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To the Graduate Council:

I am submitting herewith a thesis written by Robert Knapp Hitch entitled "Distribution of the Fishes of the Hiwassee River System--Ecological and Taxonomic Considerations." I recommend that it be accepted for eighteen quarter hours credit in partial fulfillment of the requirements for the degree Master of Science, with a major in Ecology.

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DISTRIBUTION OF THE FISHES OF THE HIWASSEE RIVER SYSTEM--
ECOLOGICAL AND TAXONOMIC CONSIDERATIONS

A Thesis

Presented to

The Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Robert K. Hitch

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ABSTRACT

This paper summarizes the results of seventy-two collections made by the author along Georgia and Tennessee portions of the Hiwassee River. The more interesting species are listed and possible habitat preferences shown by these species are noted.

A discussion of the distribution of fishes within the various tributaries of the Hiwassee is presented, as are possible reasons for the absence of fishes from certain tributary systems.

The problems associated with the taxonomy of the species of the Genera *Cottus* and *Hypentelium* are also examined.

The results of this research indicate some of the possible effects of the isolation of the fishes of the Ocoee and Toccoa Rivers.

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CHAPTER I

INTRODUCTION

The research described in this paper is a survey of the fishes in the Tennessee and Georgia portions of the Hiwassee River. This research was selected by the author with hope that data useful to both sport and scientific personnel could be discovered. Game managers need to know how the Hiwassee can best be utilized as a more productive trout stream without injuring valuable populations of endemic fishes. While gathering information about the mountain trout streams, the author hoped also to uncover clues to the nature of the ancient fish species of the Hiwassee River headwaters. A description of the research and the more interesting fish records are presented here with the investigator's thoughts concerning the present status of the Hiwassee River fishes.

CHAPTER II

THE RIVER

The Hiwassee River system is a complex of five rivers which together drain portions of southeastern Tennessee, north central Georgia, and southwestern North Carolina. These five rivers--the Hiwassee, Ocoee, Toccoa, Nottely, and Valley Rivers and their many tributaries--lie within a watershed area of 2,800 square miles.

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

The large tributaries of the Toccoa and Nottely Rivers in Georgia are very similar, having clear, cold water and similar substrates. Steep gradients and fast waters are common in the headwaters of Rock, Cooper, 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 mineral wastes persist and seem

to form a chemical barrier that inhibits dispersal of acquatic life between the Ocoee-Toccoa system and the main Hiwassee downstream.

The longest tributary of the Hiwassee, the Nottely River, is geographically and stratigraphically similar to the Ocoee-Toccoa headwaters in Georgia. The Nottely, like the Ocoee-Toccoa system, has a rocky bottom ranging from gravel to boulder-sized rocks, 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 mainly suitable for rough fish until it mixes with the waters of the main Hiwassee and Valley Rivers in Hiwassee Reservoir.

The Valley River is the most unique of the main tributaries of the Hiwassee River. The floodplain of this stream is large, and its gradient is small. Though some sewage pollution seems to come from the town of Andrews and farms exist all along its broad floodplain, the Valley River seems little affected by the activities of man (Messer, 1965).

CHAPTER III

COLLECTION SITES, MATERIALS AND METHODS

Seventy-two collections were made during the study period which ran from August 13, 1970 to July 1, 1971. These collections and three others made by the Tennessee Game and Fish Commission are listed in Appendix A.

Emphasis was placed on collecting the smaller fishes of the Hiwassee drainage 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 information about the variation of the minnow *Notropis spectrunculus* (Cope). The main channel of the river was sampled

at several sites because of the numerous types of natural habitats present and for various reasons to be discussed later in this paper.

Seines, an electrical shocker, and sodium cyanide were employed as collecting devices. Six-, ten-, and twenty-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. The bag seine was utilized only during the night collection on the lower Hiwassee.

The pulsating direct current electrical shocker was designed and built by the investigator. 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 in much the same way as described by Comiskey (1970).

All collections were preserved in ten percent formaldehyde and housed in the University of Tennessee 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). Determinations were made by the author with the help of Dr. D. A. Etnier.

The following abbreviations are used in this paper: U.T.H.R.C. denotes the University of Tennessee Hiwassee River Collection, and T.G.F.H.R.C. denotes the Tennessee Game and Fish Hiwassee River Collection.

CHAPTER IV

AN ANNOTATED LIST OF FISHES TAKEN FROM THE HIWASSEE SYSTEM AND RELATED INFORMATION

Mountain brook lamprey--*Ichthyomyzon hubbsi Raney*. This small nonparasitic lamprey was found in the cool, fast waters of two Toccoa River tributaries in Fannin County, Georgia. Raney (1952) records *I. hubbsi* from the Nottely River in Union County, Georgia. Collections of this fish in the Little Tennessee River and the Oconaluftee River in North Carolina (Raney, 1952) suggest that moderate-to-large-size streams are the normal habitat of the species.

The specimens listed by the author include two larvae from U.T.H.R.C. 57 and two adults from U.T.H.R.C. 62. The standard lengths of the larval specimens were 10.9 and 10.5 centimeters, and the lengths of the adults were 13.1 and 12.2 centimeters. The adults were collected on May 15, 1971.

An additional nonparasitic lamprey *Lampetra lamottei* (Lesueur) and two species of parasitic lamprey--*Ichthyomyzon bdellium* Jordan, *Ichthyomyzon castaneous* Hubbs and Trautman--were collected in the Tennessee portion of the main Hiwassee River. The author feels 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 River drainage.

Records for Alosa chrysochloris (Rafinesque) and Dorosoma petenese (Gunther) come from the main channel of the Hiwassee in Tennessee. Their presence in the drainage areas of North Carolina and Georgia is probable.

Brook trout--Salvelinus fontinalis (Mitchill). S. fontinalis was not taken by the author in his collections. The "brookie" is a native of the upper Tennessee drainages and is present only in the highest quality trout streams. Dahlberg and Scott (1971) record this species from the Hiwassee and Toccoa drainages in Georgia, and Messer (1965) lists collections from three locations in North Carolina.

Two other species of trout, Salmo gairdneri Richardson and Salmo trutta Linnaeus, were observed to be present in the headwaters of all the major drainage areas collected. The presence of these fish was noted under the locality data rather than in the collection lists in Appendix A. Both species have been introduced and very few specimens were taken. Rough and Big Creeks of the Ocoee drainage, and Wolf Creek of the Hiwassee drainage appear to have naturally reproducing populations of S. Gairdneri.

Stoneroller--Campostoma 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 of the main river drainage 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--Pimpephales 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 collected in many small to moderate size streams which drain the Tennessee foothills. Some specimens, however, were collected in silty lowland streams with very little gradient, and some were collected in the main channel of the Hiwassee River.

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. R. atratulus is found only in the Hiwassee and Ocoee drainages, and R. cataractae in the Nottely, Toccoa, and Valley Rivers.

Emerald shiner--Notropis atherinoides Rafinesque. The emerald shiner is represented in the author's collections 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 author, 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.

Common shiner--Notropis cornutus (Mitchill). The author collected the striped shiner in fairly large, slow-moving streams of the lowlands. Gilbert (1964), however, reports 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 white-tail 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 1500 feet above sea level (Ramsey, 1965). The collection of this species from the main Hiwassee (T.G.F.H.R.C. 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.H.R.C. 2 from the main Hiwassee River yielded two specimens of the telescope shiner, the author's samples indicate that small creeks or streams are the preferred habitat of this species. 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 author knows of no collection of N. whipplei from the Hiwassee drainages 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 drainage outside Tennessee are known.

Carp--Cyprinus carpio Linnaeus. Carp were seen to be abundant in the warmer waters of the Lower Hiwassee during the author's spear-fishing trips. The low numbers recorded in collections are probably due to the unwillingness of collectors to preserve this rough fish.

Bigeye Chub--Hybopsis amblops (Rafinesque). The author found H. amblops in the moderate to large size tributaries of the Ocoee and upper Hiwassee Rivers. Dahlberg and Scott (1971) extend the range of this species in the Hiwassee system to the Nottely River in Georgia.

Blotched Chub--Hybopsis insignis Hubbs and Crowe. The author collected four specimens of this species from the riffles of a moderate-sized tributary of the Nottely River in Union County in Georgia. Dahlberg and Scott (1971) record specimens of H. insignis from the Nottely, also. A single specimen of Hybopsis dissimilis (Kirtland) collected from the Valley River by Messer (1965) is quite likely Hybopsis 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 come from moderate to large size, clean streams with very little or no bottom vegetation.

Golden shiner--Notemigonus crysoleucas (Mitchill). The golden shiner is widely distributed in the Hiwassee drainage. The author noted that this fish is sold as bait in the area.

Southern redbelly dace--Phoxinus erythrogaster (Rafinesque). This small cyprinid was found only in a highland portion of Chestuee 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 fish 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. The fish that are associated with this new species are listed in U.T.H.R.C. 42. The undescribed dace is also found in Maddens Branch (U.T.H.R.C. 46), which, like Indian Creek, is a small, cool tributary of the Ocoee River.

Other cyprinids not found in the collections listed in this paper but reported by other workers in the area were Notropis photogenis (Cope), (Personal communication from Edward Menhinick, 1971), Notropis rubellus (Agassiz) and Clinostomus funduloides (Girard), (Dahlberg and Scott, 1971) and (Messer, 1965). Notropis photogenis can be found in large channels of the Hiwassee. 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 is most abundant in the warm pools of the lower Hiwassee region. The specimens in Indian Creek probably strayed from nearby Parksville Reservoir

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 two small tributaries of the Ocoee. Much will be said later regarding this species.

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 affinities of the hogsuckers will be discussed later in the text of this paper.

Blackspotted topminnow--Fundulus olivaceous (Storer). All killifishes collected by the author have the black dots in the dorsolateral area indicative of F. olivaceous rather than the similar F. Notatus. These fish are common in the warm and often stagnant waters of the lower Hiwassee tributaries.

From the records of Dahlberg and Scott (1971) from Georgia, the collections of the author, and personal communication with Dr. Edward Menhinick, some consideration can be given to the distribution of the redhorses. The golden redhorse, Moxostoma erythrurum (Rafinesque) and the black redhorse, Moxostoma duquesnei (Lesueur), range from the lower Hiwassee up to the moderate to large headwaters in Georgia. Moxostoma carinatum (Cope) and Moxostoma macrolepidotum (Lesueur), the river and shorthead redhorses, respectively, apparently extend upstream only as far as the Hiwassee drainage 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, in personal communication, reported that it does occur in the Hiwassee drainage of North Carolina.

Channel catfish--Ictalurus punctatus (Rafinesque). A large specimen of the channel catfish was speared by the author's brother, 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 author made no collection of P. olivaris, but two "flatheads" were caught by the Tennessee Game and Fish Commission (T.G.F.H.R.C. 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). Thd redbreast sunfish has a wide distribution in the Hiwassee headwaters. The presence of this species is quite probably the result of introduction.

Green sunfish--Lepomis cyanellus Rafinesque. The green sunfish is widespread in the colder waters of the Hiwassee system.

Warmouth--Lepomis gulosus (Cuvier). The warmouth was collected only in the lowland portions of the Hiwassee system. The author feels that the mountainous areas of the Hiwassee system offer hostile habitats for this species.

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 crappie--Pomoxis annularis Rafinesque. Although the author's collection of this species comes from the main Hiwassee in Tennessee, the existence of this species further upstream is probable.

Black crappie--Pomoxis nigromaculatus (Lesueur). The black crappie of the Hiwassee reservoirs is an important game fish to the people of Western North Carolina and Northern Georgia. The single specimen taken by the author was from a pool in Butternut Creek, near Blairsville, Georgia.

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 author found this fish 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 Micropterus salmoides (Lacepede), Lepomis machrochirus (Rafinesque), and Lepomis microlophus (Gunther).

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 the Chatuga Reservoir. Similarly, the author 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 collected a single yellow perch from the main Hiwassee two miles below the Tennessee-Georgia state line. (Etnier, 1968).

Greenside darter--Etheostoma blennioides Rafinesque. The greenside darter is widely distributed in the small-to-large, cool streams of the Hiwassee River. In Appendix A, which is a list of fishes by drainages, this species also appears as a lowland fish. The sample containing the specimens comes from Cane Creek, which has its headwaters in a mountainous region, and itself is a cool water stream.

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

Redline darter--Etheostoma rufilineatum (Cope). E. rufilineatum was present in at least some of the clear streams in all the major drainage areas sampled by the author. 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). The Tennessee Game and Fish Commission collected the bluebreasted darter on May 5, 1968 in the fast, clear waters of the main Hiwassee two miles below the Tennessee-North Carolina state line. The author and many other workers have since then sampled what seemed to be good E. camurum habitats but

with no success. The bluebreasted darter is probably very rare in the Hiwassee system.

Tennessee subnose darter--Etheostoma simoterum (Cope). The snubnose darter is found in fast-running 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.

Speckled darter--Etheostoma stigmaeum (Jordan). The speckled darter was collected on two occasions, (U.T.H.R.C. 4) and (U.T.H.R.C. 10), both from shallow riffles in South Chestuee Creek. Seemingly, this darter occurs only in the lower Hiwassee and is rare even there.

Banded darter--Etheostoma zonale (Cope). The banded darter can be 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 can be found in cool, clear, moderate-to-large-size streams. The record of the author at Wilscot Creek, (U.T.H.R.C. 64), and single specimen listed by Dahlberg and Scott (1971) are from the tributaries of the Toccoa River in Union County, Georgia. Messer (1965) records 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.

Gilt darter--Percina evides (Jordan and Copeland). P. evides appears to be an inhabitant of moderate-to-large-size streams of considerable gradient. The collections listed in this paper come from the Nottely, Toccoa, and main channel of the Hiwassee.

Olive darter--*Percina squamata* (Gilbert and Swain). This streamlined darter was usually found with *Percina aurantiaca*. The author is aware of records of this species from Cooper's Creek in the Toccoa drainage of Georgia (Dahlberg and Scott, 1971), Hanging Dog Creek of the Hiwassee drainage in North Carolina (Messer, 1965), and the author's collection from Wilscot Creek in the Toccoa drainage in Georgia.

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

CHAPTER V

DISCUSSION AND CONCLUSIONS

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

The Nottely and Hiwassee Rivers in Georgia appear, from the author's collections, to have the same endemic fauna. Similar habitats in different streams have similar species composition and available habitats are limited in diversity. The dispersal of exotic species, on the other hand, has been blocked by the Nottely Dam. 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 drainage. 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 drainage 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 (Lower Hiwassee Valley, 1963) estimates that the corporations within the

Copper Basin pump approximately 32 million gallons of industrial wastes into the Ocoee River every day. This same TVA report calculates that the river has twelve times the volume of flow that would normally be needed to dilute this water so as to minimize any toxic effects. The author has sampled the Ocoee River and has found that it is a "dead" river. A few rough fish exist in the depths of Parksville Reservoir, but in the main channel the Ocoee is devoid of normal fish life.

Large individuals of such fish as the catastomids, Petromyzontids, cyprinids, and Stizostedion vitreum (Mitchill), are absent from the Ocoee drainage. The author feels 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 catastomids, but these fish were not found there after arduous collecting by the author. Stiles (1968) spent considerable time collecting this stream, but he, 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 Industrial Water Supplies of the Tennessee Valley Region (1948) 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 of 1946. Water with a pH below 6.0 is considered to be detrimental to normal stream life by the Federal Water Pollution Control Board 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. In 1963 (Lower Hiwassee Valley, 1963) Tennessee Valley

Authority records 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.

In the author's opinion, time and the condition of the Ocoee River have had noticeable influence on the evolution of the fishes in both the Ocoee and Toccoa drainages. Shortly before 1878 (Tennessee Copper Company - A Brief Description of the Operations, 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 (Report of Activities. Tennessee Stream Pollution Control Board, 1954), the author believes that the Toccoa River fishes and, as previously mentioned, the fishes of the Ocoee headwaters, are even today stopped 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 author's 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 squammation. In 1965, N. spectrunculus from the Hiwassee were thought to all have fully-scaled backs or 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 groups in the northeastern

portion of the Tennessee River which have naked or partially naked backs. The decision to call the Hiwassee River type a fully-scaled, separate subspecies was made without examination of specimens from the Ocoee-Toccoa River system. All of the Toccoa N. spectrunculus collected by the author had the naked nape condition to a greater or lesser degree. If one assumes that the naked nape characteristic is inherited, as it has been shown to be in Etheostoma nigrum Rafinesque (Lagler and Bailey, 1947), then one would also be led to assume that the Toccoa populations of N. spectrunculus, a creature which thrives in torrents, has 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 drainage in the same stream with the unnamed Phoxinus sp. and in an adjacent stream. The author mentions the proximity of H. etowanum with relation to the Phoxinus habitat only to orient the reader. Quite likely no geological and certainly no phylogenetic relationship of great consequence exists between these fishes, as the author will explain later. What is important is that the H. etowanum has, like the Toccoa N. spectrunculus, not been able to reach the Hiwassee River by traveling down the Ocoee River. H. etowanum is, in fact, found nowhere else in the Tennessee system.

The author had hoped that Percina sciera (Swain) and Etheostoma cinereum Storer would be found in a habitat afforded by the larger streams of the lower Hiwassee, but they were never found. The author's collection records led him 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 large tributary. At the mouth of Conasauga Creek is a long riffle which could have made a fine darter habitat. Conasauga Creek, however, a stream flowing through agricultural land, carries 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 (Lower Hiwassee Valley, 1963). The Conasauga story is the story of nearly every major tributary to the lower Hiwassee. The author wondered why no animal life could be found in South Mouse, a large stream with many riffles, which enters the Hiwassee River ten miles below the mouth of Conasauga Creek. Lower Hiwassee Valley,(1963) reports that the city of Cleveland contributes a biochemical oxygen demand population equivalent of 32,000 into South Mouse. Very few of the lowland tributaries are spared such abuse.

At least two taxonomic problems gave great difficulty. The status of the Ocoee drainage fishes of the genera Cottus and Hypentelium need consideration now, by the author, and by other specialists in the future.

Within the genus Cottus two species are known to occur in the Hiwassee drainage. These are Cottus carolinae (Gill) and C. bairdi Girard. Differentiation of the two was normally found to be clear. Robins (1954) in his dissertation had indicated that C. bairdi would have an incomplete lateral line, an orange stripe running horizontally through the top of the anterior dorsal fin, and diffuse specks of pigment or no pigment on the chin. C. carolinae usually would have a more or less complete lateral line,

no orange stripe through the dorsal, and a mottled chin. After intensive collecting in the tributaries to the south of Parksville Reservoir, the author has records of two specimens of Cottus that do not fit either of the above descriptions. Both specimens have the orange band, an only 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.

The problem involving Hypentelium etowanum, a hogsucker which had previously been known only from the Alabama and Appalachicola drainages, can be more fully evaluated by the author than was the case with the Cottus problem. The descriptions of the hogsucker which is normally found within the Tennessee drainage, Hypentelium nigricans, and of H. etowanum are poor, but widely published. According to various publications, H. nigricans has a concave interorbital area as opposed to the flat head of H. etowanum, no or very faint dorsolateral horizontal lines as opposed to distinct lines in the dorsolateral area of H. etowanum, and, usually, 11-12 dorsal rays as opposed to the 9-10 rays of H. etowanum.

At this time the author has ten specimens of H. etowanum from Baker and Indian Creeks. In these creeks, H. etowanum and H. nigricans exist sympatrically. Even with such few specimens, the author can say that the standard characteristics separating these two species are not sufficient. In fact the author did not become convinced that some of the hogsuckers from the Ocoee were H. etowanum until a series of these specimens with 9-10 dorsal rays had been accumulated and the fact determined that they

had come from the same small area. The final job of determining characters which will allow positive identification of these two hogsuckers will be a large one.

From talks with farmers in the Ocoee drainage, and studies of the topography of the area, the author is of the opinion that the Hiwassee *H. etowanum* specimens are the result of an introduction. Before the interrelationships of *H. nigricans* and *H. etowanum* can be fully understood, however, the method of entry of *H. etowanum* into the Tennessee River system must be known.

H. nigricans can be found throughout most of eastern North America. All variations of this fish from that tremendous geographical area should be compared to the varieties of *H. etowanum* present in the Alabama drainage before an attempt to discern the taxonomic relationships of these two species is made.

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APPENDIXES

APPENDIX A

COLLECTIONS IN THE HIWASSEE RIVER DRAINAGE

Collections from the lower elevations in Tennessee below the 411 bridge

U.T.H.R.C. 1 Hiwassee River, 6 miles below the bridge on Highway 411, Polk Co., Tenn. July 1, 1971. D. Etnier, B. Dickinson, J. Winfield, R. Hitch. Water about three feet deep.

Nocomis micropogon (Cope)	5
Ambloplites rupestris (Rafinesque)	1
Lepomis auritus (Linnaeus)	1
Lepomis machrochirus Rafinesque	1
Percina caprodes (Rafinesque)	1
Etheostoma zonale (Cope)	5
Cottus carolinae (Gill)	38

U.T.H.R.C. 2 Oostanaula Creek, 1 mile south of Mount Harmony, McMinn Co., Tenn. April 4, 1971. R. and S. Hitch.

Semotilus atromaculatus (Mitchill)	1
Notropis cornutus (Mitchill)	1
Moxostoma duquesnei (Lesueur)	2
Ambloplites rupestris (Rafinesque)	1
Lepomis machrochirus Rafinesque	2
Etheostoma simoterum (Cope)	11
Cottus carolinae (Gill)	4

U.T.H.R.C. 3 Agency Beta Creek, near Hiwassee River, Meigs Co., Tenn. April 9, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	1
Notropis cornutus (Mitchill)	5

Notropis spilopterus (Cope)	24
Notropis whipplei (Girard)	1
Etheostoma simoterum (Cope)	1
Etheostoma zonale (Cope)	1
Percina caprodes (Rafinesque)	6

U.T.H.R.C. 4 South Chestuee Creek, 1 mile south of first crossing of Rt. 64 heading west, Bradley Co., Tenn. November 15, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	3
Notropis cornutus (Mitchill)	2
Gambusia affinis (Baird and Girard)	7
Lepomis cyanellus Rafinesque	1
Micropterus salmoides (Lacepede)	1
Etheostoma rufilineatum (Cope)	1
Etheostoma simoterum (Cope)	13
Etheostoma stigmaeum (Jordan)	1
Cottus carolinae (Gill)	10

U.T.H.R.C. 5 South Mouse Creek at intersection with Rt. 4495. Bradley Co., Tenn. November 14, 1970. R. and S. Hitch.

Dorosoma cepedianum (Lesueur)	1
Campostoma anomalum (Rafinesque)	2
Notropis cornutus (Mitchill)	1
Moxostoma erythrurum (Rafinesque)	1
Hypentelium nigricans (Lesueur)	1
Fundulus olivaceous (Storer)	5
Gambusia affinis (Baird and Girard)	9

Lepomis auritus (Linnaeus) 1

Lepomis cyanellus Rafinesque 1

Lepomis gulosus (Cuvier) 1

Lepomis machrochirus Rafinesque. 4

Micropterus salmoides (Lacepede) 3

Etheostoma simoterum (Cope) 9

Cottus carolinae (Gill) 4

U.T.H.R.C. 6 Lick Creek, 3 miles from Hiwassee River, Bradley Co., Tenn. November 14, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 1

Notropis cornutus (Mitchill) 1

Notropis spilopterus (Cope) 1

Hypentelium nigricans (Lesueur) 1

Fundulus olivaceous (Storer) 5

Etheostoma simoterum (Cope) 3

Cottus carolinae (Gill) 2

U.T.H.R.C. 7 Middle Chestuee Creek at Rt. 39, McMinn Co., Tenn. April 3, 1971. R. and S. Hitch.

Dorosoma copedianum (Lesueur) 1

Campostoma anomalum (Rafinesque) 2

Semotilus atromaculatus (Mitchill) 1

Pimephales notatus (Rafinesque) 1

Rhinichthys atratulus (Hermann) 5

Notropis cornutus (Mitchill) 1

Fundulus olivaceous (Storer) 4

Hypentelium nigricans (Lesueur) 1

Catostomus commersoni (Lacepede) 1

Lepomis cyanellus Rafinesque 2

Etheostoma simoterum (Cope) 7

Cottus carolinae (Gill) 12

U.T.H.R.C. 8 Rogers Creek, near Fiketon, McMinn Co., Tenn. April 4, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 1

Notropis cornutus (Mitchill) 5

Fundulus olivaceous (Storer) 3

Ambloplites rupestris (Rafinesque) 1

Etheostoma simoterum (Cope) 3

U.T.H.R.C. 9 Chatata Creek at intersection of Routes 4431 and 4432, Bradley Co., Tenn. November 8, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 10

Notropis cornutus (Mitchill) 13

Fundulus olivaceous (Storer) 10

Lepomis cyanellus Rafinesque 2

Lepomis machrochirum Rafinesque 3

Etheostoma blennioides Rafinesque 1

Cottus carolinae (Gill) 3

U.T.H.R.C. 10 South Chestuee Creek at the Polk-Bradley Co. line, Tenn. November 7, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 1

Fundulus olivaceous (Storer) 1

Gambusia affinis (Baird and Girard). 11

Ambloplites rupestris (Rafinesque) 1

Lepomis cyanellus Rafinesque 1

Lepomis machrochirum Rafinesque 1

Etheostoma simoterum (Cope) 2

Etheostoma stigmaeum (Jordan) 1

Cottus carolinae (Gill) 3

U.T.H.R.C. 11 Cane Creek, tributary of Conasauga Creek near Cog Hill on Rt. 4475, McMinn Co., Tenn. R. and S. Hitch.

Notropis cornutus (Mitchill) 2

U.T.H.R.C. 12 Price Creek, 3 miles from Chickamauga Reservoir, Meigs Co., Tenn. April 4, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 24

Notropis cornutus (Mitchill) 1

Rhinichthys atratulus (Hermann) 17

Fundulus olivaceous (Storer) 2

Lepomis auritus (Linnaeus) 1

Lepomis cyanellus Rafinesque 1

Micropterus dolomieui (Lacepede) 1

U.T.H.R.C. 13 Lick Branch near the Hiwassee River, Meigs Co., Tenn. April 9, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 9

Notropis cornutus (Mitchill) 4

Notropis spilopterus (Cope) 30

Notropis whipplei (Girard) 3

Notemigonus crysoleucas (Mitchill) 2

Rhinichthys atratulus (Hermann) 5

Lepomis cyanellus Rafinesque 30

Lepomis machrochirus Rafinesque 12

Micropterus dolomieui (Lacepede) 1

Percina caprodes (Rafinesque) 8

U.T.H.R.C. 14 Blue Spring Branch, tributary of North Mouse Creek, at intersection of Rt. 30, McMinn Co., Tenn. April 4, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 1

Semotilus atromaculatus (Mitchill) 8

Rhinichthys atratulus (Hermann) 5

Etheostoma simoterum (Cope) 6

Cottus bairdi Girard 9

Cottus carolinae (Gill) 1

U.T.H.R.C. 15 East Fork of North Mouse at Union, McMinn Co., Tenn. April 4, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 4

Notropis cornutus (Mitchill) 2

Rhinichthys atratulus (Hermann) 5

Hypentelium nigricans (Lesueur) 1

Etheostoma simoterum (Cope) 9

U.T.H.R.C. 16 Taylor Branch, tributary of Candies Creek, Bradley Co., Tenn. November 15, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 2

Notropis cornutus (Mitchill) 1

Notropis telescopus (Cope) 6

Semotilus atromaculatus (Mitchill) 2

Lepomis machrochirus Rafinesque 8

Micropterus punctulatus (Rafinesque) 1

Etheostoma simoterum (Cope) 11

Cottus carolinae (Gill) 9

U.T.H.R.C. 17 Tributary of Candies Creek, one mile southwest of Black Fox, Bradley Co., Tenn. October 24, 1970. R. and S. Hitch.

Notropis cornutus (Mitchill) 1

Notropis lirus Jordan 2

Notropis telescopus (Cope) 4

Fundulus olivaceous (Storer) 6

Hypentelium nigricans (Lesueur) 1

Micropterus dolomieui (Lacepede) 1

Lepomis machrochirus Rafinesque 2

Etheostoma rufilineatum (Cope) 1

Etheostoma simoterum (Cope) 4

U.T.H.R.C. 18 Conasauga Creek on state route 4276, about 4 miles west of Etowah, McMinn Co., Tenn. R. and S. Hitch.

Notropis cornutus (Mitchill) 2

Etheostoma simoterum (Cope) 2

Etheostoma zonale (Cope) 1

Cottus carolinae (Gill) 4

U.T.H.R.C. 19 Little Chatata Creek, one-half mile west of Tasso, Bradley Co., Tenn. November 8, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 3

Notropis cornutus (Rafinesque) 3

Notropis lirus Jordan 53

Gambusia affinis (Baird and Girard) 26

Ambloplites rupestris (Rafinesque) 4

Lepomis megalotis (Rafinesque) 3

Micropterus coosae Hubbs and Bailey 2

Etheostoma simoterum (Cope) 11

Cottus carolinae (Gill) 11

U.T.H.R.C. 20 Bryner Creek at Route 64, Bradley Co., Tenn. November 7, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 1

Notropis telescopus (Cope) 1

Lepomis cyanellus Rafinesque 1

Lepomis machrochirus Rafinesque 1

Lepomis microlophus (Gunther) 1

Etheostoma rufilineatum (Cope) 1

Etheostoma simoterum (Cope) 4

Cottus carolinae (Gill) 3

U.T.H.R.C. 21 Gunstocker Creek, one mile from the Hiwassee River, Meigs Co., Tenn. November 14, 1970. R. and S. Hitch.

Fundulus olivaceous (Storer) 2

Dorosoma cepedianum (Lacepede) 1

Hypentelium nigricans (Lesueur) 1

Lepomis cyanellus Rafinesque 2

Lepomis machrochirus Rafinesque 1

Etheostoma kennicotti (Putnam) 1

Etheostoma simoterum (Cope) 2

U.T.H.R.C. 22 Chestuee Creek at Nonaburg, McMinn Co., Tenn. October 25, 1970. R. and S. Hitch.

Rhinichthys atratulus (Hermann)	11
Semotilus atromaculatus (Mitchill)	11
Notropis cornutus (Mitchill)	1
Phoxinum erythrogaster (Rafinesque)	2
Etheostoma simoterum (Cope)	7
Cottus carolinae (Gill)	1

U.T.H.R.C. 23 Little Chestuee Creek, one mile downstream from Wilson Station, Monroe Co., Tenn. November 1, 1970. R. and S. Hitch.

Semotilus atromaculatus (Mitchill)	1
Notropis cornutus (Mitchill)	2
Catostomus commersoni (Lacepede)	1
Hypentelium nigricans (Lesueur)	1
Micropterus salmoides (Lacepede)	1
Etheostoma simoterum (Cope)	11
Cottus carolinae (Gill)	5

U.T.H.R.C. 24 Spring Creek, 2 miles north of intersection with Highway 30, McMinn Co., Tenn. April 4, 1971. R. and S. Hitch.

Notropis cornutus (Mitchill)	1
Pimephales notatus (Rafinesque)	6
Fundulus olivaceous (Storer)	14
Ambloplites rupestris (Rafinesque)	3
Lepomis megalotis (Rafinesque)	7
Etheostoma simoterum (Cope)	12

U.T.H.R.C. 72 Sugar Creek, Meigs Co., Tenn. 100 feet from Hiwassee River. November 14, 1970. R. and S. Hitch.

Notropis cornutus (Mitchill)	2
Fundulus olivaceous (Storer)	2
Lepomis cyanellus Rafinesque	1
Etheostoma simoterum (Cope)	2
Cottus carolinae (Gill)	3

COLLECTIONS FROM THE UPPER HIWASSEE

(In the highlands of Tennessee above the 411 bridge)

U.T.H.R.C. 26 Turtletown Creek, 100 yards from Hiwassee River, Polk Co., Tenn. October 3, 1970. R. and S. Hitch. Large rocks to boulders with fine silt in still water.

Rhinichthys atratulus (Hermann)	3
Notropis leuciodus (Cope)	12
Etheostoma zonale (Cope)	4
Etheostoma blennioides Rafinesque	1
Cottus carolinae (Gill)	3

U.T.H.R.C. 27 Coker Creek near Hiwassee River, Polk Co., Tenn. October 11, 1970. R. and S. Hitch.

Nocomis micropogon (Cope)	2
Notropis coccogenis (Cope)	28
Lepomis cyanellus Rafinesque	1
Etheostoma rufilineatum (Cope)	3

U.T.H.R.C. 28 Little Lost Creek at intersection with road to Big Lost Creek campground, Polk Co., Tenn. August 13, 1970. R. and S. Hitch. Large to medium flat rocks and some gravel.

Rhinichthys atratulus (Hermann)	24

U.T.H.R.C. 29 Big Lost Creek, near Hiwassee River, Polk Co., Tenn. October 4, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	5
Notropis coccogenis (Cope)	2
Notropis galacturus (Cope)	1
Notropis spectrunculus (Cope)	3
Notropis telescopus (Cope)	19

Etheostoma rufilineatum (Cope) 1

Etheostoma simoterum (Cope) 2

Cottus carolinae (Gill) 2

U.T.H.R.C. 30 Big Lost Creek at National Forest Campground, Polk Co., Tenn. August 13, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 7

Notropis spectrunculus (Cope) 29

Rhinichthys atratulus (Hermann) 1

Micropterus dolomieui (Lacepede) 1

Hypentelium nigricans (Lesueur) 1

Etheostoma blennioides Rafinesque 2

U.T.H.R.C. 31 Big Lost Creek, at National Forest Campground, Polk Co., Tenn. October 24, 1970. R. and S. Hitch. Night sample.

Campostoma anomalum (Rafinesque) 6

Notropis spectrunculus (Cope) 15

Semotilus atromaculatus (Mitchill) 2

Hypentelium nigricans (Lesueur) 2

U.T.H.R.C. 32 Chestnut Gap Creek, Polk Co., Tenn. August 14, 1970. R. and S. Hitch. Gravel bottom. Several Salmo gairdneri Richardson observed.

Rhinichthys atratulus (Hermann) 14

U.T.H.R.C. 33 Towee Creek, near Hiwassee River, Polk Co., Tenn. October 11, 1970. R. Hitch, C. Comiskey.

Campostoma anomalum (Rafinesque) 8

Notropis coccogenis (Cope) 13

Notropis galacturus (Cope) 3

Notropis leuciodus (Cope) 29

Notropis spectrunculus (Cope) 4

Notropis telescopus (Cope) 20

Hybopsis amblops (Rafinesque) 1

Nocomis micropogon (Cope) 3

Etheostoma rufilineatum (Cope) 14

Etheostoma simoterum (Cope) 9

U.T.H.R.C. 34 Smith Creek at intersection with National Forest Road, Polk Co., Tenn. August 14, 1970. R. and S. Hitch. About one yard wide, loose, small gravel.

Rhinichthys atratulus (Hermann). 1

Semotilus atromaculatus (Mitchill) 4

U.T.H.R.C. 35 Wolf Creek, 100 feet from Hiwassee River, Polk Co., Tenn. October 3, 1970. R. and S. Hitch. Bedrock, with many young Salmo gairdneri Richardson.

Campostoma anomalum (Rafinesque) 19

Cottus carolinae (Gill) 3

U.T.H.R.C. 36 Piney Flats Branch, tributary of Big Lost Creek on road to Rymer Camp, Polk Co., Tenn. August 14, 1970. R. and S. Hitch.

Semotilus atromaculatus (Mitchill) 5

Rhinichthys atratulus (Hermann) 23

U.T.H.R.C. 37 Loss Creek, 2 mi. from Hiwassee River, Polk Co., Tenn. October 11, 1970. R. Hitch and C. Comiskey.

Campostoma anomalum (Rafinesque) 1

Notropis spilopterus (Cope) 27

Rhinichthys atratulus (Hermann) 3

Semotilus atromaculatus (Mitchill) 8

Ambloplites rupestris (Rafinesque) 2

Lepomis cyanellus Rafinesque 1

Etheostoma rufilineatum (Cope) 18

U.T.H.R.C. 38 Spring Creek, near Hiwassee River, Polk Co., Tenn. October 24, 1970. R. and S. Hitch. Bedrock substrate.

Notropis coccogenis (Cope) 14

Notropis cornutus (Mitchill) 18

Notropis lirus Jordan 1

Notropis telescopus (Cope) 15

Hybopsis amblops (Rafinesque) 1

Notemigonus crysoleucas (Mitchill) 1

Etheostoma rufilineatum (Cope) 1

Etheostoma simoterum (Cope) 13

Cottus carolinae (Gill) 3

T.G.F.H.R.C. 2 Hiwassee River, north side of island, 6.6 air miles above 411 bridge, Polk Co., Tenn. April 11, 1969. G. Martin, P. Wilkins, W. Seawell, W. Starnes, D. Etnier.

Salmo gairdneri Richardson 1

Salmo trutta Linnaeus 11

Campostoma anomalum (Rafinesque) 4

Cyprinus carpio Linnaeus 1

Nocomis micropogon (Cope) 60

Notropis coccogenis (Cope) 12

Notropis galacturus (Cope) 2

Notropis leuciodus (Cope) 19

Notropis spectrunculus (Cope) 5

Notropis telescopus (Cope) 2

T.G.F.H.R.C. 1 Hiwassee River, 4.8 miles below 411 bridge, on south side of island, Polk Co., Tenn. April 11, 1969. G. Martin, P. Wilkins, W. Seawell, W. Starnes.

Ichthyomyzon bdellium Jordan	4
Ichthyomyzon castaneus Hubbs and Trautman	2
Notropis coccogenis (Cope)	1
Minytrema melanops (Rafinesque)	3
Micropterus punctulatus (Rafinesque)	2
Etheostoma rufilineatum (Cope)	6
Etheostoma zonale (Cope)	2
Percina evides (Jordan and Copeland)	3

U.T.H.R.C. 25 Hiwassee River, 1 mile above Rt. 58 bridge, Meigs Co., Tenn. June 26, 1971. B. Dickinson, W. Starnes. R. Hitch. Night collection.

Notemigonus crysoleucas (Mitchill)	67
Notropis atherinoides (Rafinesque)	1
Notropis cornutus (Mitchill)	3
Notropis spilopterus (Cope)	5
Notropis whipplei (Girard)	2
Pimephales vigilax (Baird and Girard)	1
Dorosoma pentenese (Gunther)	26
Alosa chrysochloris (Rafinesque)	2
Labidesthes sicculus (Cope)	25
Moxostoma duquesnei (Lesueur)	1
Micropterus salmoides (Lacepede)	5
Pomoxis annularis Rafinesque	2
Lepomis machrochirus Rafinesque	1
Lepomis microlophus (Gunther)	3

Catostomus commersoni (Lacepede)	1
Hypentelium nigricans (Lesueur)	48
Minytrema melanops (Rafinesque)	3
Moxostoma erythrurum (Rafinesque)	6
Moxostoma duquesnei (Lesueur)	12
Pylodictis olivaris (Rafinesque)	2
Amblopolites rupestris (Rafinesque)	4
Lepomis auritus (Linnaeus)	26
Lepomis cyanellus Rafinesque	1
Lepomis machrochirus Rafinesque	8
Lepomis microlophus (Gunther)	1
Micropterus salmoides (Lacepede)	1
Etheostoma blennioides Rafinesque	1
Etheostoma rufilineatum (Cope)	2
Etheostoma simoterum (Cope)	2
Etheostoma zonale (Cope)	3
Percina aurantiaca (Cope)	2
Percina evides (Jordan and Copeland)	4
Cottus carolinae (Gill)	12

T.G.F.H.R.C. 3 Hiwassee River, 2.2 mi. above 411 bridge, on south side of island, Polk Co., Tenn. April 11, 1969. G. Martin, P. Wilkins, W. Seawell, W. Starnes.

Ichthyomyzon bdellium Jordan	1
Lampetra lamottei (Lesueur)	1
Moxostoma duquesnei (Lesueur)	3
Lepomis auritus (Linnaeus)	2

Lepomis microlophus (Gunther)	1
Micropterus dolomieui Lacepede	1
Pomoxis annularis Rafinesque	1
Etheostoma blennioides Rafinesque	6
Etheostoma zonale (Cope)	2
Percina caprodes (Rafinesque)	3
Percina evides (Jordan and Copeland)	2

T.G.F.H.R.C. 4 Hiwassee River, 2 mi. below Apalachia Dam, Polk Co., Tenn. May 5, 1968. State Game and Fish Collection.

Hypentelium nigricans (Lesueur)	3
Rhinichythys atratulus (Hermann)	1
Notropis coccogenis (Cope)	1
Notropis galacturus (Cope)	9
Nocomis micropogon (Cope)	6
Moxostoma duquesnei (Lesueur)	3
Moxostoma erythrurum (Rafinesque)	1
Lepomis auritus (Linnaeus)	9
Etheostoma camurum (Cope)	2
Etheostoma rufilineatum (Cope)	3
Etheostoma simoterum (Cope)	1
Etheostoma zonale (Cope)	2
Percina aurantiaca (Cope)	4
Percina caprodes (Rafinesque)	1
Perca flavescens (Mitchill)	1
Cottus carolinae (Gill)	404

FROM THE OCOEE DRAINAGE IN TENNESSEE

U.T.H.R.C. 40 Tumbling Creek, 200 feet from Ocoee River, Polk Co., Tenn. October 3, 1970. R. and S. Hitch.

Ambloplites rupestris (Rafinesque)	2
Campostoma anomalum (Rafinesque)	3
Notropis coccogenis (Cope)	8
Notropis leuciodus (Cope)	9
Etheostoma rufilineatum (Cope)	5
Cottus carolinae (Gill)	4

U.T.H.R.C. 41 Baker Creek, one mile from Parksville Reservoir, Polk Co., Tenn. September 8, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	24
Notropis telescopus (Cope)	3
Semotilus atromaculatus (Mitchill)	2
Rhinichthys atratulus (Hermann)	6
Hypentelium etowanum (Jordan)	5
Hypentelium nigricans (Lesueur)	
Micropterus coosae Hubbs and Bailey	1
Etheostoma rufilineatum (Cope)	1
Etheostoma simoterum (Cope)	8
Cottus bairdi Girard	1
Cottus carolinae (Gill)	7

U.T.H.R.C. 42 Indian Creek, near Parksville Reservoir, Polk Co., Tenn. August 13, 1970. R. and S. Hitch. Hypentelium nigricans present also.

Rhinichthys atratulus (Hermann)	25

Semotilus atromaculatus (Mitchill) 13

Phoxinus sp. 7

Hypentelium etowanum (Jordan) 1

Gambusia affinis (Baird and Girard) 5

Etheostoma simoterum (Cope) 1

Cottus carolinae (Gill) 5

U.T.H.R.C. 43 Baker Creek, headwaters, 2 miles from Parksville Reservoir, Polk Co., Tenn. September 8, 1970. R. and S. Hitch. Hypentelium nigricans present also.

Campostoma anomalum (Rafinesque) 3

Rhinichthys atratulus (Hermann) 1

Semotilus atromaculatus (Mitchill) 1

Ambloplites rupestris (Rafinesque) 2

Lepomis cyanellus Rafinesque 1

U.T.H.R.C. 44 Haskins Creek, 100 feet from Parksville Reservoir, Polk Co., Tenn. September 8, 1970. R. and S. Hitch.

Rhinichthys atratulus (Hermann) 27

Semotilus atromaculatus (Mitchill) 1

Cottus carolinae (Gill) 2

U.T.H.R.C. 45 Big Creek at intersection with National Forest road, Polk Co., Tenn. September 19, 1970. R. and S. Hitch. Natural reproduction of Salmo gairdneri.

Rhinichthys atratulus (Hermann) 51

Nocomis micropogon (Cope) 4

Salmo gairdneri Richardson 3

Etheostoma blennioides Rafinesque 8

U.T.H.R.C. 46 Maddens Branch near Parksville Reservoir, Polk Co., Tenn. October 18, 1970. R. and S. Hitch.

Rhinichthys atratulus (Hermann)	9
Semotilus atromaculatus (Mitchill)	1
Phoxinus sp.	2

U.T.H.R.C. 47 Sylco Creek, 2 mi. from Parksville Reservoir, Polk Co., Tenn. September 19, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	2
Rhinichthys atratulus (Hermann)	3
Notropis cornutus (Mitchill)	3
Hybopsis amblops (Rafinesque)	1
Gambusia affinis (Baird and Girard)	6
Etheostoma rufilineatum (Cope)	2
Etheostoma simoterum (Cope)	2
Cottus carolinae (Gill)	3

U.T.H.R.C. 48 Rymer Spring Branch, near Ocoee River at intersection with Rt. 64, Polk Co., Tenn. October 18, 1970. R. and S. Hitch

Gambusia affinis (Baird and Girard)	8
Etheostoma simoterum (Cope)	10
Cottus carolinae (Gill)	7

U.T.H.R.C. 70 Rough Creek, 2 miles from Ocoee River, Polk Co., Tenn. October 13, 1970. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	18
Rhinichthys atratulus (Hermann)	17
Etheostoma blennioides (Rafinesque)	7
Notropis coccogenis (Cope)	26
Salmo gairdneri Richardson	2

U.T.H.R.C. 71 Greasy Creek, 1 mile from Parksville Reservoir, Polk Co., Tenn. August 21, 1970. C. Comiskey, C. Setterlund, R. Hitch.

Campostoma anomalum (Rafinesque)	47
Rhinichthys atratulus (Hermann)	43
Notropis coccogenis (Cope)	56
Etheostoma blennioides Rafinesque	8
Etheostoma rufilineatum (Cope)	24
Etheostoma simoterum (Cope)	11

COLLECTIONS MADE FROM THE TOCCOA RIVER SYSTEM

U.T.H.R.C. 49 Mouth of Flat Creek, Fannin Co., Ga. May 15, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	3
Notropis coccogenis (Cope)	3
Notropis leuciodus (Cope)	23
Rhinichthys cataractae (Valenciennes)	1
Etheostoma blennioides Rafinesque	2
Etheostoma zonale (Cope)	2
Cottus carolinae (Gill)	2

U.T.H.R.C. 50 Hemptown Creek at confluence with Cutcane Creek, Fannin Co., Ga. May 14, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	1
Notropis coccogenis (Cope)	13
Notropis leuciodus (Cope)	8
Notropis spectrunculus (Cope)	22
Nocomis micropogon (Cope)	1
Etheostoma rufilineatum (Cope)	2

U.T.H.R.C. 51 Stanley Creek, 1/4 mi. from Toccoa River, Fannin Co., Ga. May 15, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	1
Notropis coccogenis (Cope)	28
Notropis leuciodus (Cope)	13
Notropis spectrunculus (Cope)	1
Nocomis micropogon (Cope)	2
Etheostoma zonale (Cope)	3
Cottus bairdi Girard	1

U.T.H.R.C. 52 Noontootlah Creek, 1/2 mi. from Toccoa River, Fannin Co., Ga. May 30, 1971. R. and S. Hitch.

Notropis coccogenis (Cope)	13
Notropis leuciodus (Cope)	16
Nocomis micropogon (Cope)	11
Hypentelium nigricans (Lesueur)	1
Etheostoma rufilineatum (Cope)	11
Percina evides (Jordan and Copeland)	2
Cottus bairdi Girard	3

U.T.H.R.C. 53 Toccoa River near Rock Creek Fish Hatchery, Fannin Co., Ga. May 30, 1971. R. and S. Hitch.

Notropis coccogenis (Cope)	48
Notropis leuciodus (Cope)	33
Notropis spectrunculus (Cope)	60
Nocomis micropogon (Cope)	76
Moxostoma erythrurum (Rafinesque)	1
Hypentelium nigricans (Lesueur)	5
Ambloplites rupestris (Rafinesque)	1
Etheostoma blennioides Rafinesque	4
Etheostoma rufilineatum (Cope)	5
Etheostoma zonale (Cope)	3

U.T.H.R.C. 54 Weaver Creek, near the Toccoa River, Fannin Co., Ga. May 29, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	2
Notropis coccogenis (Cope)	35
Notropis leuciodus (Cope)	41
Cottus carolinae (Gill)	3

U.T.H.R.C. 55 Charlie Creek, 1 mi. from Lake Blue Ridge, Fannin Co., Ga. May 3, 1971. R. and S. Hitch.

Semotilus atromaculatus (Mitchill)	2
Hypentelium nigricans (Lesueur)	1
Ambloplites rupestris (Rafinesque)	1
Lepomis machrochirus Rafinesque	1
Cottus carolinae (Gill)	3

U.T.H.R.C. 56 Big Creek, near Toccoa River, Fannin Co., Ga. May 15, 1971. R. and S. Hitch. Many large Salmo gairdneri Richardson.

Notropis coccogenis (Cope)	7
Notropis leuciodus (Cope)	4
Notropis spectrunculus (Cope)	6
Rhinichthys cataractae (Valenciennes)	1
Campostoma anomalum (Rafinesque)	1

U.T.H.R.C. 57 Hothouse Creek, Fannin Co., Ga. April 10, 1971. R. and S. Hitch.

Ichthyomyzon hubbsi Raney	2
Notropis coccogenis (Cope)	7
Notropis leuciodus (Cope)	20
Notropis spectrunculus (Cope)	2
Semotilus atromaculatus (Mitchill)	1
Cottus bairdi Girard	9

U.T.H.R.C. 58 Sugar Creek, 1/2 mi. upstream from L. and N. Railroad Bridge, Fannin Co., Ga. May 4, 1971. R. and S. Hitch.

Notropis coccogenis (Cope)	28
Notropis leuciodus (Cope)	32
Semotilus atromaculatus (Mitchill)	3

Moxostoma erythrurum (Rafinesque) 1

Etheostoma blennioides Rafinesque 1

Cottus bairdi Girard 3

Cottus carolinae (Gill) 3

Campostoma anomalum (Rafinesque) 1

Hypentelium nigricans (Lesueur) 1

Nocomis micropogon (Cope) 1

U.T.H.R.C. 59 Sugar Creek, 4 mi. from Toccoa River, Fannin Co., Ga. May 4, 1971. R. and S. Hitch. Many young Salmo trutta Linnaeus.

Notropis coccogenis (Cope) 34

Notropis leuciodus (Cope) 31

Semotilus atromaculatus (Mitchill) 4

Moxostoma duquesnei (Lesueur) 1

Etheostoma simoterum (Cope) 1

Cottus bairdi Girard 3

U.T.H.R.C. 60 Jackcove Creek, 1/4 mi. from confluence with Sugar Creek, Fannin Co., Ga. May 4, 1971. R. and S. Hitch.

Notropis leuciodus (Cope) 1

Hypentelium nigricans (Lesueur) 1

Cottus carolinae (Gill) 2

U.T.H.R.C. 61 Star Creek, 1/4 mi. above Lake Toccoa, Fannin Co., Ga. May 14, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 12

Notropis galacturus (Cope) 2

Hypentelium nigricans (Lesueur) 1

Lepomis auritus (Linnaeus) 2

Cottus bairdi Girard 2

U.T.H.R.C. 62 Skeenah Creek, 1/4 mi. from the Toccoa River, Fannin Co., Ga. May 15, 1971. R. and S. Hitch.

Ichthyomyzon hubbsi Raney	2
Notropis coccogenis (Cope)	15
Notropis leuciodus (Cope)	33
Notropis spectrunculus (Cope)	6
Notropis telescopus (Cope)	3

U.T.H.R.C. 63 Tributary of Hothouse Creek, one mile east of Union Co., Ga. April 10, 1971. R. and S. Hitch.

Notropis coccogenis (Cope)	14
Notropis leuciodus (Cope)	19
Notropis spectrunculus (Cope)	2
Notropis telescopus (Cope)	1
Semotilus atromaculatus (Mitchill)	31
Moxostoma duquesnei (Lesueur)	8
Cottus bairdi Girard	5

U.T.H.R.C. 64 Wilscot Creek, 1/4 mi. from Lake Blue Ridge, Fannin Co., Ga. May 14, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	1
Notropis coccogenis (Cope)	4
Notropis leuciodus (Cope)	4
Nocomis micropogon (Cope)	1
Hypentelium nigricans (Lesueur)	2
Micropterus dolomieui Lacepede	3
Etheostoma blennioides Rafinesque	6
Etheostoma rufilineatum (Cope)	1

Percina aurantiaca (Cope) 4

Percina squamata (Gilbert and Swain) 5

Cottus bairdi Girard 2

Cottus carolinae (Gill) 1

COLLECTIONS FROM THE DRAINAGE OF THE NOTTELY RIVER

U.T.H.R.C. 65 Coosa Creek, at intersection with Rt. 76, Union Co., Ga. May 29, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	9
Notropis galacturus (Cope)	1
Semotilus atromaculatus (Mitchill)	1
Hybopsis insignis Hubbs and Crowe	4
Hypentelium nigricans (Lesueur)	6
Perca flavescens (Mitchill)	4
Lepomis auritus (Linneaus)	2
Micropterus punctulatus (Rafinesque)	1
Moxostoma erythrurum (Rafinesque)	2

U.T.H.R.C. 66 Nottely River at Rt. 180, Union Co., Ga. May 29, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	6
Rhinichthys cataractae (Valenciennes)	8
Hypentelium nigricans (Lesueur)	2
Dorosoma cepedianum (Lesueur)	13
Lepomis auritus (Linnaeus)	13
Ambloplites rupestris (Rafinesque)	1
Percina evides (Jordan and Copeland)	1
Cottus bairdi Girard	4

U.T.H.R.C. 67 Nottely River at Rt. 180, Union Co., Ga. May 31, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque)	4
Notropis spectrunculus (Cope)	6

Semotilus atromaculatus (Mitchill) 2

Rhinichthys cataractae (Valenciennes) 1

Lepomis auritus (Linnaeus) 2

Cottus bairdi Girard 2

U.T.H.R.C. 68 Butternut Creek, at intersection with Rt. 11, near Blairsville, Union Co., Ga. May 31, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 10

Notropis galacturus (Cope) 5

Hypentelium nigricans (Lesueur) 3

Dorosoma cepedianum (Lesueur) 3

Pomoxis nigromaculatus (Lesueur) 1

Lepomis auritus (Linnaeus) 1

Lepomis machrochirus Rafinesque 1

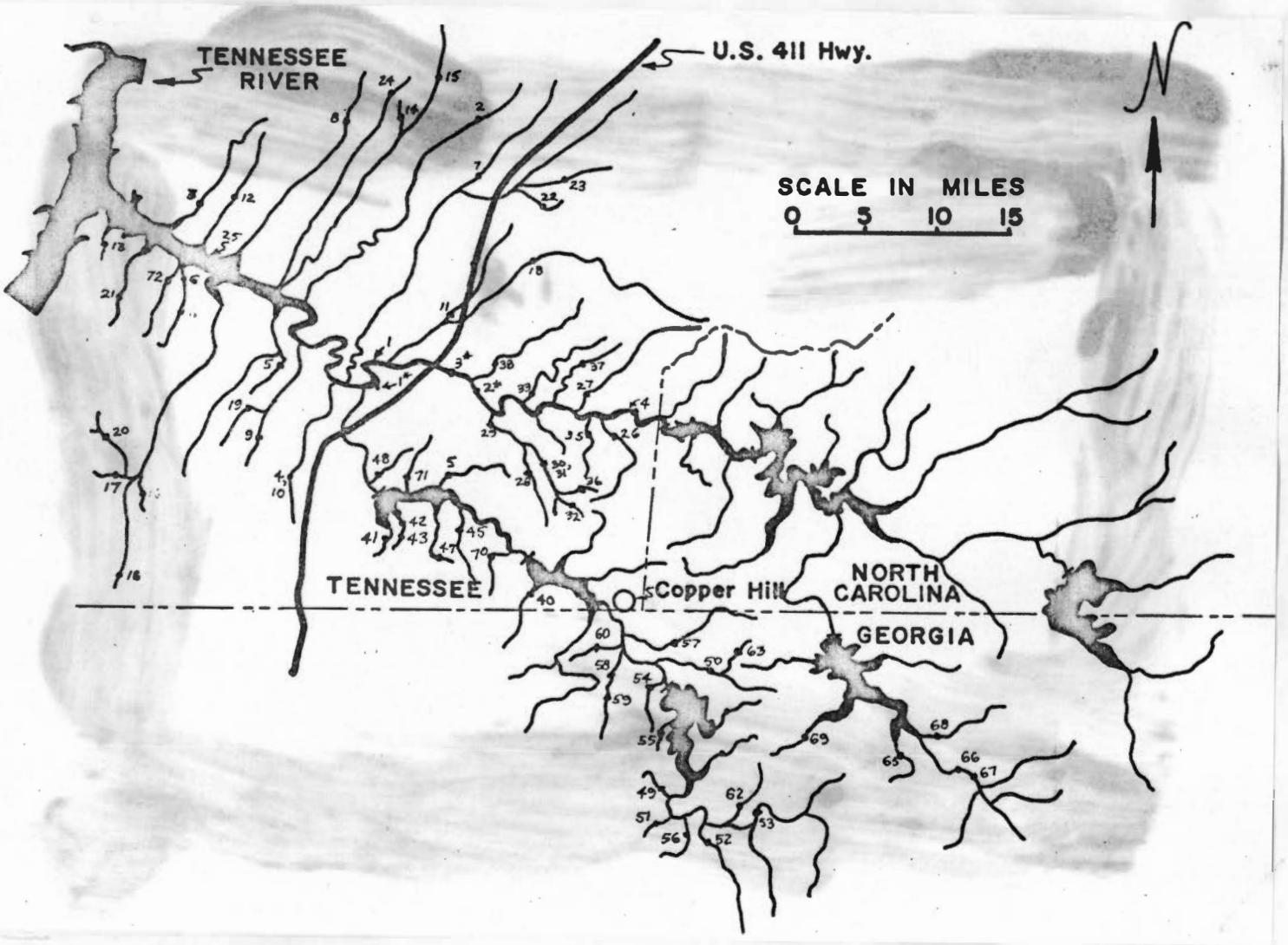
U.T.H.R.C. 69 Youngcane Creek at Queens Gap Road Crossing, Union Co., Ga. May 31, 1971. R. and S. Hitch.

Campostoma anomalum (Rafinesque) 4

Moxostoma erythrurum (Rafinesque) 1

APPENDIX B

The following map shows where collections were taken for this survey. The numbers on the map correspond with the collections listed in Appendix A. For example number one on the map indicates the site of U.T.H.R.C. 1 and one asterisk indicates the site of T.G.F.H.R.C. 1.



Map 1. The Hiwassee River

VITA

Robert Knapp Hitch was born in Oak Ridge, Tennessee on August 15, 1945. He attended elementary and junior high schools in East Tennessee. While a member of Boy Scouts of America he received such titular honors as eagle scout, Order of the Arrow member, and senior patrol leader. When Robert was thirteen his family moved to Damascus, Maryland. At Damascus High School Robert was editor-in-chief of the school newspaper and president of the dramatics club. Mr. Hitch enrolled in the University of Tennessee in 1964. During the summer of 1965 Robert studied the biology of invertebrates at the Smithsonian Institution with the financial aid of a National Science Foundation fellowship. In 1968 he received a bachelor of science degree with a major in zoology. He enrolled in the graduate school of the University of Tennessee in 1968 to study ecology and to assist in the teaching of general zoology. Mr. Hitch is a representative to the Graduate School Association and a member of Phi Sigma Biological Honor Society.

He is married to the former Susan Ann Setterlund of Ardmore, Tennessee.