chiefly in the inferior amount of vegetation eaten, in the greater quantity of mud mingled with the food, in the absence of the larger insect larvæ, and in the lack of univalve Mollusca. It resembles closely *Ictiobus cyprinellus*, but from this differs also with respect to the vegetation taken, and in its filthy feeding habits. The vegetable food was only eight per cent., mostly *Wolffia*, and that eaten by only two of the specimens. A few diatoms were mingled with the mud in three, and miscellaneous aquatic vegetation occurred in five. Mollusks made about a fourth of the food,—all the thin-shelled *Sphærium*. Insects averaged about one third, the greater part *Chironomus* larvæ. Neuroptera were eaten by only four of the specimens, and contributed only two per cent. to the food, case-worms (*Phryganeidæ*) being the only forms identified. Entomostraca made nearly a fourth, distributed through a considerable list, which included *Simocephalus americanus*, *Bosmina*, *Chydorus*, *Alona*, *Cypris*, *Cyclops*, and *Canthocamptus*. No Vermes or Polyzoa were observed, but occasional Protozoa were noticed, especially *Centropyxis* and *Diffugia*.

Looking now at the food of the family, as exhibited by the one hundred and seven specimens discussed, representing, as they do, five genera and eleven species, we conclude that the sucker family is essentially carnivorous, the vegetable food amounting to only eight per cent. of the whole, and no element of this being especially prominent. The smaller mollusks are the most important single class, the ratio of these being forty-one per cent., about three fourths of them *Sphærium*. The large quantity of aquatic insects (one third of

them Chironomus and a fourth ephemerid larvæ), the relative insignificance of Crustacea (about ten per cent.,—nearly all Entomostraca), and the practical absence of Vermes and Protozoa are the remaining salient features of the food characters of this family.

FAMILY SILURIDÆ.

The family of catfishes taken together is nearly omnivorous in habit, and their alimentary structures have a correspondingly generalized character. The capacious mouth, wide œsophagus, and short broad stomach, admit objects of relatively large size and of nearly every shape; the jaws, each armed with a broad pad of fine sharp teeth, are well calculated to grasp and hold soft bodies as well as hard; the gill-rakers are of average number and development; and the pharyngeal jaws—broad, stout arches below and oval pads above, with thin opposed surfaces covered with minute, pointed denticles—serve fairly well to crush the crusts of insects and the shells of the smaller mollusks and to squeeze and grind the vegetable objects which appear in the food. The use made of the jaws in tearing mollusks from their shells, as described further on, is probably the most peculiar feeding practice of these animals; and the indifference of several of the species to the past history or the present condition of their food, distinguishes them as the only habitual scavengers among our common fishes.

The family is a very abundant and characteristic one in this region. It ranges in size from the smaller species of *Noturus*, only an inch or two in length, to monsters more than two hundred pounds in weight; and inhabits every kind of water from the greatest rivers of the continent to small temporary ponds of surface water, where its presence is the standing wonder of the fisherman and the naturalist.

In Illinois we have three genera and twelve species of these fishes, as at present classified, none of them unfit for food except the smallest ones, and two or three of them the equals of any river fish.

My studies of their food were based upon one hundred and twenty specimens, belonging mostly to five species of *Ictalurus* and *Noturus*. The data are especially deficient with respect to the food of the largest lake and river species.

ICTALURUS FURCATUS, C. & V. CHANNEL CAT; FORK-TAILED CAT; WHITE FULTON.

This is the catfish *par excellence*, and is the best food fish of its family. It occurs only in the deeper water of the larger streams. It is common in the Mississippi and the Ohio, although much less so than the following species, but is taken rather rarely in the Illinois, where it is often called the "Mississippi cat." It is never found in lakes and ponds, and feeds, according to the reports of fishermen, almost exclusively upon other fishes. A single specimen taken at Quincy Oct. 25, 1887, had eaten fishes only.

The gill apparatus is better developed than in *Amiurus*, but is nevertheless very incomplete. The anterior arch has only one row of rakers, eleven in number below the angle, four or five above. These are longest near the upper end of the lower part of the gill, where they are about half the length of the corresponding filaments. The other gills have similar but shorter rakers, the third and fourth a double row of about equal length. None of the rakers are toothed or tuberculate. The pharyngeals, both superior and inferior, are similar to those of *Amiurus*, but relatively smaller.

ICTALURUS PUNCTATUS, Raf. BLUE FULTON; SPOTTED CAT; FIDDLER; SWITCH TAIL.

An abundant species in the larger rivers, much commoner than the preceding, but not quite so good for food, smaller, ranging more freely, and clearly a more general feeder, although its alimentary structures are not noticeably different.

The gill-rakers of the anterior arch are a trifle shorter, the longer ones being about one third the length of the corresponding filaments, and the pharyngeal structures seemingly a little heavier.

Forty-three specimens of this species were taken from the Illinois River at Peoria, Pekin, and Havana, and from the Mississippi River, near Quincy. Their dates of capture represent the spring, summer, and autumn months of the years 1878, 1880, and 1887.

About a fourth of the food consisted of vegetable matter, much of it miscellaneous and accidental, but chiefly Algæ — *Cladophora* being the most abundant form. This and other filamentous Algæ made a large part of the food of several fishes taken in October, 1878 and 1887, three having eaten nothing else. Fragments of *Potamogeton* were taken by other October specimens, making twenty per cent. of the food of three. The fact that the floating *Lenina* occurred but rarely, and then in the smallest quantity, is evidence that these cat-fishes are strictly bottom feeders. A single specimen had fed on still-house slops, as shown by the considerable amount of meal in its alimentary contents.

A dead rat, pieces of ham, and other animal *débris* attest the easy-going appetite of this thrifty species.

Fragments of fishes were found in eleven examples of this group,—commonly, however, in pieces so large as to make it certain that they were derived from those already dead. Occasionally, as in examples taken in August, 1887, from the Mississippi River, fishes probably taken alive composed the whole of the food. The species were not identifiable.

Molluscan food was a decidedly important element, being found in fifteen of the fishes and amounting to fifteen per cent. of the whole. Several specimens had taken little or nothing else,—notably six secured at Havana in September, 1887, and one at Peoria in October of the same year. The Mollusca were about equally divided between gasteropods and lamelli-branches, the former largely *Melantho* and *Vivipara*, the latter usually *Unio* or *Anodonta*.

Notwithstanding the number of bivalves eaten by these fishes, no fragment of a shell was ever found in their stomachs, but the bodies of the animals had invariably been torn from the shell while yet living—as shown both by the fresh condition of the recently ingested specimens and likewise by the fact that the adductor muscles were scarcely ever present in the frag-

ments. Indeed in only a single instance had the posterior adductor been torn loose. The Unionidæ were usually large and thin — probably in most cases Anodonta.

I have been repeatedly assured by fishermen that the catfish seizes the foot of the mollusk while the latter is extended from the shell, and tears the animal loose by vigorously jerking and rubbing it about. One intelligent fisherman informed me that he was often first notified of the presence of catfishes in his seine, in making a haul, by seeing the fragments of clams floating on the surface, disorged by the struggling captives.

Still more interesting and curious was the fact that the univalve Mollusca found in the stomachs of these fishes were almost invariably naked, the more or less mutilated bodies having only the opercles attached. How these fishes manage to separate mollusks like *Melantho* and *Vivipara* from the shell, I am scarcely able to imagine, unless they have the power to crack the shells in their jaws as a boy would nuts, and then to pick out the body afterward. Certainly the shells are not swallowed, either whole or broken.

The number of mollusks sometimes taken by a single catfish is surprising. As high as one hundred and twenty bodies and opercles of *Melantho* and *Vivipara* were counted in a spotted catfish taken at Havana in September of last year.

Insects were, however, the principal food of the specimens studied, making forty-four per cent. of all, eaten by twenty-eight of the specimens; five, in fact, had eaten nothing else, and nine others had taken ninety per cent. or more of insects. These were mostly aquatic, although now and then a fish had filled itself with terrestrial specimens. About half the insects were Neuroptera, nearly equally dragon-fly larvæ and larvæ of Ephemeridæ; but *Hexagenia* larvæ were rarely recognized. *Chironomus* larvæ made thirteen per cent. of the food, and were so frequently taken with the sand tubes they inhabit as to make it certain that they were commonly obtained from the bottom. Leeches appeared in the food of three of the specimens, and *Gordius* in one. Fragments of *Plumatella* were noticed in two, and a fresh water sponge likewise in two.

Four immature examples of this species, ranging from two and a half to four inches in length, had fed almost wholly

upon insects, a few specimens of *Allorchestes dentata* and *Daphnia* being the only other items. Eggs and young of *Hexagenia* and other ephemerids composed the greater part of the food, *Chironomus* larvæ amounting to about one half as much.*

ICTALURUS NATALIS, LeS. YELLOW CAT.

This species occurs everywhere throughout Illinois, but less abundantly than *nebulosus*, and usually in larger streams. It has not been taken by us from ponds and lakes except where these were immediately connected with rivers subject to overflow.

The alimentary structures of this species closely resemble those of *I. nebulosus*, described under the next head. Twelve specimens were collected from the Illinois River at Peoria, the Fox River at McHenry, and from one of the smaller lakes in northern Illinois, in the months of May, August, October, and November of 1878, 1880, and 1887.

The food was wholly animal with the exception of a trace of duckweeds (*Lemna* and *Wolffia*) taken by a single specimen. The scavenger habit of the species was shown by the food of the Fox River specimen, three fourths of which consisted of the remnants of a dead cat. Fishes made a larger ratio of the food than in the preceding species, amounting to about one third, most of them apparently taken alive. One, however, a sucker, was represented only by the stomach and intestines, doubtless picked up near a fish boat. The gizzard shad, certain Cyprinidæ, and undetermined suckers (*Catostomatidæ*) were recognized, four of the twelve specimens having fed wholly or almost wholly upon them. The molluscan food of these specimens was insignificant, no bivalve mollusks having been taken by them and only a few *Vivipara* and *Melantho*, amounting in all to five per cent. While insects had been eaten by four of the specimens and reached a ratio of thirty per cent., they were practically all *Hexagenia* larvæ, taken in October, 1878 and 1887. On the other hand, seventeen per cent. of the food was catfishes, taken by four of the specimens in May and August.

* A hint of the winter food is given by six specimens received from the Illinois River at Havana, February, 1888, all of which had fed only upon *Chironomus* larvæ or larvæ of *Agrion*.

Seven immature examples, from two to three and a half inches long, had fed chiefly upon Entomostraca, which made about one half the food. Among these, *Daphnia*, *Simocephalus americanus*, *Acroperus*, *Macrothrix laticornis*, *Cyclops*, and *Cypris* were determined. One fourth the food consisted of the univalve *Physa*, and one fifth of it of insect larvæ, chiefly ephemerids and *Chironomus*. A little *Wolffia* and other aquatic vegetation likewise occurred.

ICTALURUS NEBULOSUS, LeS. BULL-HEAD ; HORNED-POUT.

This superabundant species occurs in all waters and in all parts of the state, but frequents by preference ponds and muddy streams. It grows to a larger size in the rivers than elsewhere, and has many marked varieties. Its feeding habits are apparently essentially the same in all situations.

Gill-rakers fourteen in number on the anterior gill, in one row, thick, stout, not toothed, at the angle of the arch about half as long as the filaments, shortening rapidly above and below. Second gill also with a single row, shorter than those of the first; succeeding gill with two rows each of still shorter rakers, the posterior row shorter than the anterior; a smaller row upon the pharyngeal arch. The upper pharyngeals are large and broad oval pads, with convex surfaces paved with close-set, minute, sharp teeth, and act against the broad lower pharyngeals, which are similarly armed. Intestine to head and body as 1.2 to 1.

Thirty-six specimens were collected for a study of the food, — at Normal, Peoria, Pekin, and Havana, in Central Illinois; and from the Fox River and several of the small lakes in the northern part of the state. The collections were made in May, July, August, September, and October, of four different years.

The vegetable food nearly equaled that of *I. punctatus*, and was taken by seven of the specimens. One had eaten distillery slops, and in the food of the others were found *Ceratophyllum*, *Potamogeton*, *Chara*, and various *Algæ*.

Fishes made one fifth of the food,—taken however by only two of the specimens, which had eaten nothing else. One of the fishes was a perch and the other a sunfish (*Centrarchidæ*).

Mollusks made one fifth of the entire amount of the food, — more than one half of them *Sphærium*. This genus made nearly all the food of a large group taken from the Illinois River at Pekin in September, 1882, and also of two other specimens taken in the Illinois River at Peoria in October, 1887. Univalves were rarely present, amounting to only two per cent. of the food, taken however by eight of the specimens. These included the usual forms — *Valvata*, *Melantho*, and *Amnicola*, together with two or three specimens of *Physa*. Examples of *Pisidium* were rarely noted, and two had eaten *Unios*.

Nearly a fourth of the food was insects, mostly aquatic, and the larger part of them larvæ of *Diptera* — especially *Chironomus* and *Corethra*. Seven per cent. of *Neuroptera* larvæ (*Hexagenia*, *Libellulidæ*, and *Phryganeidæ*), together with a miscellaneous assortment of terrestrial species, complete the account of the insect food.

The Crustaceans (thirteen per cent.) were nearly all crayfish, traces of *Diaptomus*, *Leptodora*, *Chydorus*, etc., appearing, however, in here and there a specimen, and the little amphipod *Allorchestes dentata*, appearing in three. A leech and a nematoid worm occurred, each in one.

It will be seen that the food of this species was very widely distributed, being composed about equally of fishes, mollusks, aquatic insects, and vegetable structures, with a very considerable ratio (thirteen per cent.) of crustaceans added.

Two smaller specimens, two and three and a half inches respectively, had fed chiefly on ephemerid and *Chironomus* larvæ, small crayfish, and *Asellus*. To these were added *Corixa tumida*, *Cyclops*, *Daphnia*, filaments of *Spongilla*, *Chydorus*, *Scapholeberis mucronatus*, a few Diatoms, and traces of filamentous Algæ.

ICTALURUS MARMORATUS, Holbrook. MARBLED CAT.

This species is scarcely more than a deep-water variety of the common bull-head (*I. nebulosus*), distinguished only by the color. It occurs in the larger rivers of the State and their immediate tributaries, but nowhere, so far as I know, in stagnant waters. Our thirteen specimens were all from Peoria and Havana, taken in August, October, and November of 1878 and 1887.

The food of this species as represented by these thirteen specimens, is unusually simple for a catfish, consisting chiefly of bivalve mollusks, larvæ of *Chironomus* and *Hexagenia*, distillery slops, and accidental rubbish. Fishes are conspicuous by their absence, only a single specimen exhibiting any trace of them.

Sphærium and *Unio* made about a fourth of the food, and aquatic insect larvæ amounted to one half (*Hexagenia* thirty-five per cent. and *Chironomus* fourteen). A hydrophilid and a few terrestrial insects, a few specimens of *Vivipara* and a *Physa*, sialid larvæ (taken by two), slender leeches eaten by five, and a trace of *Potamogeton* in one, are the minor elements of this record. One of the specimens, taken in November, had eaten eighteen leeches, which made one fourth of its food. It will be noticed that three fourths of the food consisted of bivalve mollusks and insect larvæ.

LEPTOPS OLIVARIS, Raf. MUD CAT; YELLOW CAT; MORGAN CAT.

Common in the deeper waters of the larger streams. Obtained by us only from the Illinois, Wabash, and Ohio.

This is one of the largest of the river catfishes, repulsive in appearance, but above the average as food. It is reported by fishermen to feed only upon animal food — chiefly fishes — and such was the case with the two specimens examined from collections made at Quincy in August, 1887. These had fed upon the common river sunfish (*Lepomis*), several cyprinoids, and an *Amiurus* four inches long.

NOTURUS GYRINUS, Mitch.

This little catfish, the most abundant of the small species of the family, occurs throughout Illinois, but has been confined in our collections mostly to lakes, rivers, and large creeks. It is not by any means restricted to rocky situations, but seems rather to prefer the muddy parts of both the rivers and lakes in which it occurs,

Thirteen specimens were secured at Pekin and Peoria, from Clear Lake in Kentucky, and from the Fox River in McHenry county. Their food was wholly animal, with the exception of a trace of *Algæ* found in two. This group

had eaten practically nothing but Crustacea, nearly all Amphipoda (*Allorchestes*) and Isopoda (*Asellus*), the former eaten by nine, and the latter by two—both together making forty-seven per cent. of the entire food. As might be supposed from the small size of these specimens, Entomostraca were apparent in the food, although in moderate numbers (five per cent.). The forms recognized were *Simocephalus*, *Chydorus*, *Pleuroxus*, *Alona*, *Cypris*, *Candona*, *Cyclops*, and *Canthocamptus*. A planarian worm was noted in one, and specimens of *Diffugia* in another. A single example had eaten a small fish. Most of the insects were *Chironomus* larvæ (twenty-five per cent.), case-worms, and larvæ of day flies (twelve per cent.).

Comparing the principal genera of this family, as represented by the one hundred and twenty specimens examined, we find that the larger deep-water species from the great rivers of the State are apparently ichthyophagous; that the relatively minute stone cats feed on the smaller insect larvæ and the medium sized Crustacea; that the spotted cat is essentially insectivorous; that among the bull-heads the yellow cat eats the largest percentage of fishes and the marbled cat the smallest; that the latter feeds more generally upon *Unio* than any of the other species; and that mollusks at large make about one sixth of the food of the group of species which feeds upon them.

FAMILY AMIIDÆ.

AMIA CALVA, Linn. DOG FISH; MUD FISH; GRINDLE.

This species is very abundant throughout the State in the lakes and larger streams, and also common in ponds of southern Illinois. Not commonly eaten, but often caught for sport.

The food of twenty-one specimens taken from northern, central, and southern Illinois, in April, May, June, August, September, and October, was wholly animal, about one third of it fishes, among which were recognized some undetermined cyprioids and a small buffalo fish (*Ictiobus*). The other important elements were mollusks—about one fourth—and crustaceans (forty per cent.), insects being represented by an insignificant ratio (two per cent.). Even the usually abundant *Chironomus*

and ephemerid larvæ had been eaten by only one or two specimens each. The mollusks were more than two thirds Sphærium, the remainder being Vivipara and Planorbis. The Crustacea were chiefly crayfish, among them *Cambarus virilis* and *obesus*. Besides these, I noticed Crangonyx, Allorchestes, and Asellus, Cyclops and a few Cladocera (*Simocephalus americanus*, *Scapholeberis mucronatus*, and Chydorus).

FAMILY LEPIDOSTEIDÆ.

A half dozen of the river gars *Lepidosteus platystomus* and *L. osseus* had eaten nothing but fishes, including the hickory shad (*Dorosoma*), black bass (*Micropterus*), and some minnows (*Cyprinidæ*).

FAMILY POLYODONTIDÆ.

POLYODON SPATHULA, Wall. SHOVEL-FISH; PADDLE-FISH;
SPOON-BILL CAT; DUCK-BILL CAT.

This remarkable and most interesting fish, the most notable inhabitant of our waters, occurs abundantly in the Illinois, Mississippi, and Ohio, but not elsewhere within our limits. It has a more or less distinct habit of migration, being much the most abundant in spring, although taken sparingly throughout the remainder of the year. It is a gigantic species, reaching a weight of thirty pounds and upwards, and a length of six feet or more, including the paddle. It is now quite generally dressed for the market, and sold at the same rate as catfish.

It has an alimentary apparatus not less remarkable than its other characters. The broad blade-like snout, the enormous mouth and equally large gill slits, the efficient branchial strainer, and the peculiar structure of the intestine,—all indicate a peculiar alimentary regimen and unusual feeding habits. Both the upper and lower jaws of the young are provided with small, acute teeth—the upper with a band upon the vomer and palatines, besides a row on the maxillaries, and the lower with a longitudinal row extending nearly its full length—but the jaws of the adult are toothless and smooth.

This fish depends, therefore, entirely upon the very remarkable straining apparatus borne by the gills, the immense oral opening, and the equally free provision for the exit of water from the gill chamber, enabling it to pass vast quantities of water through its branchial apparatus. The gills are very elongate, each having the form, when the mouth is closed, of a slender *U* with the sides parallel and closely approximated, the lower arm, however, extending somewhat further forward than the upper. Each gill bears throughout its whole length a double series of very long, fine, numerous, and slender rakers, the two rows separated by a membranous partition borne upon the anterior surface of the arch,—this partition a little higher than the rows of rakers, and slightly thickened on the internal edge, so as to enclose the tips of the rakers when the parts of the apparatus are approximated. These rakers average fully twice the length of the corresponding gill filaments, and numbered, on the first gill of a specimen about one and a half feet long, five hundred and sixty rakers in the anterior series. A half row of similar rakers is borne by the fifth branchial arch, corresponding to the inferior pharyngeal bones of most fishes. The individual rakers are toothless, smooth, cartilaginous, and nearly naked, the filaments covered by a thin epithelium, thickened at the tip. Interlocking as these do when the branchial apparatus is extended, they form a strainer, sufficient to arrest the smallest living forms above the Protozoa. There are no pharyngeal jaws or teeth, nor is there any apparatus of mastication elsewhere.

In the absence of any raptatorial teeth or crushing apparatus in its large and feeble jaws or in its throat, it is certain that this species cannot feed upon fishes or mollusks; and the character of the intestine makes it very probable that it never purposely swallows mud or takes a large percentage of vegetable food. On the other hand, its enormous mouth, and the remarkable straining apparatus in its branchial cavity give it access to the immense stores of minute insect and crustacean life most commonly reserved for young fishes; while its structures are likewise evidently adapted to the larger soft-bodied insects and insect larvæ.

The use of the paddle-like snout is as yet a matter of conjecture, slightly assisted, perhaps, by a knowledge of the princi-

pal features of the food. The relatively minute size of the objects on which it feeds, the absence of mud from its intestine, and its seemingly positive preference for animal food, indicate that it is not only able to gather large quantities of very minute objects among the weeds and from the muddy bottom without filling itself with mud, but that it can separate the Entomostraca from the Algæ among which they swim. I cannot see how this is done unless its paddle be used to stir up the weeds in its advance, as it swims along, thus driving up the animal forms within reach of its branchial strainer, while the mud and vegetation settle out of its way.

What is the meaning of the minute and evanescent teeth on the jaws of *Polyodon*, I am unable to surmise, but judge that they can only be accounted for by reference to primitive conditions of life of which the present habits of the fish give us no hint.

Eight specimens obtained from Peoria, Pekin, and Henry on the Illinois, from the Ohio River at Cairo, and from the Mississippi at Quincy, in six different years, will probably suffice to give a fair general idea of the food, taken in connection with suggestions made above, based on a study of the structures of alimentation.

The vegetable elements of the food were eaten by four of the specimens, and amounted to only seven per cent. It is to be noted, however, that one of the specimens taken at Quincy had derived thirty per cent. of its food from a species of *Nostoc*, while another, taken at Peoria in May, had found about one fifth of its food among vegetable objects. A little *Potamogeton*, some filamentous algæ and diatoms, together with a small amount of terrestrial rubbish, were the elements recorded.

Fishes and mollusks were without representation in the alimentary contents of these specimens; while insects and crustaceans made by far the larger part of the food,—the former taken by all the specimens, and in nearly twice the ratio of the latter. The minor items of this class were *Corethra* larvæ (twelve per cent.) and *Chironomus* larvæ (five per cent.). Larvæ of *Neuroptera* made one half the food, and were eaten by six of the specimens,—*Hexagenia* larvæ alone amounting to forty-seven per cent. A few case-worms (*Phryganeidæ*),

dragon-fly larvæ (*Libellulidæ* and *Agrion*), and *Cænis* larvæ, with a few *Corisas*, aquatic beetles (*Coptotomus*), and chance terrestrial insects, were the remaining items of this class.

The crustaceans were all Entomostraca, with the exception of the amphipod *Allorchestes dentata*, noted in two specimens. Five of the specimens had eaten Entomostraca, one of them ninety per cent., and another eighty, — the remaining ratios being thirty-five, thirty, and twenty. Water mites (*Hydrachnida*) were noticed in a single specimen, leeches also in one, and *Plumatella* in another. The smaller Crustacea were so numerous that no attempt was made to exhaust the possible determinations; but in some cursory examination of this material the following forms were observed: *Daphnia pulex*, *Bosmina*, *Chydorus*, *Eurycercus*, *Leptodora*, *Cypris*, *Cyclops*, and *Canthocamptus*.

To the comparative anatomist, *Polyodon* is peculiarly notable as among the oldest of fishes, distinguished, when compared with higher species, by the persistence of juvenile characters; and similarly we find that the most remarkable feature of its food is one which it shares with young fishes in general. This is, however, a simulated correlation, the food habit not being due to a persistence of youthful structures of alimentation, but to a remarkable specialization of the apparatus of food-prehension. It must consequently be correlated with a superabundant supply of minute animal life when and where these structures originated, or, at least, when they took their present form; and taken together with the great size of this fish and its out-worn dental furniture, seemingly indicates a radical change in the feeding habits of the species, and a capacity for adaptation to new circumstances which possibly accounts for its long survival.

FOOD OF SMALLER FAMILIES.*

	<i>Lota maculosa</i>	<i>Esox lucius</i>	<i>Esox vermiculatus</i>	Summary of <i>Esox</i>	<i>Coregonus artedii</i>	<i>Dorosoma cepedianum</i>	<i>Clupea chrysochloris</i>	<i>Hyodon tergatus</i>	<i>Amia calva</i>	<i>Lepidosteus platystomus</i>	<i>Lepidosteus osseus</i>	Summary of <i>Lepidosteus</i>	<i>Polyodon spathula</i>
NUMBER OF SPECIMENS EXAMINED.	10	37	19	56	5	11	4	8	12	2	4	6	8
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
ANIMAL FOOD.....	1.00	1.00	1.00	1.00	1.00	.04	1.00	1.00	1.00	1.00	1.00	1.00	.9
I. BATRACHIA (tadpoles).....			.13	.07									
II. FISHES.....	.83	.98	.52	.75			1.00		.33	.67	1.00	.83	
Cycloid.....		.09	.11	.10									
Acanthopteri.....	.62	.23	.11	.17					.09	+		+	
<i>Perca lutea</i>.....	.62												
<i>Centrarchinae</i>.....		.21	.11	.16									
<i>Micropterus</i>.....		.03		.02									
<i>Pomoxys</i>.....		.69		.04									
<i>Gambusia patruelis</i>.....			.04	.02									
<i>Coregonus</i>.....	.10												
<i>Dorosoma cepedianum</i>.....		.46		.23			.67			.50	.25	.38	
<i>Hyodon</i>.....		.05		.03									
<i>Cyprinidae</i>.....		.03	.09	.06					.04	+	.20	.10	
<i>Catostomatidae</i>.....		.03		.01					+				
III. MOLLUSCA.....			+	+		+		+	.24				
1. <i>Univalves</i>			+	+		+		+	.07				
<i>Vivipara</i>.....									.06				
2. <i>Bivalves</i> (<i>Sphaerium</i>).....						+			.17				
IV. INSECTA.....		.02	.35	.18	.50	+	+	1.00	.02				.5
Terrestrial.....					.50	+		.64					.0
Aquatic.....		.02	.29	.15		+		.36	.02				.5
1. <i>Hymenoptera</i>.....					.11			+					
<i>Myrmecidae</i>.....					.11								
2. <i>Lepidoptera</i>.....					.13			+					
3. <i>Diptera</i>.....					.13			+	.01				.1
Terrestrial.....					.13			+					+
<i>Tipulidae</i>.....					.13			+					
Aquatic larvæ.....									.01				.1
<i>Corethra</i>.....													.1
<i>Chironomidae</i>.....									.01				.0
4. <i>Coleoptera</i>.....					.02	+		+					.0
Terrestrial.....					.02	+		+					+
<i>Chrysomelidae</i>.....					.02			+					.0
Aquatic.....								+					.0
<i>Dytiscidae</i>								+					.0
<i>Hydrophilidae</i>								+					
5. <i>Hemiptera</i>			+	+	.11	+		+	+				+

* The sign + indicates a ratio not estimated.

FOOD OF SMALLER FAMILIES.—Continued.

	<i>Lota maculosa</i>	<i>Esox lucius</i>	<i>Esox vermiculatus</i>	Summary of <i>Esox</i>	<i>Coregonus artedii</i>	<i>Dorosoma cepedianum</i>	<i>Clupea chrysochloris</i>	<i>Hyodon tergisus</i>	<i>Amia calva</i>	<i>Lepidosteus platystomus</i>	<i>Lepidosteus osseus</i>	Summary of <i>Lepidosteus</i>	<i>Polyodon spathula</i>
NUMBER OF SPECIMENS EXAMINED.	10	37	19	56	5	11	4	8	12	2	4	6	8
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
Terrestrial .....					.11			+					...
Homoptera .....					.11			+					...
Aquatic			+	+		+		+					+
Corisa			+	+		+		+					+
6. Orthoptera (Tettix)								+					...
7. Neuroptera (larvæ) .....		.02	.29	.15				.66	.01				.5
Phryganeidæ .....													.0
Odonata .....		.02	.25	.13					.01				.0
Libellulinæ .....		.02	.02	.02					.01				+
Agriion .....			.15	.07									+
Ephemeridæ .....			.04	.02				.66	+				.4
Hexagenia .....			.04	.02				.33					.4
V. ARACHNIDA						+		+					.0
VI. CRUSTACEA	17		+	+	.50	.04		+	.41	.33		.17	.3
1. Decapoda (Cambarus) .....									.38	.33		.17	...
2. Amphipoda .....									.01				+
3. Isopoda (Asellus)			+	+					+				...
ENTOMOSTRACA .....					.50	.04		+	.02				.3
4. Cludocera					+	+		+	+				+
5. Ostracoda (Cypris) .....						.04							+
6. Copepoda					+	+			.02				.0
VII. VERMES (leech)													+
VIII. BRYOZOA .....													...
(Plumatella)													+
IX. PROTOZOA .....													...
(Difflugia)						+							...
VEGETABLE FOOD			+	+		.32		+	+				.0
Miscellaneous .....						.16		+					+
Terrestrial			+	+									.0
Aquatic						+			+				.0
Lemna						+							...
Wolffia						+							...
Algae						+							.0
Nostoc .....													.0
Distillery Slops .....						.16							...
MUD AND SAND .....						.64							...

FOOD OF CATOSTOMATIDÆ.

	Placopharynx carinatus	Moxostoma aureolum	Moxostoma macrolepidotum	Summary of Moxostoma*	Minytrema melanops	Hypentelium nigricans	Catostomus teres	Carpiodes cyprinus	Ictiobus bubalus	Ictiobus urus	Ictiobus cyprinella	Summary of Ictiobus	Summary of Catostomatidæ
NUMBER OF SPECIMENS EXAMINED.	2	6	12	23*	4	5	3	19	17	17	17	51	107
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
ANIMAL FOOD .....	.95	.97	.87	.95	1.00	1.00	.94	.83	.80	.67	.65	.71	.90
I. FISHES .....	.....	.....	.....	.....	.....	+	.....	.....	.....	.....	.....	.....	+
II. MOLLUSCA .....	.32	.49	.55	.60	.87	.10	.42	.24	.30	.12	.03	.15	.41
1. <i>Univalves</i>	+	.16	.40	.27	.01	.....	.12	+	+	+	+	+	.06
Viviparidæ .....	.....	.13	.22	.20	.....	.....	.....	.....	+	.....	.....	+	.03
Somatogyrus .....	.....	.....	.06	.02	.....	.....	.....	.....	.....	.....	.....	.....	.01
Limnæa .....	.....	.....	.10	.03	.....	.....	.....	.....	.....	.....	.....	.....	.01
2. <i>Bivalves</i>	+	.33	.15	.33	.86	.10	.30	.24	.30	.14	.02	.15	.30
Sphærium	+	.17	.15	.28	.86	.10	.30	.24	.30	.14	.02	.15	.29
Unionidæ .....	.....	.....	+	+	.....	.....	.....	.....	.....	.....	.....	.....	+
III. Insecta .....	.63	.48	.32	.35	.10	.90	.03	.32	.29	.42	.33	.35	.37
Terrestrial .....	.....	.....	+	+	.....	+	.....	.....	.01	+	+	+	+
Aquatic .....	.63	.46	.31	.34	.10	.90	.03	.32	.28	.42	.36	.37	.37
1. <i>Diptera</i> .....	.03	.46	.30	.33	.10	.04	.63	.30	.19	.25	.24	.23	.17
Terrestrial .....	.....	.....	+	+	.....	.....	.....	.....	.....	+	.....	.....	+
Aquatic larvæ .....	.03	.46	.30	.33	.10	.04	.03	.30	.19	.25	.24	.24	.17
Chironomidæ .....	.03	.30	.15	.15	.10	.04	.03	.22	.19	.23	.20	.22	.12
2. <i>Coleoptera</i> .....	.50	.....	+	+	.....	.13	.....	.....	.62	+	+	+	.10
Terrestrial .....	.....	.....	+	+	.....	.01	.....	.....	.01	+	.....	.....	+
Aquatic larvæ .....	.50	.....	+	+	.....	.12	.....	.....	.01	.....	+	.....	.10
Hydrophilidæ .....	.50	.....	+	+	.....	.....	.....	.....	.01	.....	.....	.....	.09
3. <i>Hemiptera</i> .....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.01	.01	+
Corisa .....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.01	.01	+
4. <i>Neuroptera</i> .....	.10	.....	.01	.01	.....	.72	.....	.02	.08	.16	.11	.11	.10
Terrestrial .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+	.....	.....	+
Aquatic larvæ .....	.10	.....	.01	.01	.....	.72	.....	.02	.08	.16	.11	.11	.10
Phryganeidæ .....	.....	.....	.....	.....	.....	.....	.....	.01	.01	.....	.....	.....	+
Sialidæ .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.....	+
Odonata .....	.....	.....	+	+	.....	.....	.....	.....	.01	.01	.....	.01	+
Ephemèridæ .....	.10	.....	.01	.01	.....	.72	.....	.....	.06	.15	.10	.10	.16
Cænis .....	.....	.....	.....	.....	.....	.53	.....	.....	.....	.....	.....	.....	.05
Hexagenia .....	.....	.....	.....	.....	.....	.12	.....	.....	.....	.14	.09	.08	.02
IV. ARACHNIDA .....	.....	.....	.....	.....	.....	.....	.02	.....	+	+	+	+	+
V. CRUSTACEA .....	+	.....	+	+	.03	.....	.30	.23	.20	.13	.29	.21	.11

* Includes five specimens of undetermined species.

FOOD OF CATOSTOMATIDÆ.—Continued.

	Placopharynx carinatus	Moxostoma aureolum	Moxostoma macrolepidotum	Summary of Moxostoma*	Mintyrema melanops	Hypentelium nigricans	Catostomus teres	Carpionodes cyprinus	Ichtiobus bubalus	Ichtiobus urus	Ichtiobus cyprinella	Summary of Ichtiobus	Summary of Catostomatidæ
NUMBER OF SPECIMENS EXAMINED.	2	6	12	23*	4	5	3	19	17	17	17	51	107
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
Decapoda (Cambarus)	...	...	...	...	...	...	...	...	+	...	...	+	+
Amphipoda	+	...	...	...	...	...	...	+	.01	...	+	.01	.01
TOMOSTRACA	...	...	+	+	.03	...	.30	.23	.19	.13	.29	.20	.10
Cladocera	...	...	+	+	...	...	.30	.03	+	.05	.08	.05	.04
aphnella	...	...	...	...	...	...	...	...	+	...	+	+	+
aphniidæ	...	...	...	...	...	...	...	.03	+	.05	+	.02	.01
nceidæ	...	...	+	+	...	...	.30	+	+	+	+	+	.03
Ostracoda (Cypridæ)	...	...	...	...	.03	...	+	.04	+	.02	.05	.03	.02
Copepoda	...	...	+	+	+	...	+	.08	.19	.04	+	.08	.03
I. VERMES	...	...	...	...	...	...	.02	...	+	...	+	+	+
stifera	...	...	...	...	...	...	+	...	...	...	...	...	+
I. POLYZOA	+	...	...	...	...	...	...	...	.01	...	+	+	+
II. PROTOZOA	...	...	...	...	...	...	...	...	...	...	...	...	...
(Rhizopoda)	...	...	...	...	...	...	.15	+	...	+	+	+	.01
VEGETABLE FOOD.	.05	.03	.10	.04	...	+	.06	.08	.20	.33	.35	.29	.08
eds	...	...	...	...	...	...	.02	...	.02	+	.09	.04	.01
quatic	.05	.01	.07	.02	...	+	.04	.08	.15	.06	.17	.12	.05
Lemna	.03	...	...	...	...	...	...	...	+	+	+	+	.01
Wolfia	.01	...	.10	+	...	...	...	.05	.11	+	...	.03	.01
Algae	...	...	+	+	...	...	.04	+	+	.01	.15	.05	.01
Filamentous	...	...	+	+	...	...	.02	...	+	+	.05	.02	.01
Diatoms	...	...	...	...	...	...	+	+	+	+	+	+	+
stillery Slops	...	...	.03	.01	...	...	...	...	...	.21	.09	.10	.02
JD	...	+	.03	.01	+	...	...	.09	...	+	+	+	.02

* Includes five specimens of undetermined species.

FOOD OF SILURIDÆ.

	Ictalurus furcatus	Ictalurus punctatus	Amiurus natalis	Amiurus nebulosus.	Amiurus marmoratus	Summary of Amiurus	Leptops olivaris	Noturus gyrinus	Summary of Siluridæ
NUMBER OF SPECIMENS EXAMINED.	1	43	12	36	13	61	2	13	120
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.								
ANIMAL FOOD.....	1.00	.75	1.00	.77	.93	.90	1.00	.98	.96
Dead animal matter02	.13	.....	.14	.09	.....	.....	.02
I. FISHES	1.00	.10	.34	.20	.01	.18	1.00	+	.44
Percidæ20	.....	.06	.43	.....	.16
Lepomis43	.....	.14
Cyprinidæ04	.....	.....	.01	.30	.....	.10
Catostomatidæ17	.....	.....	.06	.....	.....	.01
Amiurus20	.....	.07
II. MOLLUSCA15	.05	.19	.26	.16	.....	.....	.04
1. Univalves08	.05	.02	.01	.02	.....	.....	.01
Vivipara01	.04	.....	+	.01	.....	.....	.01
Melantho03	+	.01	.....	.01	.....	.....	+
2. Bivalves07	.....	.17	.25	.14	.....	.....	.03
Sphærium13	.12	.08	.....	.....	.02
Unionidæ04	.13	.06	.....	.....	.01
III. INSECTA.....44	.30	.28	.50	.36	.....	.46	.26
Terrestrial07	.....	+	+	+	.....	.01	.01
Aquatic36	.30	.27	.50	.36	.....	.41	.24
1. Hymenoptera	+	+
2. Lepidoptera	+	+
3. Diptera13	.....	.20	.14	.11	.....	.27	.12
Terrestrial	+01	+
Aquatic13	.....	.20	.14	.11	.....	.26	.12
Corethra09	+	.03	.....	.....	.01
Chironomus13	.....	.10	.14	.08	.....	.25	.11
4. Coleoptera	+	+	.01	.01	.....	.02	.01
Terrestrial	+	+	+	+	+
Carabidæ	+	+	+	+	+
Staphylinidæ	+	+
Aquatic larvæ	+	+	.01	.01	.....	.02	.01
Dytiscidæ	+	+	+
Hydrophilidæ01	.01	.....	.....	+
5. Hemiptera01	.....	+	.....	+	.....	.....	+
Terrestrial	+	+
Aquatic01	.....	+	.....	+	.....	.....	+
Corixa	+	+	+	+
6. Orthoptera05	.....	.....	+	+	.....	.....	.01

FOOD OF SILURIDÆ.—Continued.

	Ictalurus furcatus	Ictalurus punctatus	Amiurus natalis	Amiurus nebulosus.	Amiurus marmoratus	Summary of Amiurus	Leptops olivaris	Noturus gyrinus	Summary of Siluridæ
NUMBER OF SPECIMENS EXAMINED.	1	43	12	36	13	61	2	13	120
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.								
Acrididæ .....		.04	.....	.....	.....	.....	.....	.....	.01
7. Neuroptera (larvæ).....		.23	.30	.07	.35	.24	.....	.12	.10
Phryganeidæ .....		.01	.....	+	.....	+	.....	.02	.01
Sialidæ		+01	+	+	.....	.....	+
Odonata .....		.08	.....	.02	.....	.01	.....	.....	.01
Libellulinae .....		.07	.....	.02	.....	.01	.....	.....	.01
Agrioninae .....		.01	.....	.....	.....	.....	.....	.....	+
Ephemmeridæ .....		.09	.30	.04	.35	.23	.....	.10	.08
Hexagenia .....		.03	.30	.04	.35	.23	.....	.....	.03
IV. ARACHNIDA		+	.01	.....	+	+	.....	.....	+
V. CRUSTACEA .....		.03	.17	.13	.....	.10	.....	.52	.19
1. Decapoda (Cambarus).....		.03	.17	.12	.....	.10	.....	.....	.02
2. Amphipoda (Allorchestes).....		+01	.....	+	.....	.25	.08
3. Isopoda (Asellus).....	22	.07
ENTOMOSTRACA	+	+05	.02
4. Cladocera	+	+02	.01
5. Ostracoda	+	+
6. Copepoda	+	+03	.01
VI. VERMES .....		.01	.....	.01	.02	.01	.....	+	.01
Hirudinei .....		.01	.....	.01	.02	.01	.....	.....	.01
Nematodes		+	+	+	+
VII. BRYOZOA (Plumatella).....		+	+
VIII. PORIFERA (Spongilla).....		+	+
IX. PROTOZOA (Difflugia).....		+	+
VEGETABLE FOOD .....		.25	+	.23	.07	.10	.....	.02	.04
Miscellaneous .....		.01	.....	.05	+	.02	.....	.01	+
Aquatic .....		.23	+	.16	+	.66	.....	.01	.03
Lemna		+	+	+	+
Wolfia	+	+	+
Potamogeton .....		.06	.....	.01	+	.01	.....	.....	+
Algæ .....		.16	.....	.02	.....	.01	.....	.01	.02
Distillery slops.....		.01	.....	+	.07	.02	.....	.....	.01
MUD	+	+	+

ERRATA.*

Page 5, line 3 of table, second column, for 39 read 38 ; line 6, second column for 121 read 120.

Page 9, line 17, for *conjunction* read *conjugation*.

Page 21, line 13, for *Ricciacie* read *Ricciaceæ*.

Page 67, line 17 from bottom, for *fraligifolia* read *fragilifolia*.

Page 123, line 4 from bottom, and page 126, line 1, for *Tricholeæ* read *Trichocoleæ*.

Page 126, line 2, for *Tricholea* read *Trichocolea*.

Page 177, line 16, for *Lecythia* read *Lecythea*.

Page 333, line 1, after *Tachidius* add *Lilljeb*.

Page 338, under *Daphnella brachyura*, line 16, insert *Hab.*—Massachusetts (*Birge*), Minnesota (*Herrick*).

Page 340, line 5, for *Scapaoleberis* read *Scapholeberis*.

Page 389, line 7 from bottom, for *carpogonium* read *sporocarp* ; lines 9, 12, 15, for *ögonium* read *carpogonium*.

Page 391, line 1, for *Cessatii* read *Cesatii*.

Page 400, line 4, for *Myceliumin conspicuous* read *Mycelium inconspicuous* ; line 14, for *coleosporium* read *Coleosporium*.

Page 401, line 9, for *connatus* read *connata* ; line 12, for *Taraxicum* read *Taraxacum*.

Page 408, line 15, for *macrocarpa* read *macrospora* ; line 18, for *Hypohyllous* read *Hypophyllous*.

Pages 470 and 471, head of column 11, for *cyprinella* read *cypri-nellus*.

Page 503, lines 8, 14, and 17, for *cyprinella* read *cyprinellus*.

* For additional errata see page 247.