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NOTES ON THE FISHES OF EAST TENNESSEE

By Barton Warren Evermann and Samuel F. Hildebrand

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## INTRODUCTION.

In September and October, 1893, the senior writer of this paper made an examination of a number of the springs and streams of east Tennessee for the purpose of selecting a site for a Federal fish-cultural station in that State.

The field investigations were begun September 24 and continued until October 19, during which time Dr. Evermann was assisted by Dr. Revere R. Gurley, then of the United States Fish Commission, and Dr. Josiah T. Scovell, of Terre Haute, Ind.

In addition to an examination of numerous springs with special reference to their suitability for fish-cultural purposes, many of the streams of east Tennessee were investigated with regard to the volume and character of their waters, the physical characteristics of the country through which they flow, and the abundance and distribution of the different species of fishes and other aquatic life which they contain.

A full and detailed report on the fish-cultural phases of the investigations was made to the Commissioner of Fisheries immediately upon the completion of the field work.

Although the study of the fishes collected was begun at that time, a multiplicity of other and more pressing duties intervened, and not until recently was an opportunity presented for completing the report.

## GENERAL PHYSICAL FEATURES OF EAST TENNESSEE AND DESCRIPTIONS OF THE REGIONS AND WATERS EXAMINED.

The investigations were confined almost wholly to east Tennessee, and entirely to the Tennessee River Basin. The valley of east Tennessee, as a continuation of the great valley of Pennsylvania and Virginia, aids in forming one of the principal features of the Appalachian Mountain system. It trends from northeast to southwest with other members of the system and is between 50 and 60 miles wide. It is bounded on the southeast by the Bald, Great Smoky, and Unaka Mountains which rise to an elevation of 4,000 to 5,000 feet. On the northwest it is bounded by the Cumberland Plateau, which has an elevation of about 2,000 feet. The valley has an elevation of about 700 feet in the southwest, rising to about 1,400 feet in the northeast.

The mountains on the southeast are of Lower Silurian, Cambrian, or older rocks, while the plateau on the northwest is of Devonian and Carboniferous strata. The rocks of the valley itself are mainly of the Upper Silurian. The numberless mountain ridges which subdivide the great valley into many minor ones are mainly composed of compact limestones and sandstones, while the valleys are of shales and fragile schists.

The most extensive exposure of rocks seen in the valley was in the neighborhood of Chattanooga.

In the valley of Chickamauga Creek the lowest stratum is a massive limestone called the Chickamauga limestone, while Missionary Ridge, forming the western boundary of this valley, is composed mainly of Knox dolomite. In the valley of Chattanooga Creek west of the ridge, Chickamauga limestone occurs again, while Lookout Mountain on the west rises from this limestone through Knox dolomite and Devonian strata to a heavy bedded carboniferous sandstone, known as the Walden sandstone, at an elevation of 2,000 feet, which is about the elevation of the western boundary of the great valley. Lookout Creek on the west has cut down to the Chickamauga limestone, while the hills on the west rise to the Walden sandstone again.

The soil covering these rocks is frequently clay, often very red and filled with masses of flint or chert. In some places the soil is sandy, and in many places seemed to be of poor quality. The forests are mainly of oak and pine, with hickory, maple, sweet gum, sycamore, sassafras, blue beech, laurel, and cedar, with willows, alders, etc., along the streams, and some chestnuts on the higher ridges.

#### KNOXVILLE AND VICINITY, SEPTEMBER 27 AND 28.

Several springs in the vicinity of Knoxville were examined, among them the following being the most important:

*Fountain Head Springs at Fountain City.*—These are four or five in number, the largest, known as Fountain Head Spring, emerges from near the base of a clay bank about 10 feet high, and flows off through a relatively level tract of land, after forming a small marsh near the spring. The temperature of the water at 10.30 a. m. was 58° F. Measured immediately below the spring the stream averaged 2½ feet wide, 5 inches deep, and flowed three-fifths of a foot per second. This gives a flow of about 280 gallons per minute. The water is pure and clear and the pond below is filled with water cress.

A few rods distant are two other springs, each of which, however, is smaller than the one just described. The temperature is about the same in all of these springs.

The total amount of water that could be obtained here by bringing the various springs together is probably about 400 gallons per minute.

*Callahan Springs.*—These springs are located about 5 miles northwest of Knoxville. The principal one comes out from limestone rock, flows about one-quarter of a mile, when it disappears and follows an underground passage for about 200 feet; then it appears as a stream about 2½ feet wide, 2½ inches deep, and flowing 10 feet in seven seconds. This indicates a volume of about 300 gallons per minute. The temperature of the water at 4.20 p. m. at the place where it finally leaves the rock was 58.5° F.

*Tennessee River.*—The Tennessee River was fished at the mouth of Lyon Creek.

*Lyon Creek.*—This creek was examined near the insane asylum, about 5 miles west of Knoxville. It was fished for the last half mile of its course. Width 13 to 15 feet; depth less than a foot; current about 1½ feet per second; temperature at noon 60° F.; of air in shade at 10 a. m., 62° F.

The bed and banks of this stream are of red clay, the bottom quite muddy in most places; some limestone rock; banks usually 2 to 5 feet high, covered with a good

growth of willows, sycamores, oaks, walnuts, papaws, etc. In the stream there are many logs and much rubbish.

From Knoxville southwesterly for some 70 miles to Athens, only limestones were seen. The Knoxville dolomite, which is abundant at Chattanooga and intervening localities, is very prominent at Knoxville. Some of the beds are fine-grained, hard, and blue; some contain numerous chert nodules which fill the soil resulting from the decay of such rocks. These beds of clay and chert are often compact enough to stand firmly in vertical sections. The rocks generally are much tilted, often standing at a high angle. These rocks abound with fissures and small caves, and springs are common everywhere, but no springs of large size occur in the immediate vicinity of Knoxville.

CHATTANOOGA AND VICINITY, SEPTEMBER 29 TO OCTOBER 2.

*Newman Spring, Ga.*—This spring is about 6 miles southeast of Chattanooga, on the east side of Missionary Ridge near Rossville Gap, and a few rods from the Tennessee line. There are several small springs here which, by damming (about 6 feet high one-fourth mile below the spring), have been converted into a large pond known sometimes as Green's pond. This pond is about 20 by 80 rods and covers 8 to 10 acres. We had no facilities for measuring the depth, but it is probably 10 feet or more in the deepest places. Most of the springs are now beneath the surface of the pond. One spring at the west end flows about 30 gallons. Its temperature was 59° F. at 4 p. m., when the air was 72° F. At the lower (east) end of the pond the temperature at a depth of 2 feet was 63° F., while at the surface near the west end it was 67° F. The pond is well filled with *Myriophyllum*, *Potamogeton*, *Chara*, *Lemna*, various species of algæ, and other species of water-loving plants. Desmids and diatoms and the smaller crustaceans seemed to be abundant. The water is hard and, of course, comes from limestone. The water is led from the pond through a race to a gristmill a short distance below, and finally finds its way into South Chickamauga Creek, where it enters the State of Tennessee. The total amount of water supplied by this pond was estimated by us at 1,500 gallons per minute. The land surrounding the pond is mostly of yellow clay and sand and is extensively cultivated.

*Crawfish Springs, Ga., September 30.*—These springs, situated about 12 miles south of Chattanooga near the West Chickamauga Creek, are of enormous size. The upper one, near the Park Hotel, had been dammed, thus forming a large pool 15 to 25 feet deep. The water is exceedingly clear, small objects upon the bottom being distinctly seen in a depth of 12 feet. The temperature at 8½ feet depth at noon was 59° F. The dam, measured on the lower side, is about 15 feet high, or nearly that height above the surface of the water in the stream immediately below.

The waste water flowing over the lip of the dam measures 11 feet wide, 2 inches deep, and flows 3 feet per second. This is about 2,500 gallons a minute. The amount wasting through the power house is probably as many gallons more, so that the entire flow of this one spring may be put at 5,000 gallons per minute, or 7,200,000 gallons per day.

Below this spring the large stream which flows from it runs for several rods through a rather deep gorge which it has worn through the limestone rock, then the banks become lower, particularly the left one. At a distance of less than a mile from the spring its outlet unites with West Chickamauga Creek. At various places in this course there are springs which come out in the bed of the stream; one just below the railroad bridge

probably furnishes even more water than the Crawfish Spring proper. These various springs augment the stream greatly, so that, measured near its mouth, it was found to average 120 feet wide and 5 feet deep, but possesses a rather slow current.

The upper spring and much of the outlet are abundantly supplied with *Myriophyllum*, among which small crustaceans and mollusks abound.

Many years ago the United States Fish Commission placed a few rainbow trout in this spring. It was stated that the plant proved very successful, and much sport was afforded to local anglers and guests.

*Chickamauga Creek.*—This stream was examined at Lee and Gordon's mill, on the Lafayette road, 3 miles from Crawfish Springs. The stream, which has a rocky bed in most places where examined, is here 62 feet wide, 1 foot deep, current  $1\frac{3}{7}$  feet per second, temperature  $63^{\circ}$  F. Fishes were quite abundant.

South Chickamauga, Chattanooga, and Lookout Creeks have rocky beds, and when the water in the Tennessee is low the currents of these creeks are rapid, but when the water is high in the Tennessee it backs up these creek channels for miles, depositing great quantities of sediment. Across the river north of Chattanooga, rocks, soil, and timber are much the same as on the south side of the river.

*Read's Spring, October 1.*—This spring, about 7 miles north of Chattanooga, is really a series of small springs, altogether forming a creek of considerable size. The largest one issues from the limestone bluff at the head of the creek and is a very nice spring. The temperature is  $58^{\circ}$  F. and the flow, when increased by the addition of a number of much smaller springs a few yards below, is about 300 gallons per minute.

The springs and streams are well filled with various species of algæ, insect larvæ, and small mollusks.

*Nickajack Cave and Stream, October 2.*—This cave, at Shellmound, about 20 miles southwest of Chattanooga, has been eroded from limestone rock by a little stream which flows into the Tennessee within a mile of the cave. When high, the river backs up into the cave for a long distance. The cave seemed to have increased downward by erosion and upward through the fall of strata from above. The mouth of the cave is about 150 feet wide and 75 feet high. The stream was followed into the cave for more than half a mile. It was found to be a continuous stream, 1 to 2 feet deep and 8 to 10 feet wide in most places, but at irregular intervals there were pools 2 to 4 feet deep. Curiously enough, this stream seems to be subject to considerable fluctuation in volume. No fishes are known from this cave except from near the entrance, but a species of blind crawfish occurs in limited numbers.

#### CLEVELAND, TENN., OCTOBER 3 AND 4.

Cleveland, about 30 miles a little northeast of Chattanooga, is situated in an undulating region in which we saw nothing but limestone rocks, from which springs issued in abundance. There are a great many springs, large and small, in the vicinity of Cleveland, of which the most important are:

*Craigmile's Springs.*—These are situated 1 mile north of Cleveland. By damming and embanking, a pond of an acre or more has been formed. The principal spring issues from the limestone at the upper edge of the pond. The total flow is about 400 gallons per minute. The water is of good quality. The temperature of the water as it issues from the rock is  $59^{\circ}$  F.; in a small spring below the dam it is  $60^{\circ}$  F.; while in

the boat house it was 68° F. at 10 a. m. when the air was 74° F. There is considerable algæ and Chara growing in the pond.

*Payne's Spring*.—This spring is located about 2 miles north of Cleveland. It emerges at the foot of a low hill, which is of red clay resting on sandstone. It is a very fine spring, flowing about 1,000 gallons per minute. The temperature of the water is 58° F. The stream flowing from it is filled with water cress. The outlet is in South Mouse Creek, a short distance to the north.

*Stith's Springs*.—About 1 mile south of Cleveland are two good springs, about one-fourth mile apart. The combined flow is about 275 to 300 gallons and the temperature of the water is 59° F.

*Julian's Spring*.—This is a large spring about 8 miles southeast of Cleveland. It has a flow of over 400 gallons per minute, and the temperature was 59.5° F. when the air was 74° F. The soil in this region is thin and mostly red clay. The vegetation in the streams was especially abundant, the algæ, water cress, etc., greatly obstructing the flow of the water. The forests are mainly of oak with some pines and other trees. We noticed three oaks, three elms, pine, chestnut, black walnut, maple, tulip, sweet gum, dogwood, ash, cedar, hickory, ironwood, persimmon, sassafras, blue beech, sumach, wild cherry, redbud, sycamore, wild plum, willow, alder, elder, etc., making up quite a varied forest vegetation, indicating considerable variety of soil and possibly of rocks, but to a casual observer the outcropping rocks seemed much the same everywhere in the region about Cleveland.

#### ATHENS, TENN., OCTOBER 4 TO 7.

About Athens, 30 miles east of north from Cleveland, the country is more broken and uneven. The rocks were generally limestone, but near Arnwine Spring, about 5 miles north of Athens, other rocks were seen. This region is also well supplied with springs and streams. Within a few miles are several of the most important rivers of east Tennessee. To the southward 12 to 15 miles is the Hiawassee, to the northeast about 20 miles is the Little Tennessee, while the Tennessee River is only 15 miles distant on the west or 25 miles on the northeast. These and a great number of smaller streams near-by are all excellent fish streams. Among the more important springs which we examined in the vicinity of Athens are the following:

*Arnwine Spring, or Mallock Spring*.—This spring is about 5 miles north of Athens. It is a very large and excellent spring, issuing from a fissure in the limestone at the base of a gentle hillside, and at once forming a large stream which flows southeast over granitoid, schistose, and other metamorphic rocks through a narrow valley which becomes wider as the distance from the spring increases. This spring is tributary to a branch of North Mouse Creek, which flows for a short distance over metamorphic rocks, but most of its course is over a limestone bed. The temperature of the water in the spring was 57.5° F. at 3.30 p. m. when the air was 72° F. The volume of water furnished by this spring is over 2,000 gallons per minute.

The spring, mill race, and upper end of the pond are well filled with water vegetation, consisting chiefly of mosses on the rocks, Lemna, Chara, and filamentous algæ. We were surprised to find no water cress, Myriophyllum, or Potamogeton in this spring and pond.

In the mill race and stream are a great many small gasteropods and small blobs, and crawfish, young dace, and frogs are quite numerous.

The stream below the mill is well suited to such small fishes as darters and minnows, and we found 10 or 12 species of these two families. Smallmouth black bass and rock bass are abundant farther down the stream.

*Norvel Spring.*—This spring is situated about 7 miles east of Athens, or 2 miles north of Tellico Junction. This, like all other springs of east Tennessee, comes out of limestone rock. The stream, measured 2 rods below the spring, was found to be 52 inches wide, 4 inches deep, and to flow  $1\frac{3}{8}$  feet per second, which would give a volume of more than 1,000 gallons per minute. The temperature of the water was  $59^{\circ}$  F. at 9 a. m. when the air was  $67^{\circ}$  F.

The opening through which the spring issues from the rock is unusually large, and the sound of running water from some distance back of the opening can be distinctly heard. It was stated that on at least one occasion, during a heavy rain, cornstalks and other surface rubbish came up in the spring; these, presumably, had been carried underground through some "sink" connected with the stream somewhere. At such times the water must necessarily become more or less muddy.

*Eastannaula Creek.*—This is a small stream flowing southwest through the town of Athens and joining the Hiwassee near Calhoun. The water is relatively warm and the species of fishes found were chiefly minnows and darters.

#### TELLICO PLAINS, TENN., OCTOBER 7 TO 9.

On Tellico River, about 20 miles east of Athens, the rocks are metamorphic; no limestone seen; only slates, schists, granites, and other forms of metamorphic rocks; soil scanty. Timber varied; fewer oak, more pine, chestnut, black walnut, maple, beech, dogwood, ash, hickory, whitewood, sweet gum, and others were seen. Water plants were not abundant and those found were different from any observed before. Between Athens and Tellico mainly limestone with much red soil.

The Tellico River at Tellico Plains breaks through the last important foothills of the Great Smoky Mountains, turns abruptly northward, and joins the Little Tennessee about 30 miles northeast of Athens. The Tellico is one of the most beautiful and interesting of the many fine streams which have their sources in the Great Smokies. At Tellico Plains it is a cold clear stream about 60 feet wide. Its banks, however, are 80 to 90 feet apart, so that in high water the stream is considerably wider. The granite axis of the fold flanked by shale is shown here. Just above the "Mansion" house the stream flowing over the upturned edges of this shale, whose dip is upstream, causes a very pretty series of rapids when the water is not too low, otherwise a series of isolated streams and pools 1 to 4 feet deep. The river here averaged perhaps 2 feet deep and had a very swift current. Lower down in the more level country the current is less rapid and the depth is correspondingly greater. In the more rapid portions of the river the rocks are covered with a species of moss which adheres very closely to them and among which small mollusks and insect larvæ were abundant. The principal fishes in this part of the stream were darters, which were found to be quite plentiful. In the deeper and more quiet water the smallmouth black bass, pike (*Lucius*), wall-eyed pike, and goggle-eye are abundant, affording much sport to local fishermen.

The upper portion of this river would apparently prove very suitable for trout, unless the rapacious species already mentioned be too numerous.



## MARYVILLE, TENN., OCTOBER 9 TO 10.

There are many springs in the vicinity of Maryville, only a few of which were examined.

*Pistol Creek.*—This is a small stream flowing through the town. It is about 15 feet wide and 1 foot deep, and is fed chiefly by springs, some of which are of large size.

There is one spring a short distance west of the Jackson House which furnishes about 350 gallons per minute. Another in the town east of the hotel runs about 450 gallons per minute; its temperature was 59° F. at 6 a. m. when the air was 55° F.

About 2 miles northeast of the town is a series of small springs, the total flow of which is probably 400 gallons per minute. The temperature is 59° F.

## GREENVILLE, TENN., OCTOBER 10 TO 11.

At Greenville, something over 75 miles northeast of Knoxville, only limestone rocks were seen, and they were the only rocks noticed between the two places. This is also a region of springs, and several very good ones are found in and about the town. There is one large spring in the town near the Grand Central Hotel.

*Davis Spring*, about 1½ miles northwest of Greenville, is quite a good spring, flowing about 500 gallons per minute. Temperature 59° F., air 84° F.

*Big Spring.*—This spring is about 8 miles southwest of Greenville and flows only about 500 gallons per minute. Temperature of water 59° F., air 68° F.

*Nolichucky River.*—This is a stream of considerable size, flowing westward from the Unaka Mountains through Greene County to the French Broad River southwest of Morristown. It was visited at Love's ferry south of Greenville. At that place it is about 250 feet wide, 10 to 15 feet deep, and has a strong current. The Nolichucky is one of the best fish streams in east Tennessee. Algæ, Chara, water cress, Lemna, and other aquatic vegetation are abundant in the springs and little streams flowing from them and in protected places in the river.

*Roaring Fork.*—We visited Roaring Fork about 5 miles northeasterly from Greenville. In all directions rock, soil, and timber were much the same; soil red and thin on the hills, lighter colored and thicker in the valleys; on the hills forests of oak and chestnut with occasional pines and hickories. In the valleys sycamore, maple, elm, and willow were common; beech, mulberry, black walnut, whitewood, redbud, and others were seen.

## TAZEWELL, TENN., OCTOBER 12 TO 14.

Tazewell, Claiborne County, is about 40 miles north and a little east of Knoxville. The rock of this region is chiefly limestone which is readily soluble, as evidenced by the numerous caves of considerable size. Tazewell is 100 to 150 feet below the summits along the divide between Powell and Clinch Rivers, both of which flow southwesterly, each about 6 miles from Tazewell, the former to the north and the latter to the south. The town is 400 to 450 feet above the level of the rivers. The country is rocky and broken, abounding in steep slopes, narrow valleys, and rapid streams. The rocks are mainly limestones, but we saw one thin bed of shale; soil scanty; agriculture practicable only in the narrow valleys; forests of oak, pine, chestnut, sassafras, persimmon, etc., on the higher slopes, with maple, hickory, box elder, ash, willow, etc., along the stream. Near the railway station there is an opening into a large cave and other caves are found in the immediate vicinity.

*Clinch River.*—We examined this river at Walker's ford about 8 miles in a direct line southwest from Tazewell. At that place the river is about 400 feet wide, shallow, and easily waded in most places. The current is swift, and there are many small islands in the river. The rocks are chiefly limestone, but one bed of shale was noticed. The soil is thin, and agriculture is practically confined to the narrow valleys.

This stream is well supplied with fishes, the species of minnows, darters, and suckers being especially numerous. The Clinch River is also remarkable for its rich molluscous fauna, the species of gasteropods being especially abundant and interesting.

Three small creeks enter the Clinch River at or near Walker's ford. Bear Creek joins it from the northeast and Flint Creek from the south, their mouths being almost directly opposite each other. Just above the ford the river has cut its way through Lone Mountain, and just below the ford it has cut in a similar way through Wallen's ridge, below which Straight Creek enters the Clinch from the northeast.

*Ousley Spring.*—This spring, about 8 miles from Tazewell, flows approximately 500 gallons per minute. It is surrounded by trees. The stream formed by the spring is nearly  $3\frac{1}{2}$  feet wide, 2 to 4 inches deep, and has a 2-foot current. The temperature was  $55.5^{\circ}$  F., the coldest we found in Tennessee. The stream comes out near the base of a limestone ledge on the left side of the road going to Walker's ford, and flows across the road and into a meadow.

#### CUMBERLAND GAP, OCTOBER 14 TO 19.

Cumberland Gap, about 12 miles in a direct line northwest of Tazewell, is an interesting locality from a geological point of view. The upper strata on either side of the Gap are of red sandstone, the lower strata east of the Gap of limestone, all in nearly horizontal strata. But in the Gap there is a mass of shale or slate through which a railway tunnel has been driven. We did not work out the relations of these strata, but the slate in the Gap and not east of it at the same level suggests an old anticlinal which has been covered by nearly horizontal strata of limestones and sandstones. In the cave just east of the Gap the strata seem to dip a little toward the west, at least the stream in the cave crowds the west wall which overhangs the stream. The cave exhibits well several kinds of cave action. By mechanical action and by solution the stream is enlarging the cave downward and sidewise. Rocks falling from above furnish material for rock fragments which aid in erosion, while they are dissolved by the water and broken upon each other. In other places the fallen rocks are cemented together by stalagmitic matter from dripping water, and in some cases chambers are being obliterated by the growth of stalactites which serve as pillars to prevent the rocks from falling, and then the room is at length filled by the slowly forming stalagmite. Soil thin. Forests of chestnut and oak, some pine, maple, sassafras, etc.

*King Solomons Cave.*—This cave was examined October 14. One enters the cave through a house built over its mouth. The descent of 15 to 20 feet into the cave is made by a winding stairway. After going some little distance a small creek about 10 feet wide and 18 inches deep is reached. Several hauls were made with a small seine, but no fish were found. It is doubtful if any are there. The only animal life noted were two salamanders, crickets, flies (probably two species), one spider, a beetle, and a worm. A species of mould was abundant. At the mouth of the cave we caught two specimens of *Rhinichthys atronasmus* which had been put there by the owner of the house.

*Ball Creek.*—This is a small stream rising just west of Tazewell and, flowing south, joins Big Sycamore Creek a mile above the latter's union with the Clinch. A small collection of fishes was made in this creek.

*Big Sycamore Creek.*—This creek, tributary to Clinch River, was examined by Dr. Gurley and some fishes obtained.

*Indian Creek.*—Dr. Gurley examined this tributary of Powell River near Cumberland Gap October 17. He also made small collections in Nigger Cave on the same date.

Following is a list of the streams and springs examined and the localities at or near which they were visited. Collections were obtained at most of the places mentioned.

For convenience of reference the names of the streams and springs are arranged in alphabetic order. For detailed descriptions of the various places see pages 434-441.

Arnwine, or Matlock, Spring and Creek, 5 miles north of Athens or 2 miles north of Mount Verd, October 4, 5.

Ball Creek, near Tazewell, October 15.

Bear Creek, near Walker's ford, 12 miles southwest of Tazewell, October 12.

Big Spring, 8 miles southwest of Greenville, October 11.

Big Sycamore Creek, near Tazewell, October 18.

Callahan Springs, 5 miles northwest of Knoxville, September 27.

Chickamauga Creek, at Lee and Gordon's mill, September 30.

Clinch River, at Walker's ford, 12 miles southwest of Tazewell, October 12.

Craigmile's spring, 1 mile north of Cleveland, October 3.

Crawfish Springs, near Chickamauga, September 30.

Davis Spring, 1½ miles from Greenville, October 11.

Eastanaula Creek, at Athens, October 7.

Flint Creek, near Walker's ford, 12 miles southwest of Tazewell, October 12.

Fountain Head Springs, at Old Camp Ground, Fountain City, 5 miles north of Knoxville, September 27.

Green's pond, or Newman Spring, 6 miles southeast of Chattanooga near Rossville Gap, September 29.

Greenville Spring, in the town of Greenville near the Grand Central Hotel, October 10.

Indian Creek, near Cumberland Gap, October 17.

Julians Spring, 8 miles southeast of Cleveland, October 4.

King Solomons Cave, at Cumberland Gap, October 14.

Lyon Creek, 5 miles west of Knoxville, near the insane asylum, September 28.

Matlock, or Arnwine, Spring and Creek, 5 miles north of Athens or 2 miles north of Mount Verd, October 4, 5.

Newman Spring, or Green's pond, 6 miles southeast of Chattanooga, September 29.

Nickajack Cave and Stream, at Shellmound, 22 miles west of Chattanooga, October 2.

Nigger Cave, at New Tazewell, October 12.

Nolichucky River, at Love's ferry south of Greenville, October 11.

Norvel Spring and branch, 7 miles east of Athens, or 2 miles north of Tellico Junction, October 7.

Ousley Spring, 8 miles from Tazewell, October 12.

Payne's spring, 2 miles north of Cleveland, October 3.

Pistol Creek and Springs, at Maryville, October 10.

Read's spring, 7 miles north of Chattanooga, October 1.

Roaring Fork, 5 miles north of Greenville, October 11.

Springfield Springs, 2 miles northeast of Maryville, October 10.

Stith's springs, 1 mile south of Cleveland, October 4.

Tellico River, at Tellico Plains, October 8.

Tennessee River, near mouth of Lyon Creek, 5 miles west of Knoxville, September 28.

Wildwood Spring, at Wildwood, 9 miles from Chattanooga, October 2.

Wine House Cave, at Shellmound, about 22 miles west of Chattanooga, examined October 19, 1901, by Prof. W. P. Hay.

## ANNOTATED LIST OF SPECIES.

Following is an annotated list of the species of fishes obtained or observed during these investigations. Unless otherwise stated, the specimens from each stream or spring were obtained at the place mentioned in the alphabetically arranged list of streams, springs, and localities on page 441.

1. *Ictalurus punctatus* (Rafinesque). Channel cat.

Four specimens, 2.25 to 3.25 inches long, from Ball Creek; four, 3 to 3.5 inches long, from Clinch River; and one, 2.5 inches long, from Chickamauga Creek.

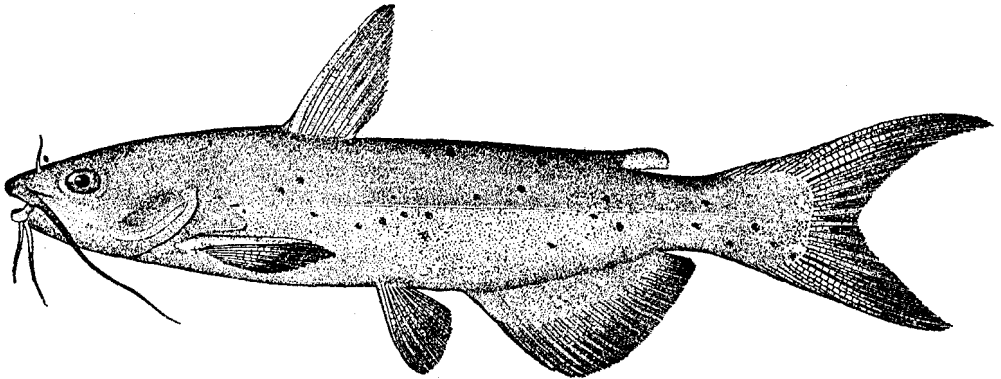


FIG. 1.—*Ictalurus punctatus*. Channel cat.

2. *Leptops olivaris* (Rafinesque). Mud cat; yellow cat.

Three young, 4 to 5.5 inches long, from Clinch River.

3. *Schilbeodes eleutherus* (Jordan). Mad tom.

Abundant in Clinch River; seven specimens saved, 1.5 to 2.25 inches long.

4. *Schilbeodes miurus* (Jordan). Mad tom.

Common in Clinch River, Tennessee River, and Chickamauga Creek. Nine specimens, 1.5 to 2.5 inches long, from Clinch River; one, 2.25 inches long, from Tennessee River; and three, 2 to 2.75 inches long, from Chickamauga Creek.

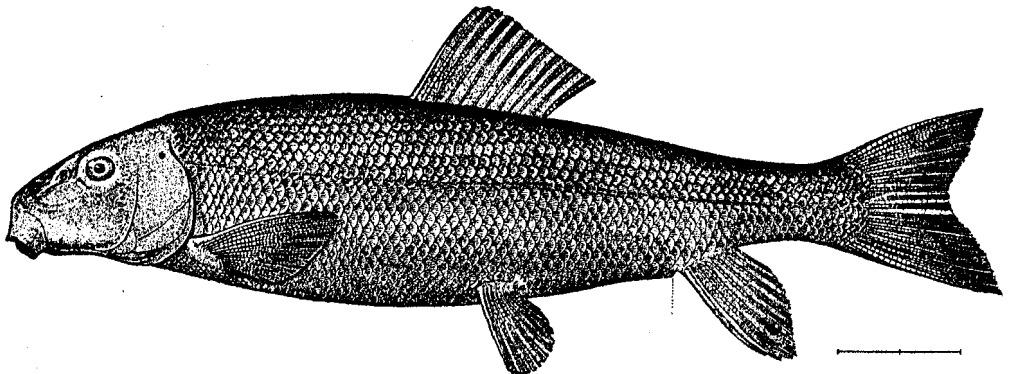


FIG. 2.—*Catostomus commersonii*. Common white sucker.

5. *Catostomus commersonii* (Lacépède). Common white sucker.

One specimen, 3 inches long, from Ball Creek; five, 4.5 to 6.5 inches long, from Arnwine Spring Creek; eight, 5 to 10 inches long, from Eastaunaula Creek; and several from Roaring Fork.

6. *Catostomus nigricans* Le Sueur. Hog sucker; stone roller.

Common in most streams examined. Three specimens, 3 to 3.75 inches long, from Ball Creek; two, 2 and 4 inches long, from Tennessee River; four, 4.5 to 9.5 inches long, from Eastaunaula Creek; one of 5 inches long, from Arnwine Spring; four, 3 to 3.5 inches long, from Tellico River; and one 3 inches long, from Chickamauga Creek. Specimens also from Indian Creek, Roaring Fork, and Clinch River.

7. *Moxostoma aureolum* (Le Sueur). Common redhorse.

Abundant nearly everywhere. Twenty-eight specimens, 2.5 to 3.75 inches long, from Indian Creek; twelve, 2.25 to 3 inches long, from Ball Creek; twelve, 2.75 to 3 inches long, from Clinch River; one 2.75 inches long, from Nolichucky River; five, 3.75 to 8.5 inches long, from Roaring Fork; six, 2.5 to 6.25 inches long, from Tennessee River; one 9 inches long, from Arnwine Spring Creek; and six, 4 to 9 inches long, from Chickamauga Creek.

The free edge of the dorsal fin is slightly concave in all our specimens.

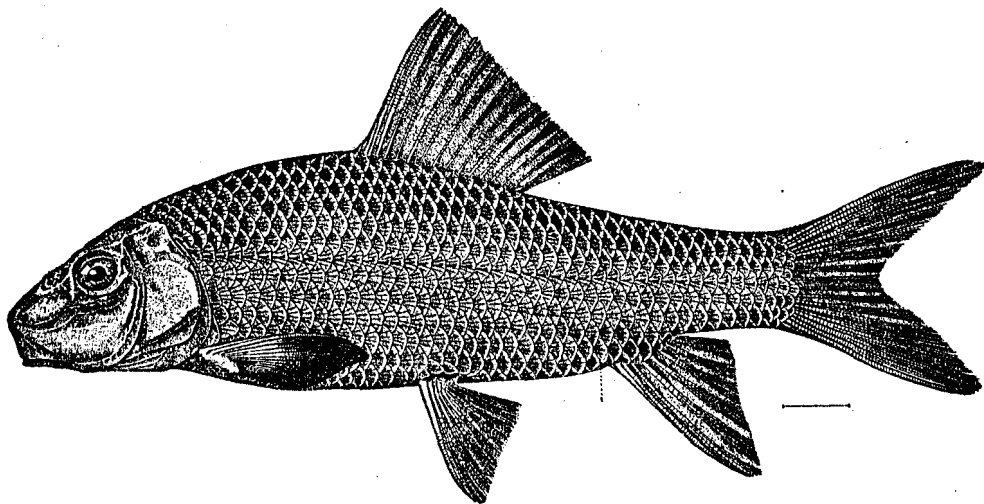


FIG. 3.—*Moxostoma aureolum*. Common redhorse.

8. *Placopharynx duquesnii* (Le Sueur). Big-toothed sucker.

A fine specimen of this species was examined by the senior writer on July 4, 1878, at Alexander's on the French Broad River, from which the fish was caught.

9. *Campostoma anomalum* (Rafinesque). Stone roller; rot-gut minnow.

Abundant in most places. Forty-seven specimens, 2 to 6 inches long, from Indian Creek; seventeen, 1.75 to 4.75 inches long, from Ball Creek; three, each 2.75 inches long, from Clinch River; thirty-six, 2.25 to 5.5 inches long, from Roaring Fork; fifty-four, 1.5 to 5.75 inches long, from Eastaunaula Creek; and one 4.75 inches long, from Chickamauga Creek. It was also found in the Tellico River.

10. *Chrosomus erythrogaster* (Rafinesque). Red-bellied dace.

Observed only in Roaring Fork.

11. *Pimephales notatus* Rafinesque. Blunt-nosed minnow.

Found by us only in Chickamauga Creek, from which we have two specimens each 2 inches long.

12. *Semotilus atromaculatus* (Mitchill). Horned dace; creek chub.

Two specimens, 3.5 and 5.5 inches long, from Ball Creek; four, 4.25 to 5.25 inches long, from Eastaunaula Creek; and one 2.25 inches long, from Norvel Spring.

13. *Cliola vigilax* (Baird & Girard).

One specimen, 2.5 inches long, from Ball Creek; fourteen, 1.5 to 2.25 inches long, from Clinch River; three, 2 to 2.25 inches long, from Tennessee River; and three, 1.75 to 2.5 inches long, from Chickamauga Creek.

14. *Notropis blennioides* (Girard). Straw-colored minnow.

Thirteen specimens, 1.5 to 1.75 inches long, from Indian Creek; twelve, 1.5 to 2 inches long, from Ball Creek; nine, 1.5 to 1.75 inches long, from Clinch River; and seven, 1.75 to 2.25 inches long, from Roaring Fork.

15. *Notropis shumardi* (Girard).

Two specimens, each 2.5 inches long, from Indian Creek.

16. *Notropis galacturus* (Cope).

Very common throughout the region examined. Eighty-eight examples, 1.75 to 4.25 inches long, from Indian Creek; thirty-six, 1.75 to 4.75 inches long, from Clinch River; twelve, 1.75 to 2.25 inches long, from Tennessee River; one 3 inches long, from Roaring Fork; forty-seven, 2 to 4 inches long, from Eastaunaula Creek; twenty-five, 2.5 to 4 inches long, from Tellico River; and twelve, 2 to 3 inches long, from Chickamauga Creek. Specimens also from Ball Creek.

The young among these specimens have the mouth almost terminal and the gape oblique. When the fish reaches a length of about 2.5 inches the mouth becomes subinferior, the gape nearly horizontal, and the upper jaw projecting.

17. *Notropis cornutus* (Mitchill). Shiner.

Very common throughout the entire region. Ten specimens, 3.25 to 5 inches long, from Indian Creek; eight, 2.75 to 6 inches long, from Ball Creek; two, each 2 inches long, from Walker's ford; thirty, 1.75 to 4.5 inches long, from Roaring Fork; three, 3.25 to 6 inches long, from Eastaunaula Creek; two, each 5 inches long, from Arnwine Spring Creek; and one 3 inches long, from Tellico River. Specimens were obtained also from Nolichucky River and Chickamauga Creek.

18. *Notropis coccogenis* (Cope).

A fairly abundant species. Four specimens, 3.25 to 4 inches long, from Indian Creek; one 1.5 inches long, from Ball Creek; twenty-nine, 2.75 to 4.25 inches long, from Arnwine Spring; twenty-nine, 2 to 3.75 inches long, from Tellico River; and ten, 2.5 to 3 inches long, from Chickamauga Creek.

19. *Notropis zonatus* (Agassiz).

Five specimens, 2 to 2.75 inches long, from Nolichucky River.

Head 4.2; depth 4.5; D. 8; A. 10; scales 6-40-4, 15 before the dorsal; pectoral not reaching ventrals; dorsal inserted slightly behind ventrals. No distinct lateral band; no caudal spot; fins plain.

This species has previously been recorded only from the mountain streams in the Ozark region of Missouri and Arkansas.

20. *Notropis rubricroceus* (Cope). Red fallfish.

Four specimens, 2 to 2.25 inches long, from Cleveland, Tenn., probably from South Mouse Creek, where they were collected May 18, 1894, by Mr. J. D. Patton, who kindly sent them to us. The species was not obtained by us in 1893.

21. *Notropis leuciodus* (Cope).

This species was found only in Indian Creek and Tellico River, in each of which it is fairly abundant. We have nineteen specimens, 1.5 to 2.5 inches long, from Indian Creek, and nine specimens of same size from Tellico River.

22. *Notropis telescopus* (Cope).

Abundant in Indian Creek and Tellico River, but not seen elsewhere. We have sixty-five specimens, 1.5 to 2.75 inches long, from Indian Creek and seventy-five, 2 to 3.25 inches long, from Tellico River.

23. *Notropis stilbius* Jordan.

One specimen, 1.75 inches long, from Ball Creek; forty-one, 1.75 to 2 inches long, from Clinch River; one 2 inches long, from Tellico River; four, each 2 inches long, from Nolichucky River; and four, 2 to 2.75 inches long, from Chickamauga Creek.

This minnow has been previously recorded only from the Alabama basin, where it is said to be abundant. It is apparently very close to *N. telescopus*, but the larger eye and more backward insertion of the dorsal of the present species separate the two. Eye 3 in head, longer than snout; distance from origin of dorsal to base of caudal equal to distance from middle of eye to origin of dorsal.

24. *Notropis micropteryx* (Cope).

We have forty-four specimens, 1.75 to 2.25 inches long, from Clinch River, and three, 2.5 to 2.75 inches long, from Tennessee River.

25. *Phenacobius uranops* Cope.

Three examples, 3 to 4 inches long, from Indian Creek; two, 3 and 3.25 inches long, from Ball Creek; one 3.25 inches long, from Clinch River; and six, 2.5 to 3.25 inches long, from Chickamauga Creek.

Scales in lateral series, 53 to 64; before dorsal, 22 or 23.

26. *Rhinichthys atronasmus* (Mitchill). Black-nosed dace.

A species widely distributed throughout this region. We have twenty-two specimens, 1.5 to 3 inches long, from Indian Creek; two from King Solomons Cave; thirty-one, 1.25 to 3 inches long, from Ball Creek; eight, 2 to 3.5 inches long, from Nigger Cave; one 1.75 inches long, from Roaring Fork; thirteen, 2.5 to 3.25 inches long, from Eastaunaula Creek; and five, 1.5 to 2.5 inches long, from Norvel Spring.

This species as represented in this collection is very variable. Depth in length of body, from 5 to 6; length of snout very variable; examples from Ball Creek have snout almost as long as examples of the related species, *R. cataractæ*; eye 1.25 to 2 in length of snout; scales 60 to 70; size of barbel quite variable. Our alcoholic specimens show no distinct variation in color.

Smaller scales and a more distinct barbel are characters given to distinguish the variety *croceus* from the typical species, but specimens from Nigger Cave, 2 to 3.5 inches long, have 70 scales in a lateral series, with the barbel scarcely visible; other examples, from Indian Creek, 1.75 to 2.25 inches long, have 60 scales in a lateral series, and a very evident barbel.

27. *Hybopsis hyostoma* (Gilbert).

Only two specimens obtained, one 2.25 inches long, from Clinch River and one 1.5 inches long, from Tennessee River.

28. *Hybopsis monaca* (Cope).

Two specimens, each 2.75 inches long, from Indian Creek; six, each 2.75 inches long, from Clinch River; also obtained from Ball Creek.

29. *Hybopsis dissimilis* (Kirtland). Spotted shiner.

This species, though widely distributed, was not abundant anywhere. We have eight specimens, 2.25 to 3.5 inches long, from Indian Creek; two, 2 and 3 inches long, from Tennessee River; and one, 3 inches long, from Tellico River. We also have specimens from Ball Creek and Chickamauga Creek.

30. *Hybopsis amblops* (Rafinesque). Silver chub.

This species was not found to be abundant, but it is distributed throughout the entire region examined. We have 32 specimens, 1.5 to 2.75 inches long, from Indian Creek; two, 1.5 and 1.75 inches long, from Ball Creek; seven, 2 to 3.5 inches long, from Clinch River; three, each 1.75 inches long, from Tennessee River; one 2 inches long, from Roaring Fork; one 2.75 inches long, from Eastaunaula Creek; and five, 2.5 to 3 inches long, from Chickamauga Creek. We also found it in Tellico River.

31. *Hybopsis kentuckiensis* (Rafinesque). Hornyhead; river chub.

One of the most abundant and widely distributed fishes of the region. We have 59 specimens, 1.75 to 5 inches long, from Indian Creek; ten, 1.5 to 6.5 inches long, from Ball Creek; seven, 2.5 to 3 inches long, from Clinch River; two, 2.5 and 5.5 inches long, from Tennessee River; two, 4.25 and 4.75 inches long, from Eastaunaula Creek; five, 2 to 4.5 inches long, from Tellico River; one 5.25 inches long, from Arnwine Spring Creek; and twenty-nine, 2 to 5.5 inches long, from Chickamauga Creek.

32. *Fundulus catenatus* (Storer).

Our collections contain 141 specimens, 1.5 to 3.75 inches long, from Indian Creek; five, 2.5 to 3.25 inches long, from Ball Creek; ten, 1.75 to 2.75 inches long, from Clinch River; and one 1.75 inches long, from Tellico River.

33. *Fundulus notatus* (Rafinesque). Top minnow.

Five specimens, 1.25 to 2.25 inches long, from Norvel Spring, the only place where it was seen.

34. *Typhlichthys subterraneus* Girard. Small blindfish.

On October 19, 1901, Prof. W. P. Hay, while studying the crawfish fauna of Tennessee, visited Nickajack Cave and other caves in the vicinity of Shellmound. In Wine House Cave, which is probably

a part of Nickajack Cave, he saw a small blindfish which was almost certainly this species. He was unable to capture it.

Wine House Cave is reached by going through the cellar of a house, then down a passage about 80 feet.

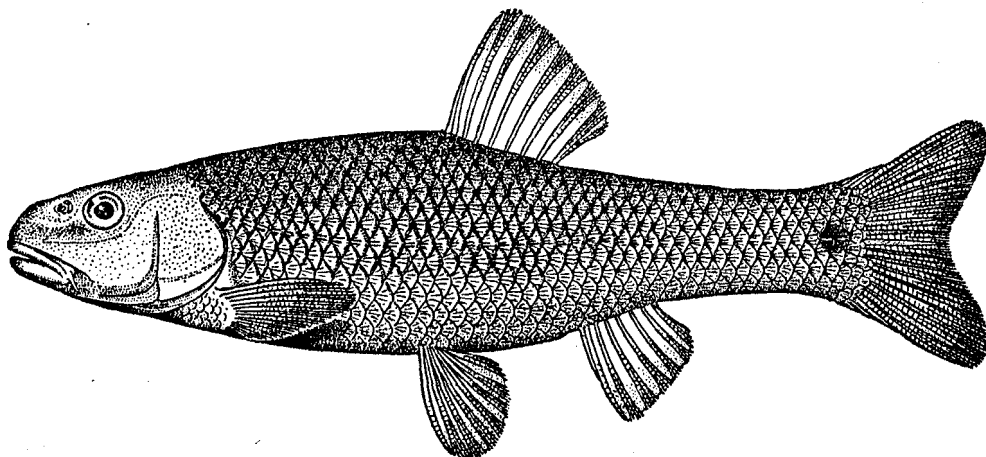


FIG. 4.—*Hybopsis kentuckiensis*. Hornyhead.

35. *Ambloplites rupestris* (Rafinesque). Rock bass; red-eye; goggle-eye.

Only a few small specimens of this fish were obtained. We have six examples, 1 to 4 inches long, from Clinch River; one 3 inches long, from Roaring Fork; and eight, 1 to 4 inches long, from Eastaunaula Creek. It is also known to occur in the Tellico River.

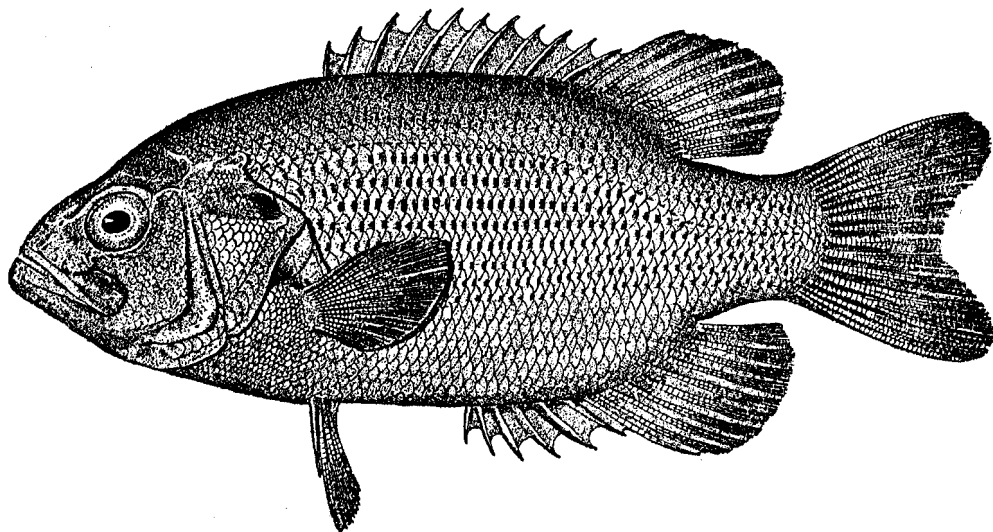


FIG. 5.—*Ambloplites rupestris*. Rock bass.

36. *Lepomis megalotis* (Rafinesque). Long-eared sunfish.

Common throughout the region but only small examples obtained. Six specimens, 1.75 to 2 inches long, from Ball Creek; five, 1.75 to 2.75 inches long, from Clinch River; one 1.75 inches long, from Tellico River; two, each 3 inches long, from Arnwine Spring; and one 1.5 inches long, from Chickamauga Creek.

37. *Lepomis pallidus* (Mitchill). Bluegill.

Found by us only in Arnwine Spring, whence we have three specimens 4.75 to 6.5 inches long.



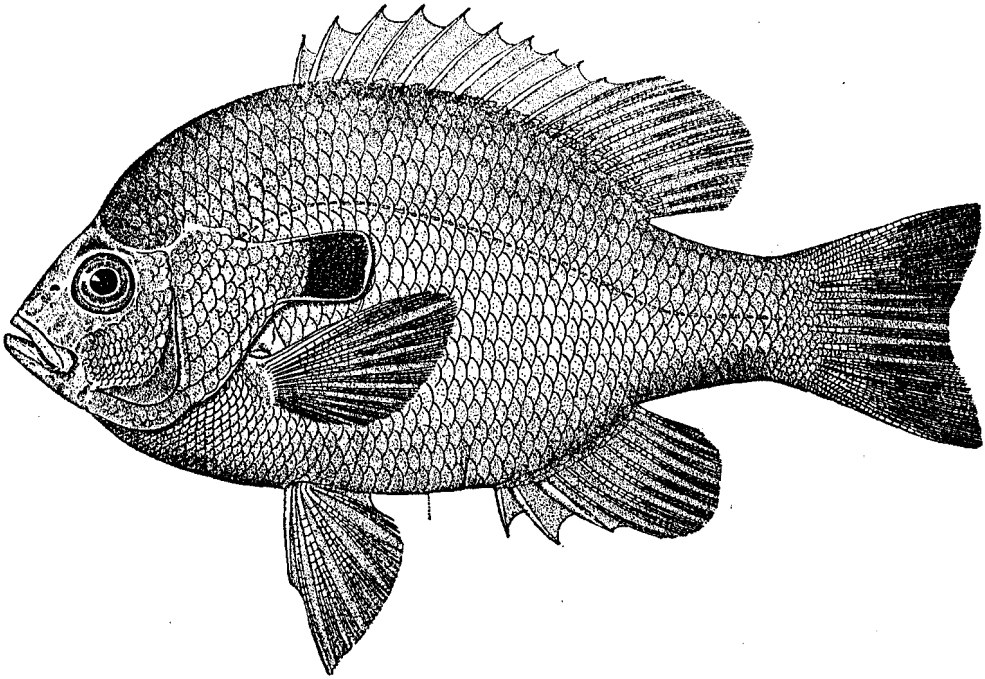


FIG. 6.—*Lepomis megalotis*. Long-eared sunfish.

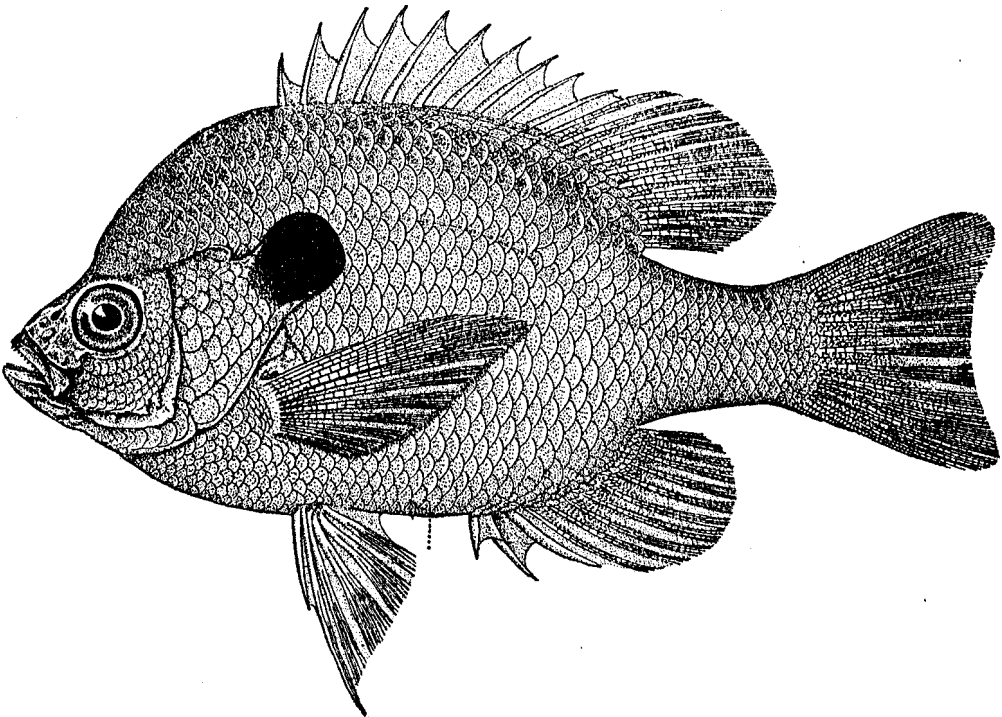


FIG. 7.—*Lepomis pallidus*. Bluegill.

38. *Micropterus dolomieu* (Lacépède). Smallmouth black bass.

Only small specimens obtained. Seventeen, 2.25 to 3.75 inches long, from Indian Creek; three, 2.25 to 2.5 inches long, from Ball Creek; three, 3.5 to 4.5 inches long, from Clinch River; and two, each 3 inches long, from Tellico River. It was also obtained in Chickamauga Creek.

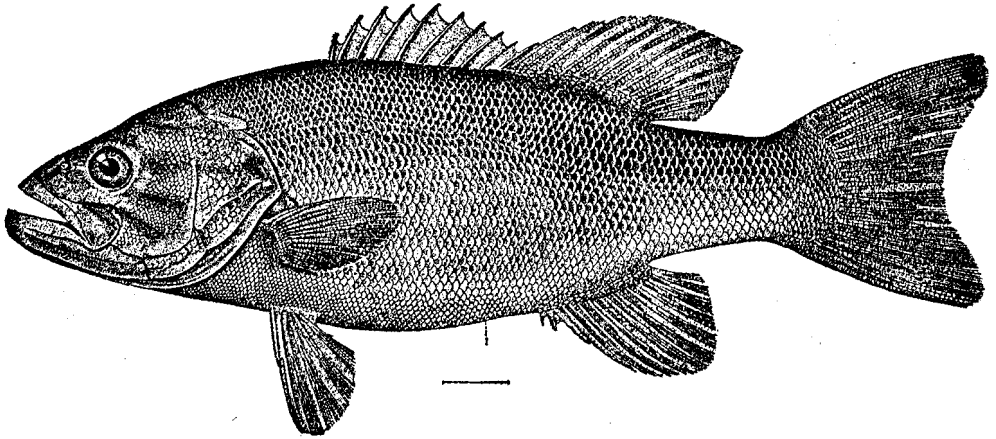


FIG. 8.—*Micropterus dolomieu*. Smallmouth black bass.

39. *Micropterus salmoides* (Lacépède). Largemouth black bass; "green trout."  
Found by us only in Clinch River and Chickamauga Creek.

40. *Stizostedion vitreum* (Mitchill). Wall-eyed pike.

Reported as common in the Tellico River, but no specimens were obtained.

In a letter dated March 2, 1904, Dr. E. G. Anderson, of Newport, Tenn., reports the capture, in the French Broad River near that place, of three fine examples of wall-eyed pike. They measured 28, 29, and 31½ inches in length, and weighed 8½, 9, and 12 pounds, respectively. They were caught by Mr. J. C. King, of Rankin, Tenn.

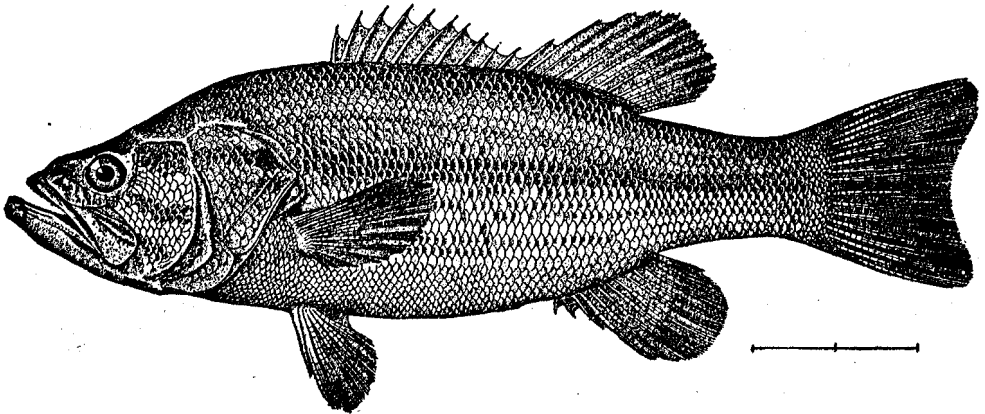


FIG. 9.—*Micropterus salmoides*. Largemouth black bass.

41. *Stizostedion canadense* (Smith). Sauger; sand pike.

One specimen, 14 inches long, from Big Sycamore Creek.

42. *Percina caprodes* (Rafinesque). Log perch.

Not common. Found by us only in Indian and Ball Creeks and Tennessee River.

43. *Hadropterus macrocephalus* (Cope).

Found by us only in Indian Creek, whence we have one specimen 2.75 inches long. Scales in lateral line 80 to 83, 80 pores.

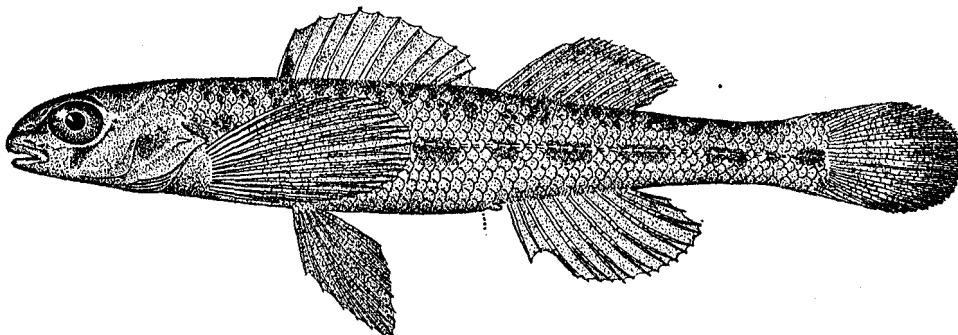
44. *Hadropterus aspro* (Cope & Jordan). Black-sided darter.

Found by us only in Ball Creek, from which we have three specimens, each 2.15 inches long.

Head 4 in body; D. XII or XIII, 13; A. II, 9 or 10; scales 5 to 7-57 to 60-9 to 11. Fewer scales in transverse series than given in current descriptions.

45. *Hadropterus evides* (Jordan & Copeland).

Widely distributed but not many specimens obtained. Five examples, 1.25 to 2.5 inches, from Clinch River. It was also found in the Tellico River.

FIG. 10.—*Cottogaster copelandi*.46. *Hadropterus scierus* Swain.

Seven specimens, 2.25 to 3 inches long, from Clinch River.

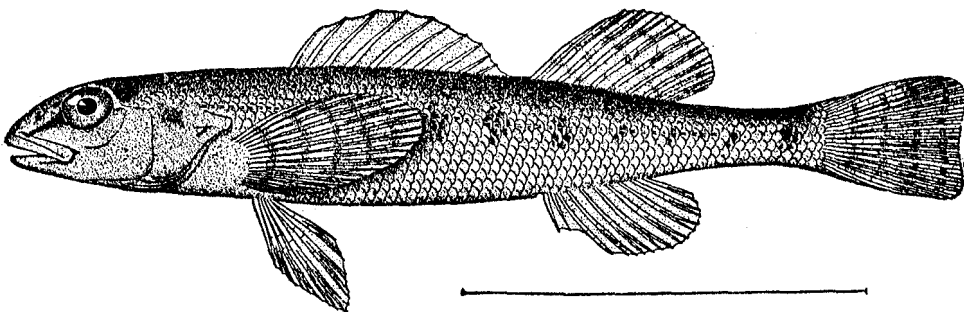
47. *Hypohomus aurantiacus* (Cope).

This beautiful darter was found only in Clinch River at Walker's ford, where two fine specimens, 2.5 and 3 inches long, respectively, were secured. They showed the following life colors: Belly and lower two-thirds of side white, with slight greenish shade; middle of side with a series of almost continuous large rectangular black blotches, extending forward across the opercle and preopercle, under eye, and around snout, but scarcely on upper jaw; anterior end of this series mostly below lateral line, posterior half with lateral line running through its middle; side above this band very light straw yellow with a series of about 21 to 23 small dark spots running from occiput to under soft dorsal; a dark median line and some dark clouding on back; fins all plain, except tip of spinous dorsal, which is light orange.

48. *Cottogaster copelandi* (Jordan).

Seven specimens, each 1.25 inches long, from the Tennessee River.

Only the anterior portion of the belly naked; ordinary scales for a short distance in front of anal.

FIG. 11.—*Ulocentra stigmæa*.49. *Ulocentra stigmæa* (Jordan).

Eleven specimens, 1.5 to 2.75 inches long, from Ball Creek, and two, each 2.5 inches long, from Arnwine Spring Creek.

We have compared these with specimens from Wolf and Obeyes Rivers collected by Dr. Kirsch. Two forms are represented.

Examples from Wolf and Obeyes Rivers in general agree with the cotypes, which were secured from the United States National Museum for comparison, but they differ in having the cheeks naked,

fewer scales (five) in a transverse series below the lateral line, and the lateral line extending as far back as the last ray of the soft dorsal, wanting on 13 to 15 scales. Other examples from Ball Creek and Arnwine Spring Creek have a more slender body; ventral outline nearly straight; longer snout, which is less convex in profile than in the typical form; mouth horizontal, lower jaw included, premaxillary with a narrow frenum. Scales 6-50 to 54-7. Lateral line incomplete, pores wanting on 7 to 10 scales. Breast naked, opercles with large scales, cheeks with a small patch of scales back of the lower posterior border of the orbit. These specimens are closely related to the form *saxatilis*, described as a distinct species by O. P. Hay,<sup>a</sup> but which was later found to be identical with *stigmaea* by Dr. Gilbert.<sup>b</sup>

50. *Ulocentra gilberti* Evermann & Thoburn.

Three specimens, 1.5 to 2 inches long, from Clinch River.

This species was described by Evermann and Thoburn.<sup>c</sup> The above specimens represent the type and cotypes. United States National Museum type no. 47511.

51. *Ulocentra meadiae* Jordan & Evermann.

Three specimens, each 2 inches long, from Indian Creek.

This species was described by Jordan and Evermann.<sup>d</sup> The above specimens represent the type and cotypes. United States National Museum type no. 48903.

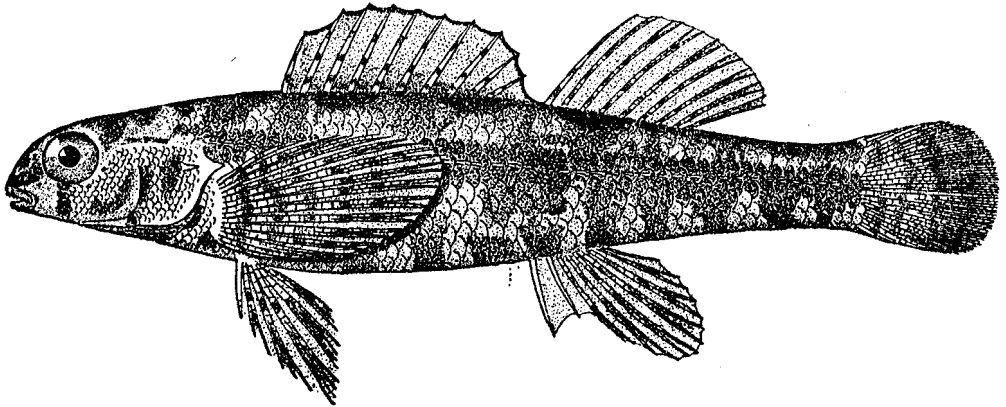


FIG. 12.—*Etheostoma zonale*.

52. *Ulocentra simotera* (Cope).

One hundred seventy-eight specimens, 1.25 to 2.25 inches long, from Indian Creek; twenty-eight, 1.75 to 2 inches long, from Ball Creek; fifty-six, 1.25 to 2.25 inches long, from Roaring Fork; six, 1.5 to 2.5 inches long, from Eastaunaula Creek; three, 1.5 to 2 inches long, from Tellico River; and fifty-two, 1.5 to 2.25 inches long, from Arnwine Spring Creek.

A variable species. Opercles scaly; cheeks often closely scaled; sometimes almost naked; premaxillary occasionally joined to the forehead by a narrow frenum. Color variable; some examples with faint blotches on back and sides; other examples with quite evident blotches on back and sides; these sometimes connecting at sides, forming bars posteriorly; a few specimens with a dark lateral band.

53. *Diplesion blennioides* (Rafinesque). Green-sided darter.

This species was found to be fairly abundant throughout this region. Forty-seven specimens, 1.75 to 3.25 inches long, from Indian Creek; one, 3.75 inches long, from Ball Creek; eight, 2.5 to 3.75 inches long, from Clinch River; one, 4 inches long, from Tennessee River; six, 2.5 to 3.5 inches long, from Chickamauga Creek.

54. *Etheostoma variatum* Kirtland.

One specimen from Indian Creek.

55. *Etheostoma zonale* (Cope).

Eighty specimens, 1.5 to 2 inches long, from Indian Creek; one, 1.5 inches long, from Ball Creek; one, 2.25 inches long, from Eastaunaula Creek; and nine, 1.75 to 2 inches long, from Chickamauga Creek. This species was obtained also from the Tellico River.

<sup>a</sup> Proceedings U. S. National Museum, vol. 3, 1880, p. 495.

<sup>b</sup> Bulletin U. S. Fish Commission, vol. IX, 1889, p. 150.

<sup>c</sup> Bulletin U. S. National Museum, no. 47, p. 1049.

<sup>d</sup> Bulletin U. S. National Museum, no. 47, p. 2852.

56. *Etheostoma camurum* (Cope). Blue-breasted darter.

Thirty-five specimens, 1.25 to 2.25 inches long, from Clinch River. Specimens were also obtained from Indian Creek, Ball Creek, Tennessee River, and Tellico River.

57. *Etheostoma maculatum* Kirtland.

Found in Indian and Ball Creeks and Clinch, Tennessee, and Tellico Rivers.

58. *Etheostoma rufilineatum* (Cope).

Twenty-nine specimens, 1.25 to 2.5 inches long, from Indian Creek; two, 1.5 to 2.5 inches long, from Ball Creek; nine, 1 to 2 inches long, from Clinch River; two, 1.75 and 2 inches long, from Tennessee River.

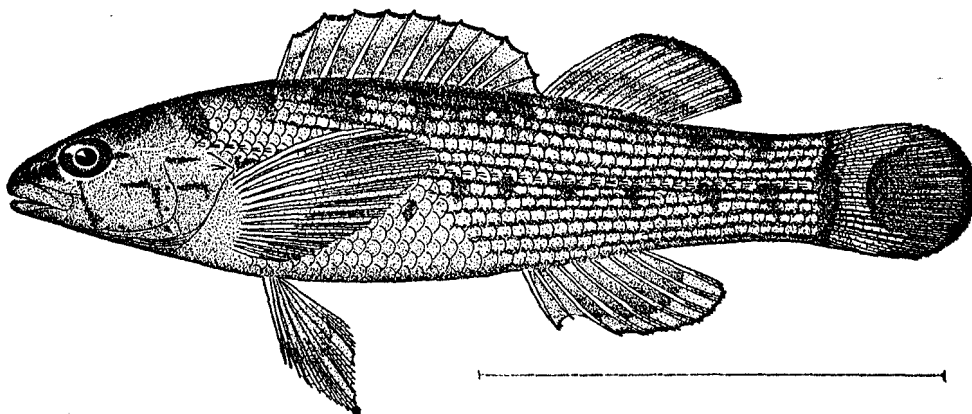


FIG. 13.—*Etheostoma rufilineatum*.

59. *Etheostoma flabellare* Rafinesque. Fan-tailed darter.

This species was found in but two places. One specimen, 1 inch long, from Indian Creek; four, 1.25 to 1.5 inches long, from Ball Creek.

60. *Cottus ictalops* (Rafinesque). Miller's thumb.

This species common throughout this region. Sixty specimens, 1.25 to 2.25 inches long, from Indian Creek; twenty-seven, 1.25 to 3.75 inches long, from Ball Creek; three, each 1.5 inches long, from Tennessee River; one, 3.5 inches long, from Nolichucky River; forty-eight, 1.5 to 4 inches long, from Arnwine Spring; twenty-five, 1.5 to 4 inches long, from Eastaunaula Creek; three, 1.5 to 3.75 inches long, from Norvel Spring; twenty-three, 1.25 to 3.25 inches long, from Chickamauga Creek; and two from Nickajack Cave.