

FISHES OF THE HIWASSEE RIVER SYSTEM—ECOLOGICAL AND TAXONOMIC CONSIDERATIONS

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ABSTRACT

Seventy-two collections of fishes were made in the Hiwassee River and its tributaries between August, 1970, and July, 1971. Greatest emphasis was placed on studies of the ecological relationships, distribution, and taxonomy of smaller species. Seventy-two species of fishes are known to occur in the Hiwassee system, with species of special significance including *Ichthyomyzon hubbsi*, *Notropis spectrunculus*, an undescribed dace of the genus *Phoxinus*, *Hypentelium etowanum*, *Micropterus coosae*, *Percina flavescens*, *Etheostoma camurum*, *Percina aurantiaca*, *P. burtoni*, and *P. squamata*. Mining wastes were found to have greatly reduced the diversity of fishes in the Ocoee River and some of its tributaries.

INTRODUCTION

The Hiwassee River system is a complex of five rivers which together drain portions of southeastern Tennessee, northcentral Georgia, and southwestern North Carolina. These five rivers—the Hiwassee, Ocoee, Toccoa, Nottely, and Valley rivers—lie within a watershed area of 2,800 square miles, as indicated in Figure 1.

The Ocoee River is the largest single contributor of water to the Hiwassee system. It joins the Toccoa River in extreme southeastern Tennessee. These two rivers form a stream very nearly as long as the main Hiwassee with its northern tributary, the Nottely.

The largest tributaries of the Toccoa and Nottely rivers in Georgia are very similar, having clear, cold water and rocky substrates. Steep gradients and fast waters are common in the headwaters of Rock, Copper, and Fightingtown creeks, but the Ocoee-Toccoa tributaries have only moderately fast currents.

Below the Tennessee-Georgia line the Ocoee River undergoes a marked change. A load of silt is carried from Ducktown to the Ocoee by North Potato and Brush Creeks. Rough Creek and Big Creek, flowing

from the southwest off Big Frog Mountain, bring fast, clear, cold water to a silty, scouring Ocoee which falls 600 feet in less than 10 miles until it reaches Parksville Reservoir. The reddish-brown silt has settled from the water which leaves the lake, but the dissolved mineral wastes persist and seem to form a chemical barrier that inhibits dispersal of aquatic life between the Ocoee-Toccoa system and the main Hiwassee downstream.

The Nottely River is similar to the Ocoee-Toccoa headwaters in Georgia. The Nottely, like the Ocoee-Toccoa system, has a rocky bottom ranging from gravel to boulders and is also an excellent trout stream. The Nottely keeps its fine qualities until it is interrupted just south of the Georgia-North Carolina line by Nottely Dam. The river below the dam was found by Messer (1965) to be a habitat suitable mainly for rough fish until it mixes with the waters of the main Hiwassee and Valley rivers in Hiwassee Reservoir.

Seventy-two collections were made from August, 1970, until July, 1971. Emphasis was placed on collecting the smaller fishes of the Hiwassee system in Tennessee. The Tennessee Valley Authority (1971) has considerable data concerning the larger lowland fishes of this area. The fishes of northern Georgia have been recently surveyed (Satterfield, 1961), as have the fishes of the North Carolina portion of the drainage (Messer, 1965).

Toward the end of the survey, some collecting was done in the main channels of the Ocoee and Hiwassee Rivers. This was done with the hope of finding some of the normal small lowland fishes of the Tennessee River tributaries, such as *Percina sciera* (Swain) and *Pimephales vigilax* (Baird and Girard).

Some streams were sampled more than one time either at a single site or at several sites along their courses. Baker and Indian creeks on the south side of Parksville Reservoir received two collections each in the hope that useful data could be gathered concerning an undescribed species of the genus *Phoxinus*. Similarly, many collections were made in Big Lost Creek to obtain

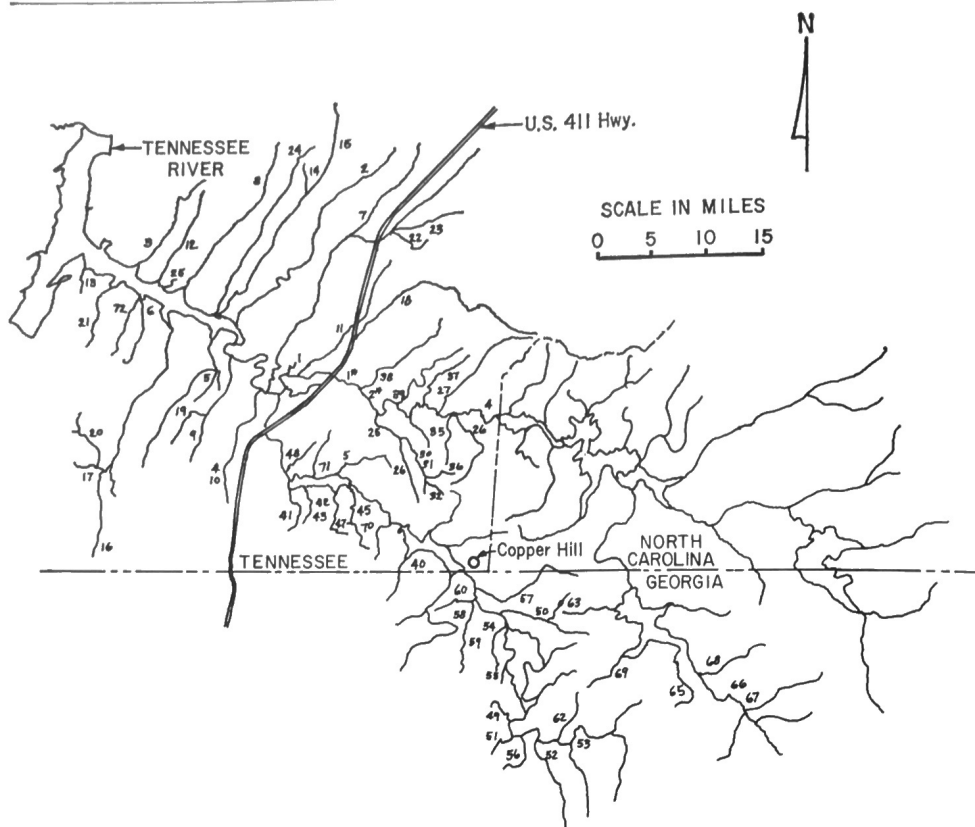


FIG. 1: Map of the Hiwassee River Drainage

(* Indicates a Tennessee Fish and Game Commission Collection)

information about the variations of the minnow *Notropis spectrunculus* (Cope).

S seines, an electric shocker, and sodium cyanide were employed as collecting devices. Six- and ten-foot small mesh seines were the most commonly used collecting tools. The highly maneuverable six-foot seine was found to be quite effective for encircling brush overhanging the bank, in order to catch centrarchids. A 30-foot bag seine was utilized only during a night collection on the lower Hiwassee. The pulsating direct current electrical shocker was designed and built by the senior author. It was used primarily in sampling the tributaries of the main Hiwassee River between the Tennessee-Georgia line and the bridge on U.S. Highway 411. In this area streams were of moderate current so that the researchers could wade while carrying the shocker. Also, the streams were clear enough so that the stunned fish could be seen on the bottom and collected with dip nets.

Where traditional methods were found to be ineffective, sodium cyanide, acting as a terminal oxidase inhibitor, was used to stun the fishes. All collections were preserved in ten percent formaldehyde and housed in the University of Tennessee at Knoxville Fish Collection.

Calculations of meristics and morphometrics used in this research were made in accordance with the standard procedures described by Hubbs and Lagler (1958). Scientific and common names used follow Bailey, *et al.* (1970). All identifications were made by the authors.

The following abbreviations were used in this paper: U.T. denotes the University of Tennessee at Knoxville Hiwassee River Collection, and T.G.F. denotes the Tennessee Game and Fish Hiwassee River Collection. The locations of these collections are shown in Figure 1 and the numbers denoting these collections are given in the text.

SPECIES COLLECTED

Mountain brook lamprey—*Ichthyomyzon hubbsi* Raney. This small non-parasitic lamprey was found in the cool, fast waters of two Toccoa River tributaries in Fannin County, Georgia. Collections of this fish in the Little Tennessee River in North Carolina (Raney, 1952), suggest that moderate to large-size streams are its normal habitat. Our specimens included two larvae from U.T. 57 and two adults from U.T. 62. The lengths of the larval specimens were 10.9 centimeters and 10.5 centimeters, and the lengths of the adults were 13.1 centimeters and 12.2 centimeters. The adults were collected on May 15, 1971.

An additional non-parasitic lamprey, *Lampetra lamottei* (Lesueur), and two species of parasitic lampreys—*Ichthyomyzon bdellium* (Jordan) and *Ichthyomyzon castaneus* (Girard)—were collected in the Tennessee portion of the main Hiwassee River. The authors feel that these fishes occur in the Hiwassee headwaters only rarely.

Gizzard shad—*Dorosoma cepedianum* (Lesueur). The gizzard shad was found in the Hiwassee River in Tennessee and the Nottely River in Georgia. This species exists in many of the large channels of the Hiwassee system.

Records for *Alsoa chrysochloris* (Rafinesque) and *Dorosoma petenense* (Gunther) come from the main channel of the Hiwassee in Tennessee. Their presence in the North Carolina and Georgia portions of the system is also probable.

Brook trout—*Salvelinus fontinalis* (Mitchill). The "brookie" is a native of the upper Tennessee drainages and is present only in the highest quality trout streams. Dahlberg and Scott (1971) recorded this species from the Hiwassee and Toccoa systems in Georgia, and Messer (1965) listed collections from three locations in North Carolina.

Rainbow and brown trout—*Salmo gairdneri* Richardson and *Salmo trutta* Linnaeus—were observed to be present in the headwaters of all the major drainage areas collected. Both species have been introduced and very few specimens were taken. Rough and Big Creeks of the Ocoee system, and Wolf Creek of the Hiwassee system appear to have naturally reproducing populations of rainbow trout.

Stoneroller—*Compostoma anomalum* (Rafinesque). The stoneroller was the most widely distributed cyprinid in the Hiwassee system. Although found to be most abundant in the higher elevations, it was also collected in the lowland streams tributary to the main river in Tennessee.

Bluntnose minnow—*Pimephales notatus* (Rafinesque). This minnow was collected in the slow waters of the lowland tributaries to the Hiwassee, and in the main channel of the lower Hiwassee River.

Bullhead minnow—*Pimephales vigilax* (Baird and Girard). This small cyprinid was found only in the warm, slow waters of the lower Hiwassee.

Blacknose dace—*Rhinichthys atratulus* (Hermann). The blacknose dace was found at higher elevations than the blacknose dace. Separation of the two species in the river is distinct. *Rhinichthys atratulus* was found only in the Hiwassee and Ocoee systems, and *R. cataractae* in the Nottely, Toccoa, and Valley Rivers.

Longnose dace—*Rhinichthys cataractae* (Valenciennes). The longnose dace was found at higher elevations than the blacknose dace. Separation of the two species in the river is distinct. *Rhinichthys atratulus* was found only in the Hiwassee and Ocoee systems, and *R. cataractae* in the Nottely, Toccoa, and Valley Rivers.

Emerald shiner—*Notropis atherinoides* Rafinesque. The emerald shiner was represented by a single large specimen collected from the main Hiwassee near Lake Chickamauga.

Warpaint shiner—*Notropis coccogenis* (Cope). Individuals or small groups of the warpaint shiner were commonly collected in the large, swift tributaries of the Toccoa and Ocoee Rivers by the authors, and in the Valley River system by Messer (1965). All collections of *N. coccogenis* were made in streams with sand, gravel, or rock bottoms. Ramsey (1965) reported this species in the Nottely River.

Striped shiner—*Notropis cornutus chrysocephalus* (Rafinesque). The authors collected the striped shiner in fairly large, slow-moving streams of the lowlands. Gilbert (1964), however, reported that the fish has been collected from the Tennessee-Georgia border area.

Whitetail shiner—*Notropis galacturus* (Cope). This species is widely distributed, but rarely abundant, in the Hiwassee system. Though found primarily in clear streams of moderate size and current, specimens were also collected in the main river. Gibbs (1961) collected the whitetail shiner in the Nottely and Toccoa systems and Messer (1965) in the Valley River.

Mountain shiner—*Notropis lirus* (Jordan). This cyprinid was common in the southern tributaries of the lowland Hiwassee. The mountain shiner was usually collected in streams of moderate size and current. Many of these streams flowed through agricultural land.

Mirror shiner—*Notropis spectrunculus* (Cope). The mirror shiner was generally found in the fast-moving, clean waters of the higher elevations. This cyprinid is not normally found below an altitude of 1,500 feet above sea level (Ramsey, 1965). The collection of this species from the main Hiwassee (T.G.F. 2), however, was taken at an altitude of about 800 feet above sea level.

Spotfin shiner—*Notropis spilopterus* (Cope). The spotfin shiner was found in the relatively warm portions of the lower Hiwassee and its lowland tributaries. All collections of this species came from slow, turbid water.

Telescope shiner—*Notropis telescopus* (Cope). Although T.G.F. 2 from the main Hiwassee River yielded two specimens of the telescope shiner, small creeks or streams were the preferred habitat. This fish was not found to be abundant in the lowlands or headwaters of the Hiwassee River. The scarcity of this species is notable when its well-documented abundance in the waters of the very similar river, the French Broad, is known (Gilbert, 1969).

Steelcolor shiner—*Notropis whipplei* (Girard). The authors know of no collection of *N. whipplei* from the Hiwassee system which does not also contain specimens of the closely-related spotfin shiner. *N. whipplei* appears to be less common than the spotfin. No records from the Hiwassee system outside Tennessee are known to the authors.

Carp—*Cyprinus carpio* Linnaeus. Carp were observed to be abundant in the warmer waters of the lower Hiwassee during the senior author's skindiving trips. The low numbers recorded in collections are probably due to the unwillingness of collectors to preserve the carp and to the difficulty encountered in catching this species.

Bigeye chub—*Hypobopsis amblops* (Rafinesque). The authors found *H. amblops* in the moderate to large-sized tributaries of the Ocoee and upper Hiwassee Rivers. Dahlberg and Scott (1971) extended the recorded range of this species in the Hiwassee system to the Nottely River in Georgia.

Blotched chub—*Hypobopsis insignis* Hubbs and Crowe. Four specimens of this species were collected from the riffles of a moderate-sized tributary of the Nottely River in Union County in Georgia. Dahlberg and Scott (1971) also recorded specimens of *H. insignis* from the Nottely. A single specimen of *Hypobopsis dissimilis* (Kirtland) reported from the Valley River by Messer (1965) is regarded as a misidentification of *H. insignis*.

River chub—*Nocomis micropogon* (Cope). The river chub

was found in every major drainage area of the Hiwassee except the lowland streams. All collections of this species came from moderate to large clean streams with very little or no bottom vegetation.

Southern redbelly dace—*Phoxinus erythrogaster* (Rafinesque). This small cyprinid was found only in a highland portion of Chestnut Creek near Nonaburg, Tennessee. The stream in the area sampled was about seven feet wide and about one to three feet deep. The water was cool and slow and the stream bottom was silt or red clay. Such a restricted range within a drainage area is not unusual for this species.

Phoxinus sp.—An undescribed species of the genus *Phoxinus* which had been previously discovered in the Pigeon River system (Ross and Carico, 1963) was collected in 1970 by Dale and Pat Walker in Indian Creek (personal communication). The undescribed dace is also found in Maddens Branch, which, like Indian Creek, is a small, cool tributary of the Ocoee River. All specimens of this new dace have been received by Dr. David Etnier and currently are kept in the University of Tennessee fish collection on the Knoxville campus.

Other cyprinids not found in the authors' collections but reported by other workers as being in the Hiwassee system were *Notropis photogenis* (Cope), (Edward Menhinick, personal communication), *Notropis rubellus* (Agassiz) and *Clinostomus funduloides* Girard (Dahlberg and Scott, 1971; Messer, 1965). *Notropis rubellus* is found in streams of considerable gradient and moderate depth. The *Clinostomus* is predominately a headwater fish.

Mosquitofish—*Gambusia affinis* (Baird and Girard). The mosquitofish was most abundant in the warm pools of the lower Hiwassee region. The specimens in Indian Creek probably strayed from nearby Parksville Reservoir.

Blackspotted topminnow—*Fundulus olivaceus* (Storer). All killifishes collected by the authors had the black dots in the dorsolateral area indicative of *F. olivaceus* rather than the similar *F. notatus*. These fish were common in the warm and often stagnant waters of the lower Hiwassee tributaries.

Alabama hogsucker—*Hypentelium etowanum* (Jordan). This fish was thought to be confined to the Gulf Coastal drainage but has, somehow, invaded the Ocoee system. Presently this fish is known only from Baker Creek of the Ocoee system.

Northern hogsucker—*Hypentelium nigricans* (Lesueur). The northern hogsucker was found in all drainage areas collected. The habitat preference for this species is a stream with cool, fast water and a gravel bottom. The occurrence of the two species of hogsuckers will be discussed later in the paper.

From the Georgia records of Dahlberg and Scott (1971), the collections of the authors, and personal communication with Dr. Edward Menhinick, some consideration can be given to the distribution of the redhorses. The golden redhorse, *Moxostoma erythrum* (Rafinesque) and the black redhorse, *Moxostoma duquesnii* (Lesueur), range from the lower Hiwassee up to the moderate to large headwaters in Georgia. *Moxostoma carinatum* (Cope) and *M. macrolepidotum breviceps* (Cope), the river and shorthead redhorses, respectively, apparently extend upstream only as far as the Hiwassee system of North Carolina. The migratory redhorses have not been recorded from the Ocoee for many years.

Spotted sucker—*Minytrema melanops* (Rafinesque). The spotted sucker appears to remain close to the main channel of the Hiwassee in Tennessee.

White sucker—*Catostomus commersoni* (Lacepede). The white sucker seems to be primarily a lowland fish. Menhinick, however, (pers. com.) reported that it does occur in the Hiwassee system of North Carolina.

Channel catfish—*Ictalurus punctatus* (Rafinesque). A large specimen of the channel catfish was speared by Thomas Tipton Hitch

in the deep waters of the Hiwassee about one mile upstream from the Highway 411 bridge. Fishermen often speak of the good catfishing in the river, and the channel catfish undoubtedly accounts for much of their success.

Flathead catfish—*Pylodictis olivaris* (Rafinesque). This species is an inhabitant of lakes and large rivers. The authors made no collection of *P. olivaris*, but two "flatheads" were caught by the Tennessee Game and Fish Commission (T.G.F. 1). The University of Georgia is reported by Dahlberg and Scott (1971) to have a collection of this species from Lake Blue Ridge, Georgia.

Redbreast sunfish—*Lepomis auritus* (Linnaeus). The redbreast sunfish was probably introduced but it is now an important element of the lower Hiwassee panfishery.

Green sunfish—*Lepomis cyanellus* Rafinesque. The green sunfish is widespread in the headwaters of the Hiwassee system.

Warmouth—*Lepomis gulosus* (Cuvier). The warmouth was collected only from and is probably restricted to the lowland portions of the Hiwassee system.

Longear sunfish—*Lepomis megalotis* (Rafinesque). The longear sunfish was collected only in the lowland streams of the Hiwassee. The preferred habitat of this fish is slow water of moderate depth and temperature.

White and black crappie—*Pomoxis annularis* Rafinesque and *P. nigromaculatus* (Lesueur). Both species of crappie occur in the reservoirs of the Hiwassee system, with occasional specimens straying into pool areas in some of the larger streams.

Rock bass—*Ambloplites rupestris* (Rafinesque). The rock bass was taken in every major tributary of the Hiwassee. Though found in the lower elevations as well as the headwaters, *A. rupestris* is mainly an inhabitant of cool mountain streams.

Redeye bass—*Micropterus coosae* Hubbs and Bailey. According to Ramsey (1965), this fish is an introduction to the Hiwassee system. The authors found this bass only along the southern tributaries of the Hiwassee and Ocoee Rivers.

Spotted bass—*Micropterus punctulatus* (Rafinesque). The spotted bass was collected in the cool waters of the main Hiwassee in Tennessee and in the Nottely River in Georgia.

Analysis of the natural distribution patterns of many species of the family Centrarchidae was obscured by artificial introduction. Species known to have been widely introduced into the Hiwassee include the largemouth bass, *Micropterus salmoides* (Lacepede), the bluegill, *Lepomis macrochirus*, Rafinesque, and the redear sunfish, *Lepomis microlophus* (Günther).

Yellow perch—*Perca flavescens* (Mitchill). The yellow perch is a native of the Great Lakes and Atlantic coastal drainages and has most likely been introduced into the Hiwassee system. Messer (1965) observed these fish in a feeder stream of Chatuga Reservoir. Similarly, the authors collected this fish in Coosa Creek near an impoundment of the Nottely River in Union County, Georgia. In 1968, the Tennessee Game and Fish Commission (personal communication) collected a single yellow perch from the main Hiwassee two miles below the Tennessee-Georgia state line. The original identification of this fish has been verified by Dr. David Etnier and the specimen is being held in the fish collection of the University of Tennessee in Knoxville.

Greenside darter—*Etheostoma blennioides* Rafinesque. The greenside darter is widely distributed in the small to large, cool streams of the Hiwassee River.

Stripetail darter—*Etheostoma kenicottii* (Putnam). Found only in the warm, sluggish waters of the lower Hiwassee, the stripetail darter seems to be restricted to the lowland habitats.

Redline darter—*Etheostoma rufilineatum* (Cope). *Etheostoma*

rufilineatum was present in at least some of the clear streams in all the major drainage areas sampled by the authors. Little temperature preference was noted for this species although a decided tendency toward streams with substrate particles gravel size or larger was noted.

Bluebreasted darter—*Etheostoma camurum* (Cope). Two specimens were collected on May 5, 1968, by Tennessee Game and Fish personnel (personal communication) in the main channel of the Hiwassee two miles below the Tennessee-North Carolina border. In his recent description of *E. chlorobranchium*, Zorach (1972) indicated that neither *E. camurum* nor *E. chlorobranchium*, was known from the Hiwassee system. Since these very similar species are separable with certainty only when nuptial males are available, it is difficult to assign these two specimens to either of the above species with confidence. Zorach's (1972) range map would indicate that the specimens represent *E. chlorobranchium*. The fact that they are both mature males (57 and 60 mm standard length) but lacked the characteristic green pigmentation of *E. chlorobranchium* at a time approaching the spawning season indicates that they are *E. camurum*. Both specimens have 57 lateral-line scales. Vertebral counts, kindly provided by Mr. B. A. Thompson, Tulane University, were 38 and 39. Since Dr. Zorach's paper is considerably less than a final analysis of the *E. camurum* complex, we have chosen to allocate these specimens to the established taxon.

Tennessee snubnose darter—*Etheostoma simotermum* (Cope). The snubnose darter is found in swift streams, but it lives in the slower portions of these streams and usually in sandy areas. Because of its habitat preferences, this darter is at home from the sometimes muddy Gunstocker Creek near the mouth of the Hiwassee to the cool headwater streams of the Toccoa River in Georgia.

Chickamauga darter—*Etheostoma stigmaeum jessiae* (Jordan and Brayton). The Chickamauga darter was collected on two occasions (U.T.K. 4 and 10), both from shallow riffles in South Chestnut Creek, Bradley County, Tennessee. Seemingly, this darter occurs only in the lower Hiwassee and it is rare even there. The Chickamauga darter may be elevated to full species status in the future (pers. com., Dr. Wm. M. Howell, Cornell University), and is treated as a valid species distinct from *E. stigmaeum* by many ichthyologists at present.

Banded darter—*Etheostoma zonale* (Cope). The banded darter was found in some of the clear tributaries of all the major drainage areas comprising the Hiwassee River system.

Tangerine darter—*Percina aurantiaca* (Cope). The tangerine darter was found in cool, clear, moderate to large size streams. Our specimens from Wilsco Creek, Fannin County, Georgia (U.T.K. 64), and a single specimen listed by Dahlberg and Scott (1971) are from the tributaries of the Toccoa River. Messer (1965) recorded *P. aurantiaca* from tributaries of the Valley and Hiwassee Rivers in Cherokee County, North Carolina. Tennessee Game and Fish collections extend the distribution downstream to the main channel of the Hiwassee in Tennessee. A recent acquisition of an extremely large male from the mouth of Turtletown Creek, Polk Co., Tenn., provided by Monte Seehorn and Wm. Hess of the U.S. Forest Service, is noteworthy. One month after collection the specimen was 175 mm total length and 152 mm standard length. All the Hiwassee River system *Percina aurantiaca* specimens have been verified by Drs. David A. Etnier and John S. Ramsey.

Blotchside logperch—*Percina burtoni* Fowler. Our only record of this rare and poorly known species is from Spring Creek, a tributary to the lower Hiwassee in McMinn County, Tennessee. The specimen was collected by Mr. Monte Seehorn, U.S. Forest Service, with a back-pack shocker on July 8, 1971, and has been deposited at Auburn University.

Gilt darter—*Percina evides* (Jordan and Copeland). *Percina evides* appears to be an inhabitant of moderate to large size streams of considerable gradient. We collected specimens from the Nottely, Toccoa and the main channel of the Hiwassee.

Dusky darter—*Percina sciera* (Swain). A single specimen is available from Rogers Creek above the Tennessee State Highway 30 bridge, McMinn County, Tennessee, August 24, 1971. The specimen was made available to us by Mr. William Seawell, Tennessee Game and Fish.

Olive darter—*Percina squamata* (Cope). This streamlined darter was usually found with *Percina aurantiaca*. The authors are aware of records of this species from Cooper's Creek in the Toccoa system of Georgia (Dahlberg and Scott, 1971), Hanging Dog Creek of the Hiwassee system in North Carolina (Messer, 1965), our collection from Wilsco Creek in the Toccoa drainage in Georgia (U.T.K. 64), and a single juvenile from the main channel of the lower Hiwassee.

Two species in the family Cottidae occur in the Hiwassee drainage. *Cottus caroliniae* (Gill), the banded sculpin, and *Cottus bairdi* (Girard), the northern sculpin, occur sympatrically in all major drainage systems. The banded sculpin was by far the more common of the two in the lowlands. The authors' records indicate that the two occur in approximately the same numbers in the Hiwassee tributaries of Georgia.

DISCUSSION

On the basis of the distributional records available, consideration can be given to the ecological and taxonomic problems posed by the faunal relationships within the Hiwassee River system.

The Nottely and Hiwassee Rivers in Georgia appear to have the same native fauna. Similar habitats in different streams have similar composition and available habitats are limited in diversity. The dispersal of exotic species, on the other hand, has been blocked by Nottely Dam. The records of other researchers, such as Miller (1968), Messer (1965) and Ramsey (1965) indicate that the Valley River in North Carolina has much the same fish fauna as the Nottely and Hiwassee Rivers in Georgia.

The Ocoee River system contains the most interesting problems in the Hiwassee system. Many clear, cool streams feed the Ocoee, but few fish species are found in them. The main Ocoee River below Ducktown has been modified so strongly by man that the original character of the river and its fauna is difficult to ascertain. Further, the agents that have changed the Ocoee River may well have had important effects on other Hiwassee system areas.

The warmer waters of the lowland streams contain the greatest variety of fish species. Man's activities there also seem to be reducing the inherent diversity of the environment.

The main channel of the Ocoee is the key to questions concerning the nature of the Ocoee River fauna. A Tennessee Valley Authority report (1963) estimated that the corporations within the Copper Basin pumped approximately 32 million gallons of industrial wastes into the Ocoee River every day. This same TVA report calculated that the river had twelve times the volume of flow that would normally be needed to dilute this water so as to minimize any toxic effects. The authors have sampled the Ocoee River and have found that it is a "dead" river. A few rough fish exist in Parksville Reservoir, but the main channel of the Ocoee is devoid of normal fish life.

Large individuals of such fish as the catostomids, petromyzontids, cyprinids, and *Stizostedion vitreum* (Mitchill), are absent from the Ocoee system. The authors feel that these migratory fishes are usually killed by toxic chemicals in Parksville Reservoir before they are mature enough to reproduce and repopulate Ocoee tributaries. Large, warm Sylco Creek would normally be capable of sustaining carp (*Cyprinus carpio* Linnaeus) and catostomids, but these fish were not found there after arduous collecting by the authors. Stiles and Etnier (1971) spent considerable time collecting this stream, but they too found no migratory fishes.

Other evidence is available which indicates that the fish of the Ocoee tributaries should be considered a trapped fauna. In a 1948 TVA publication, the pH of the Ocoee below the Copper Basin was reported to range from a low of 3.9 to a high of only 5.8 between October of 1944 and September 1946.

Water with a pH below 6 is considered to be detrimental to normal stream life by the Federal Water Pollution Control Administration report, *Water Quality Criteria* (1968). According to the same report fish life below a pH of 4.0 is virtually unknown. Today the quality of the Ocoee River water has somewhat improved. Tennessee Valley Authority records (Tennessee Valley Authority, 1963) showed an average pH of 5.5 for the Ocoee River at Parksville. This indicates that, on an average, Copperhill operations may now lower the pH of the Ocoee by a value of only 1.5 from the near neutral waters of the Toccoa River.

The pH of the Ocoee waters may no longer be a constant problem, yet occasionally some toxicant reaches a level so high that only catfish are able to survive. The thoroughness with which this toxicant denudes the biota of the Hiwassee is itself a strong indication that this chemical is copper and its sulphate salts. If, indeed, this is the case, a remedy may lie in the planting of water weeds downstream from the copper mining works. Muirhead-Thompson (1971) points out that sulphates, though highly soluble under normal conditions, are precipitated out in waters with high organic content such as that produced by plants. Aquatic vegetation is not presently common in the Upper Hiwassee system.

In the authors' opinion, time and the condition of the Ocoee River have had noticeable influence on the evolution of fishes in both the Ocoee and Toccoa drainages. Shortly before 1878 (Tennessee Copper Company, 1908) the attempt to treat low grade sulfide ores began which eventually brought the destruction of much Ocoee River fauna and estrangement of the fishes of the Toccoa from the rest of the Tennessee drainage. Though the toxicity of the Ocoee waters has been considerably lessened by innovations such as sedimentation and neutralization of copper mining wastes (Tennessee Stream Pollution Control Board, 1954), the authors believe that the Toccoa River fishes, and, as previously mentioned, the fishes of the Ocoee headwaters, are even today prevented from traveling downstream to the main Hiwassee. The consequences of this almost 90 years of isolation are in a small way shown by the distribution of *Notropis spectrunculus* (Cope) and *Hypentelium etowanum* (Jordan).

The authors' inclusion of *Notropis spectrunculus* into the group of fishes which might indicate the degree of isolation within the Ocoee-Toccoa system stems from previous study of this minnow's squamation. In 1965, *N. spectrunculus* from the Hiwassee were thought to all have fully scaled napes (Ramsey, 1965). Consideration was, in fact, given to the possibility of assigning the Hiwassee population a subspecies status so as to differentiate them from the *N. spectrunculus* population in the more northeasterly portion of the Tennessee River which have naked or partially naked napes. The tentative decision to call the Hiwassee River type a fully-scaled, separate subspecies was made without examination of the specimens from the Ocoee-Toccoa River system. All of the Toccoa *N. spectrunculus* collected by the authors had the naked nape conditions to a greater or lesser degree. If one assumes that the naked nape characteristic is inherited, as has been suggested for *Etheostoma nigrum* Rafinesque (Lagler and Bailey, 1947), then one would also be led to assume that the Toccoa populations of *N. spectrunculus* have been unable to negotiate the poisons and hydroelectric dams of the Ocoee River so as to enter the Hiwassee and mate with the fully-scaled types there.

The importance of *Hypentelium etowanum* lies in the existence of this sucker in the Ocoee system in Baker Creek. *Hypentelium etowanum* has, like the Toccoa *N. spectrunculus*, not been able to reach the Hiwassee River by traveling down the Ocoee River. *Hypentelium etowanum* is, in fact, found nowhere else in the Tennessee system. It seems likely that *H. etowanum* is a relatively recent introduction to the Ocoee River.

The authors had hoped that *Etheostoma cinereum* Storer would be found in habitats afforded by the main channel of the lower Hiwassee, but it was never found. The authors' collection records led them to other papers which partially explained this phenomenon. The main channel of the Hiwassee is probably too cold for these fishes as it flows from the mountains and it remains too cold for four or five miles downstream from the foothills. At about the fourth mile, the Hiwassee River is met by Conasauga Creek, a stream flowing through agricultural land and carrying a silt load that destroys most of the good quality fish habitat for another one-half mile downstream. With the silt comes treated and untreated sewage from the town of Etowah (Tenn. Valley Authority, 1963). We wondered why no animal life could be found in South Mouse Creek, a large stream with many riffles, which enters the Hiwassee River ten miles below the mouth of Conasauga Creek. A TVA report (1963) reports that the city of Cleveland contributes a biochemical oxygen demand population equivalent of 32,000 into the South Mouse Creek. Very few of the lowland tributaries are spared such abuse.

The Ocoee River fishes of the genera *Cottus* and *Hypentelium* present a taxonomic problem. Within the genus *Cottus* two species are known to occur in the Hiwassee system. These are *Cottus caroliniae* (Gill) and *C. bairdi* Girard. Differentiation of the two was normally found to be clear. Robins (1954) in his dis-

sertation had indicated that *C. bairdi* would have an incomplete lateral-line, an orange stripe running horizontally through the anterior dorsal fin, and diffuse specks of pigment or no pigment on the chin. *Cottus caroliniae* usually would have a more or less complete lateral-line, no orange stripe through the dorsal, and a mottled chin. Intensive collecting in the tributaries to the south of Parksville Reservoir yielded two specimens of *Cottus* that do not fit either of the above descriptions. Both specimens have the orange band, a slightly incomplete lateral line, and a greatly mottled chin area. Species of *Cottus* from the Eastern United States have not been described in sufficient detail (Robins, 1954). Until such descriptions are made, the true character of the Hiwassee specimens cannot be determined.

Of particular interest in this study was the discovery of a population of *Hypentelium etowanum* in Baker Creek, Polk Co., Tenn. This species is known only from the Mobile Bay and Appalachian drainages. We have taken only *H. etowanum* in Baker Creek, while hogsuckers from the remainder of the system are clearly *H. nigricans*. Methods of differentiating between these two very similar species are rather arbitrary. According to various keys to North American freshwater fishes *H. nigricans* has a concave interorbital area as opposed to the flat interorbital area of *H. etowanum*; dorso-lateral stripes faint or lacking compared to well developed in *H. etowanum*; and 11-12 dorsal rays versus 9-10 dorsal rays in *H. etowanum*. Jenkins (1970) lists another extremely useful character involving the number of scale rows above the lateral-line. The count, made obliquely forward from the lateral-line in the scale row in front of the dorsal fin and then obliquely backward to the lateral-line, not counting the lateral-line scale on either side, is usually 15 or more in *H. nigricans* and 14 or less in *H. etowanum*. All of the 15 hogsuckers from Baker Creek agree with *H. etowanum* in both meristics and morphology. From talks with farmers in the Ocoee system, and studies of the topography of the area, we are of the opinion that the Hiwassee *H. etowanum* population is the result of an introduction.

Finally, some comments should be made concerning the probable increased utilization of the Hiwassee River as a trout river. As mentioned earlier, Wolf Creek of the Hiwassee system and Rough and Big Creeks of the Ocoee system currently have reproducing populations of rainbow trout. Stocking of different strains of rainbows in these streams could lead to competitive exclusion of the reproducing populations. The streams containing natural populations of brook trout mentioned by Dahlberg and Scott (1971) and Messer (1965) should, of course, not be subjected to either stockings of browns or rainbows for both of the latter species tend to displace brook trout.

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