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Identification and Analysis of Ichthyofaunal Remains from Late Pleistocene-Holocene Deposits of Cheek Bend Cave (40MU261), Maury County, Tennessee

William Clark Dickinson
University of Tennessee, Knoxville

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I am submitting herewith a dissertation written by William Clark Dickinson entitled "Identification and Analysis of Ichthyofaunal Remains from Late Pleistocene-Holocene Deposits of Cheek Bend Cave (40MU261), Maury County, Tennessee." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Ecology and Evolutionary Biology.

David A. Etnier, Major Professor

We have read this dissertation and recommend its acceptance:

Arthur Echternacht, J. Larry Wilson, Paul W. Parmalee, Walter E. Klippel

Accepted for the Council:

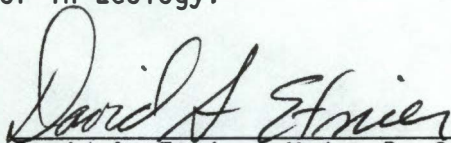
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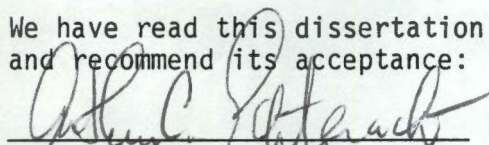
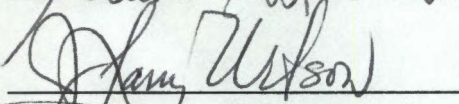
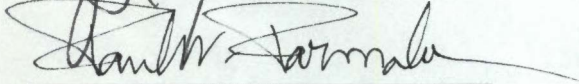
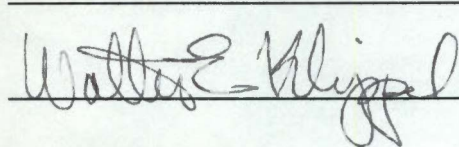
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David A. Ethnier, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:


Vice Provost
and Dean of The Graduate School

IDENTIFICATION AND ANALYSIS OF ICHTHYOFAUNAL REMAINS
FROM LATE PLEISTOCENE-HOLOCENE DEPOSITS OF
CHEEK BEND CAVE (40MU261),
MAURY COUNTY, TENNESSEE

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

William Clark Dickinson
December 1986

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ABSTRACT

Knowledge of the character of the late Pleistocene-Holocene ichthyofauna of the middle Duck River was acquired as a result of identification and biostratigraphic analysis of numerous fish bone fragments from the well-stratified deposits of Cheek Bend Cave, a small rockshelter situated in the limestone bluffs along the Duck River in Maury County, Tennessee. Forty-five unequivocal fish taxa (representing 12 families) were identified, of which 25 taxa occurred in Late Wisconsinan strata, 33 in Holocene strata, and 13 in both depositional sequences. Fifteen of the Late Wisconsinan taxa and 18 Holocene taxa appear to represent initial records for these periods, while 17 taxa are recorded for the first time from fossil deposits. Composing this latter group are small fish taxa from the following families: Cyprinidae, Ictaluridae, Cyprinodontidae, Percidae, and Cottidae.

Of particular interest are an apparently undescribed, extinct cyprinid taxon (mid-Holocene) that presumably has close affinities with species of the modern genera Dionda and Hybognathus and an unusual form of Noturus flavus (Late Wisconsinan and Holocene) which appears to be somewhat distinct from modern counterparts. Although not identified from the cave deposits, Lagochila lacera, the harelip sucker, practically unknown from prehistoric deposits, was identified from the Middle to Late Archaic Hayes Site located on the Duck River in the cave vicinity. From a distributional standpoint, one species identified from the mid-Holocene deposits, Noturus flavater, is noteworthy.

Its modern range is restricted to the southern Ozark region in Missouri and Arkansas.

Indirect evidence of a changing fish fauna is inferred from the concentration of certain groups of fishes in the Holocene strata, namely the Lepisosteidae, Ictaluridae, Cyprinodontidae, and the genus Lepomis. These groups may have been only marginally represented (at least locally) in the presumed middle Tennessee boreal forest region during the last glacial maximum, a distributional situation perhaps analogous to their modern distributions that appear to complement the boreal region of North America. More direct evidence was obtained as a result of the identification, from Pleistocene strata, of three species whose modern ranges are outside the Tennessee region completely (Perca flavescens, Nocomis biguttatus) or to a large extent (Esox masquinongy).

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I. INTRODUCTION

The composition of late Quaternary vertebrate faunas of eastern North America is probably best known from studies of terrestrial vertebrates, primarily mammals. Consequently, the effects of Late Wisconsinan-Holocene climatic changes on the composition, distribution, and extinction of vertebrates are best understood from studies of land-dwelling forms.

Conversely, modification of the eastern North American ichthyofauna in response to these changes is poorly documented; indeed, knowledge of the composition of late Quaternary fish faunas is rudimentary, being non-existent for most areas (Miller 1959, Uyeno and Miller 1963, Miller 1965, Jenkins et al. 1972, Swift and Wing 1968). A number of recent comprehensive works concerning late Quaternary vertebrate studies (e.g., Martin and Wright 1967, Porter 1983, Wright 1983, Genoways and Dawson 1984) have no sections devoted to fishes. While some scattered Late Wisconsinan local ichthyofaunas are known from eastern North America, they are mostly represented by low species diversity, often contain mixed glacial and post-glacial components, and in some cases have only been partially studied and/or provisionally reported.

Reports of Holocene vertebrate paleontological sites (e.g., construction site excavations, natural traps or shelters such as caves and crevices, owl roosts) are scarce in the abundance of

Holocene literature as compared to the number of cultural sites (Semken 1983). Likewise, much of our knowledge of prehistoric Holocene fishes is archaeologically derived, with most of the significant reports of fishes postdating 1950 (Parmalee 1985). However, information on species composition discerned from aboriginal sites may reflect such biases as the nature of the fish populations that were exploited (as influenced by local habitat and fish behavior patterns such as spawning migrations), as well as human variables (e.g., success of capture, size and taste preferences, seasonality of fishing, fishing methods).

While a few late Quaternary deposits rich in diversity of well-preserved fish remains are known, it is rare to find a site that contains both well-stratified Late Wisconsinan and Holocene deposits, particularly in the Mid-South. A deposit of this nature might provide information leading to detection of significant faunal changes and a possible correlation with presumed climatic modification during this time interval.

A depositional site having characteristics that potentially fulfill the criteria above (for analysis of late Pleistocene-Holocene fishes) is Cheek Bend Cave, a small rockshelter situated in the limestone bluffs along the Duck River, approximately 13 km ESE of Columbia, Maury County, Middle Tennessee. Discovered in 1977 by archaeological survey crews from the Department of Anthropology of The University of Tennessee, the site was initially found to contain large numbers of bone fragments distributed within two

distinct zones of aggradation in well-stratified deposits near the cave entrance. The results of several years of excavation (1978-1979, 1982-1983), sorting, and identification revealed the remains of at least the following numbers of vertebrate taxa: mammals (55), birds (60), amphibians (22), reptiles (16), and fish (25) (Klippel and Parmalee 1982a, Klippel and Parmalee 1984).

Of particular interest was the recognition of a number of boreal and/or prairie species of birds and mammals identified from strata of the lower (Late Wisconsinan) zone (e.g., boreal owl, Aegolius funereus; hawk owl, Surnia ulula; prairie chicken, Tympanuchus cupido; arctic shrew, Sorex arcticus; heather vole Phenacomys intermedius; 13-lined ground squirrel, Spermophilus tridecemlineatus) (Klippel and Parmalee 1982a). In addition, the recovery (from the lower zone) of partial remains of the wood turtle (Clemmys insculpta), primarily a northern species, was reported (Parmalee and Klippel 1981a). Strata of the upper (Holocene) zone contained mostly remains of animals existing in the area today.

Although three columns were originally excavated, fish remains were reported (by the author) from only one of these (Klippel and Parmalee 1982a). The study reported herein is the result of the identification and analysis of fish bone fragments from all three columns in an attempt to reconstruct the Late Wisconsin-Holocene ichthyofauna of the central Duck River, a river with an extant fish fauna considered to be one of the most diverse in North America (Nieland 1979, Etnier and Jenkins 1980).

Supplementary information derived from partial identification of material from a small fraction of a fourth column (1982-1983 excavations), as well as that acquired from limited identification of material from nearby archaeological sites, is also presented. The fish faunal composition representing both time intervals (spanning at least the last 16,000 years) is analyzed for significant modification, particularly in conjunction with the paleovegetational and faunal changes (in response to climatic change) in this region that have been suggested by Delcourt (1979) and Klippel and Parmalee (1982a).

Primary objectives of this study were to:

1. Identify to the lowest possible taxon as many elements as possible and practicable,
2. Characterize the cave fish fauna (using ecological and distributional information for extant forms),
3. Compare fish species assemblages represented in late Pleistocene strata with those from Holocene strata as a means of detecting potential faunal changes resulting from transition of glacial to postglacial conditions, and
4. Compare the fish taxa from the cave deposits with the modern Duck River fish fauna to assess potential changes in species composition and possibly river habitat conditions.

II. LITERATURE REVIEW

The developing field of North American late Cenozoic paleo-ichthyology was pioneered almost entirely by E. D. Cope in the 19th century (Smith 1981). Research in the present century has largely been dominated by C. W. Hibbard and R. R. Miller and their students, with much of the work concentrated in deposits west of the Mississippi River. Most of these accounts were summarized in three major works (Miller 1959, Uyeno and Miller 1963, Miller 1965). Records from these important reviews and subsequent studies have been compiled into the most comprehensive list of Neogene through Holocene fossil fishes to date by G. R. Smith (1981). According to Smith, research on Cenozoic fossil fishes has emphasized descriptive natural history with minimal theoretical contribution. He further stated (1981, p. 164) that "Reconstruction of past environments, hydrography, and dispersal, as well as documentation of species occurrences in relation to stratigraphy, have been (and continue to be) primary objectives."

Fossil fish studies of the Late Wisconsinan (the most recent period of maximum glacial advance in the mid-latitudes of the United States) are few and often limited in scope. For eastern North America only 57 unequivocal fish taxa (including some of uncertain identity) were listed by Smith (1981) as late Pleistocene (post-Kansan) in age, a seemingly depauperate list representing the last two interglacial and glacial periods.

The emphasis of the following literature review of Late Wisconsinan ichthyofaunal studies will be on eastern North American local fish faunas, with some discussion of Late Wisconsinan sites west of the Mississippi River from the Dakotas south through Texas. This seems appropriate not only because a review of fossil fishes from this region and period of time has not previously been attempted, but it is also felt that some of the drainage regions of the east-central United States (e.g., Ohio Valley, Ozark Plateau) may have been potential sources of some of the Late Wisconsinan-Holocene Duck River ichthyofauna. Because of the large number of Holocene sites (mostly archaeological) in North America and the limitations they may present in determining unbiased faunal composition, only select sites (mostly those proximal to the Cheek Bend Cave area in the Tennessee River Valley) will be discussed.

As the Pleistocene-Holocene boundary (as well as Holocene chronology) is time-transgressive with respect to latitude (Delcourt and Delcourt 1981, Semken 1983), determination of pertinent sites for review may be difficult, particularly if they are stratigraphically and geographically widely disjunct. Compounding the problem are many sites where stratification is non-existent (i.e., Pleistocene and Holocene faunal components are mixed) or, as in the case of Brynjulfsen Cave No. 1 (Parmalee and Oesch 1972), Pleistocene indicator taxa (usually extinct and/or boreal mammals) may not correlate desirably with an absolute date (in this case, 9440 ± 760 years before the present or YBP). An additional problem frequently encountered is

that often local biotas and/or taxa have been designated merely as Pleistocene, late Pleistocene, or Wisconsinan in age and they may or may not represent Late Wisconsinan deposition.

Based on extensive North American paleovegetation studies, Delcourt and Delcourt (1981), in regard to the time-transgressive nature of the Pleistocene-Holocene boundary, stated that it occurred as early as 12,500 YBP in the Southeast, but as late as 11,000 YBP in the Northeast. In the comprehensive treatment of Holocene mammalian biogeography in the east-central United States, Semken (1983), following Wendland (1978), limited Holocene sites to those 10,000 years old or less. In the survey of literature for the present study, this demarcation was found to be in common usage in various late Quaternary faunal studies. Thus, in the following discussion of Late Wisconsinan fossil fish studies, generally those sites that are dated (relatively or absolutely) in the range of about 22,000 YBP to 10,000 YBP are considered, with a few exceptions. In regard to discussion of the numbers of taxa from various sites and assemblages, the frequently used terms "unequivocal" and "distinct" emphasize maximum diversity of taxa from a site rather than certainty of identification of taxa.

Eastern North American Sites

Several of the earlier documentations of Quaternary fossil fishes (Dawson 1872; Leidy 1889; Lambe 1904; Hay 1917, 1923, 1927, 1929) were mapped and/or referenced in one or more of the following

papers: Uyeno and Miller (1963), Miller (1965), Smith (1981). Although they may not represent Late Wisconsinan deposits (the only references to age given were Pleistocene, late Pleistocene, or Wisconsinan), they were surveyed, nonetheless, via these papers and found to report no more than one or two taxa each. Those sites listed in the papers by Hay were located mostly along the east coast and from them a total of only three freshwater families (Lepisosteidae, Amiidae, Centrarchidae) were represented. The sites reported by Dawson (1872) and Lambe (1904) were located in Canada near the Hudson River and contained only remains of Gasterosteidae and Atlantic salmon (Salmo salar), respectively. Leidy (1889) reported Acipenser fulvescens and Ictalurus nebulosus from cave deposits in eastern Pennsylvania.

In a more recent study by Champagne et al. (1979), four species (Salvelinus namaycush, Osmerus mordax, Gasterosteus aculeatus, Myoxocephalus thompsoni) were reported from a probable Late Wisconsinan or early postglacial deposit (ca. 10,000 YBP) near Ottawa, Ontario, Canada. A late Pleistocene record of the cyprinid Pimephales promelas from Canada has also been documented (Gardiner 1966 in Smith 1981).

Much of the area in the central Great Lakes region (southern Wisconsin, Michigan, northern Indiana) was inundated by ice during the Late Wisconsinan, resulting in a paucity of remaining fish deposits; however, fish remains from post-glacial deposits (less than 3,000 YBP to about 7,700 YBP) have been discovered in bog and

lake sediments from these areas. The fossils (totaling 21 unequivocal taxa) represent recent species near their modern ranges (Wilson 1967, Bland and Bardack 1973, Teller and Bardack 1975, Teller-Marshall and Bardack 1978, Hubbs 1940). An exceptional portion of this formerly glaciated region is the Driftless area of Wisconsin from which Late Wisconsinan fish remains (2 undifferentiated vertebrae) were identified (Moscow Fissure, $17,500 \pm 1,500$ YBP) according to Foley (1984).

From Meyer Cave (Monroe County, Illinois) a small faunal assemblage including at least six species (representing six families) of fishes, all of which are routinely found in the area today, was reported by Parmalee (1967). Although unstratified, recovery of some elements of boreal mammals suggested an early post-Pleistocene age (ca. 10,000 - 8,000 B.C.). Farther east, the Late Wisconsinan (ca. 14,000 YBP) Prairie Creek Site in southwestern Indiana (Davies County), is the source of a large volume of fish material. The assemblage (currently under study by the author) preliminarily consists of at least 20 unequivocal taxa, possibly including several southern range extensions of the extant Indiana ichthyofauna. Elsewhere in the Midwest the first fossil record of mudminnows (Umbra) in North America came from Late Wisconsinan (10,000 - 11,000 YBP) bog deposits in western Ohio (Todd 1973).

In the region of the Ridge and Valley physiographic province extending from northern Virginia into eastern Tennessee, there are several Late Wisconsinan sites with records of fish remains. Near

the West Virginia border in north-central Virginia, the unstratified Natural Chimneys deposit (cave and owl roost) was the source of Late Wisconsinan to early Holocene faunal remains (birds and mammals), including extinct mammalian megafauna. Fish remains (noted as common in the matrix) were identified only as indeterminate Cyprinidae and Catostomidae (Guilday 1962). Remains of 57 uniformly small fish (referred to seven taxa) were recovered from the late glacial deposits ($> 10,000$ YBP) of Clark's Cave, Bath County, Virginia (Guilday et al. 1977). Interesting among the taxa are the uncommonly reported freshwater eel Anguilla cf. bostoniensis (= A. rostrata), two cyprinid taxa (Nocomis cf. raneyi and Semotilus cf. corporalis), and the madtom catfish genus Noturus. Post-Wisconsinan vertebrate remains (including unidentified fish vertebrae and jaw fragments) from a fissure deposit near Ripplemead, Virginia (at the southern West Virginia border), were reported by Weems and Higgins (1977). In addition to elements of several extinct mammalian megafauna, McDonald and Bartlett (1983) reported five bones belonging to the family Catostomidae from Late Wisconsinan palustrine deposits ($13,460 \pm 420$ YBP) near Saltville, Smyth County, Virginia. Examination of these bone fragments and additional material from the site by the author has resulted in verification of four distinct taxa, with most of the remains referable to the white sucker, Catostomus comersoni. From Beartown Cave in extreme northeastern Tennessee (Sullivan County), Guilday et al. (1975) reported one fish taxon (Ictalurus sp.) in their paper on caribou from the Pleistocene of

Tennessee. In the same county, 14 unequivocal taxa of fishes were identified from the Baker Bluff Cave deposit (Guilday et al. 1978). Some of these (in the lower levels) are presumably Pleistocene in age as initial deposition was radiocarbon dated at 19,100 YBP.

In the Highland Rim physiographic province of Tennessee, a few unidentified cyprinid (?) vertebrae have been reported from Robinson Cave (Overton County) which has been dated as late Pleistocene (Rancholabrean) based on the faunal assemblage (Guilday et al. 1969). In the Nashville Basin the First American Bank Site (Nashville, Davidson County, Tennessee), dated as early as 9410 ± 155 to $10,035 \pm 650$ YBP, was the source of several extinct mammalian megafauna, as well as a few indeterminate fish scales (Guilday 1977). Late Pleistocene (Rancholabrean) deposits containing catfish vertebrae (Ictalurus ? sp.) were excavated from the Little Kettle Creek site in the Piedmont of northeastern Georgia (Voorhies 1974).

Swift and Wing (1968) presented a general discussion of fossil bony fishes in Florida in which only several freshwater species were mentioned as occurring in Pleistocene deposits. In addition to ganoid fishes, two catfishes (Ictalurus nebulosus and I. punctatus) and one centrarchid (Lepomis microlophus) were listed. Apparently a number of these remains were identified from the Vero Beach locality, a site formerly investigated by Hay (1917) and later by Weigel (1963).

Cavender et al. (1970) reported a Late Wisconsinan pickerel (Esox cf. niger) from the Ichucknee River local fauna (fluvial)

deposits in Columbia County, Florida); also mentioned were remains of suckers and catfishes in association with the pickerel. They further stated that this represented the initial fossil record of Esox in Florida. Crossman and Harington (1970) mentioned, however, a brief comment by Myers (1938) concerning a large jaw of either E. lucius or E. masquinongy from the Pleistocene of Florida. Although the possibility of either of these latter species formerly occurring in Florida seems unlikely based on their modern distribution and ecology, the generic referral presumably is valid. This would be in apparent agreement with the designated Florida Esox sp. locality on the global distribution map (including modern range and various fossil localities) of Esocidae in Crossman and Harington (1970). However, in a subsequent paper (Crossman 1978), the fossil occurrence of Florida E. niger is denoted on the distribution map for that species. Complicating matters further, this is in disagreement with his discussion of the fossil record for this species in North America, in which he points out that the only two possible fossil records were from Texas and Oklahoma (1978, p. 21).

Sites West of the Mississippi River (Central United States)

Five species of fishes (representing four families) were identified from lacustrine deposits of the Seibold Site (ca. 9,500 YBP) in southeastern North Dakota (Cvancara et al. 1971). The fossils, generally well-preserved complete skeletons (some with

scales), represent species that exist in the area today: Hybognathus hankinsoni, Notropis heterolepis, Fundulus diaphanus, Perca flavescens, and Eucalia (= Culaea) inconstans. From Sheridan County North Dakota postglacial lake deposits, two cyprinid species, Semotilus atromaculatus and Chrosomus (= Phoxinus) neogaeus, and one sucker, Catostomus commersoni, were tentatively identified (Sherrod 1963); however, their stratigraphic position is obscure (Cvancara et al. 1971).

Probably the most significant late Quaternary fish site in the north-central plains is the Wisconsinan Ree Heights deposit (Hand County, South Dakota). Initially described as Eocene by Cope (1891), the ichthyofauna has since been revised and expanded (Ossian 1973) following subsequent studies of the geology and paleontology of the site vicinity. Twelve taxa, including the initial fossil reports of darters (Etheostoma exile and Percina cf. copelandi), a madtom catfish of the subgenus Rabida (Noturus cf. hildebrandi), and two sunfish (Lepomis gibbosus and L. macrochirus) were reported.

From Boney Spring (Benton County, Missouri), located in the western Ozark highlands, 11 unidentified fish fragments (10 vertebrae and one fragmentary tooth) from spring deposits (late Woodfordian, ca. 13,000 - 16,500 YBP) were identified (Saunders 1977). Parmalee and Oesch (1972) listed three fish taxa (Cyprinidae sp., Ictalurus sp. and cf. Lepomis sp.) from Brynjulfsen Cave No. 1 (9,440 ± 760 YBP) in north-central Missouri (Boone County), in addition to several extinct mammalian megafauna.

Several Late Wisconsinan fish sites are known from Texas. A single fish taxon, Lepomis cf. cyaneus, was identified from a deposit (ca. 11,000 YBP) in Randall County (Schultz and Cheatum 1970). Near the eastern base of the Texas Panhandle (Hardeman County), the Groesbeck Creek fauna (16,775 \pm 565 YBP) reportedly included abundant fish remains representing many genera and species (Dalquest 1965); however, these records are presumably still unpublished. The Late Wisconsinan Ben Franklin local fauna in northeastern Texas (Delta County) was investigated by Uyeno (1963), who reported six unequivocal taxa including Esox sp. (probably E. americanus or E. niger); all the taxa can be found living in the area today. Swift (1968) listed six unequivocal freshwater fish taxa from the mid-late Wisconsinan (20,000 to 40,000 YBP) Ingleside Pit deposit in San Patricio County, Texas; the freshwater pond deposit is located within 2 km of the coast. According to Swift, fish distributions in Texas apparently underwent minimal change during late Pleistocene times. From the Louisiana Gulf Coast two taxa of Wisconsinan fishes (Lepisosteus spatula; Osteichthys indet.) were listed by Domning (1969).

Holocene Paleoichthyology

As previously mentioned, most of our knowledge of North American fish faunas occurring since the terminus of the Wisconsin glacial period comes from archaeological studies; also discussed were some potential factors that may affect fish faunal interpretation

from such sites. Semken (1983) compared Holocene paleontological and zooarchaeological samples for use in faunal analyses and discussed various factors that may influence faunal accumulation in both types of deposits. Parmalee (1968) discussed the use of cave and archaeological animal remains as indicators of Holocene animal populations and distribution in Illinois. Two major sources of literature on archaeological faunal analyses are the extensive bibliographies by Bogan and Robison (1978) and Lyman (1979), including works by such pioneers in the field as Paul W. Parmalee, John E. Guilday, and Stanley J. Olsen. Although the majority of pertinent references emphasize terrestrial vertebrates, a number of papers are concerned with fish faunal material either directly or indirectly (e.g., identification, subsistence, utilization). Cleland (1966) provided a map and extensive list of archaeological sites (with faunal remains) occurring in much of the upper east-central United States, including lists of fishes from several sites. Probably the most comprehensive work available on the use of fish remains in archaeological and paleoenvironmental studies is that of Casteel (1976); however, most of the examples of application utilize fish species or assemblages from the western United States, and from other countries. Details of North American aboriginal fishing methods and fish food preferences, as well as fish life history and distribution information, are provided in the comprehensive work by Rostlund (1952).

Although a few Holocene deposits have yielded diverse fish faunas, as have the Apple Creek Site (Parmalee et al. 1972) and the Newbridge

Site (Styles 1981), which both list about 30 taxa, they are usually from late Holocene (generally Woodland through Historic) deposits. The vast majority of Holocene sites (particularly Early through Middle-Archaic) have been found to contain much less diversity in fish taxa. With few exceptions there appears to be a definite paucity of small fish species (e.g., minnows, darters) recorded from archaeological sites. This size bias in species is likely due, in part, to one or more of the factors (or related factors) discussed earlier (e.g., aboriginal preference, success of capture); however, modern variables may have played a role, too. For example, field recovery techniques, sampling methodology, accessibility of diverse fish skeletal collections, and interests and expertise of the investigators may be largely responsible, in some cases, for the lack of small fish species identifications in zooarchaeological (as well as paleontological) reports.

The more routine use of improved faunal recovery techniques such as fine screening (Hibbard 1949) and flotation (Struever 1968), as well as greater emphasis on identification and utilization of small remains from natural and archaeological sites, will likely augment our knowledge of Holocene fish faunas in the future. A growing number of diversified collections of Holocene fish material awaiting detailed identification are presently stored at various institutions (pers. comm., Holmes A. Semken, Jr., Paul W. Parmalee). As it would be far beyond the scope of the present discussion to attempt a review of all eastern North American Holocene sites with

records of fish remains, only a few, primarily some of those located in the Tennessee River Valley, will be mentioned here.

In the region of the southern bend of the Tennessee River several Holocene fish sites are known. From the Westmoreland-Barber Site (Archaic to Late Woodland), Hamilton County, Tennessee, seven unequivocal taxa were identified (Faulkner and Graham 1966). Fairly typical of a big river fauna, the species complex included such forms as Ictalurus punctatus, Stizostedion vitreum, and Aplodinotus grunniens, the source of which was presumably the Tennessee River. Ten distinct taxa were listed from Early Archaic to Mississippian deposits in Russell Cave (Jackson County, Alabama). The assemblage, including such taxa as I. punctatus, Lepisosteus sp. and Ictiobus sp., was very similar to the Westmoreland-Barber fish fauna and, likewise, presumably originated in the nearby Tennessee River (Griffin 1974). Oakley and Futato (1975) compiled a list of vertebrates (including fish) from archaeological sites in the Bear Creek watershed (northwestern Alabama) and correlated the list of fish taxa with those from some other sites in the southeastern United States. A total of only 10 unequivocal taxa was listed from 13 sites; again, these were primarily the big river forms mentioned above. From the Anderson Site (ca. 5,000 B.C.), located on the Harpeth River near Franklin, Tennessee, 49 fish bones (from a total of about 35,000 faunal elements) were identifiable to only three taxa (Ictalurus punctatus, Moxostoma sp., Lepisosteus sp.); however, many small elements were apparently lost in the screening process (pers. comm., Mr. John Dowd, Nashville, Tennessee).

Late Holocene fish remains have been reported from Mississippian sites in the upper Duck River area (Faulkner et al. 1976, Robison 1977). From the three sites studied by Robison, a total of nine unequivocal taxa was identified. With the exception of Noturus sp. (madtom catfish) and a cyprinid taxon (cf. Hybopsis sp.), the assemblage consisted of larger taxa frequently reported from archaeological sites (e.g., Moxostoma sp., Ictalurus sp., Micropterus sp.).

A number of archaeological sites in the vicinity of Cheek Bend Cave are currently under investigation by various workers (primarily at The University of Tennessee, Knoxville) participating in the Columbia Archaeological Project. Preliminary lists of fish taxa from two of these sites will be briefly discussed in the Results section.

Additional Literature

Lundelius et al. (1983) have compiled a comprehensive summary paper on late Pleistocene terrestrial vertebrate faunas from North America, with inclusive regional lists of localities and other pertinent information along with accompanying species lists; a number of these papers likewise include information on fishes from those sites.

Underhill (1957) has provided a distributional study of Minnesota minnows and darters as related to Pleistocene glaciation. In a recent paper concerning the origin and zoogeography of the ichthyofauna of the Great Lakes Basin, Bailey and Smith (1981)

discuss not only the stages in the evolution of the basin and its fauna, but also the use of various refugia, as well as specific problems in local speciation and biogeography.

Climatic inference based on fossil fish assemblages was initiated by C. L. Smith (Smith 1954, 1958, 1961, 1962, 1964) according to G. R. Smith (1981), although it has rarely been attempted (if at all) using eastern North American Late Wisconsinan faunas. G. R. Smith (1963) reported on a late Illinoian fish fauna from Meade County, Kansas, and its climatic significance.

Lundberg (1975) published a comprehensive treatment of the fossil catfishes (Ictaluridae) of North America. Included in this summary work are Late Wisconsinan records of several species of the genus Ictalurus from three sites in Florida (Ichucknee River, Sewanee River, and Vero Beach). Additionally, I. melas, the black bullhead (Quitaque local fauna, Motley County, Texas), as well as Pylodictus olivaris, the flathead catfish and I. furcatus, the blue catfish (Centipede Cave local fauna, Val Verde County, Texas), were listed.

III. ENVIRONMENTAL SETTING

Physiography and Ecology of Cave Vicinity

Cheek Bend Cave (40MU261) is located in the south-facing limestone bluffs at the lower end of Cheek Bend (ca. River Mile 152.3) in the Duck River, about 13 km ESE of Columbia, Maury County, Tennessee (Fig. 1). Situated approximately 20 m above the river bed, it is the largest of three small caves along that stretch of the bluff, with a length of 194.4 m and a vertical extent of 13.8 m. Resting near the base of the bluff (primarily consisting of Ridley Limestone of the Stones River Group), the three caves lie approximately 192 m above mean sea level (MSL) (Klippel and Parmalee 1982a).

The cave vicinity, as well as much of the middle Duck River, is located in the Nashville Basin (Central Basin) physiographic region (Fig. 2). This region is in the Interior Low Plateaus physiographic province (Hunt 1974) which extends from the unglaciated areas of southern Ohio and Indiana south to the Tennessee River in northern Alabama (Fig. 3).

Located almost entirely in central Tennessee, the Nashville Basin is one of four sections of the Interior Low Plateaus province. The other sections are the Highland Rim, which completely encloses the basin, the bluegrass section (Lexington Plain) in eastern Kentucky and the Shawnee section in the western Kentucky area (Fenneman 1938).



A



B

Fig. 1. Photographs depicting location of Cheek Bend Cave (40MU261). A. Aerial photograph of south-facing limestone bluffs above the Duck River. B. Entrance to Cheek Bend Cave. (On file in Department of Anthropology, The University of Tennessee, Knoxville.)

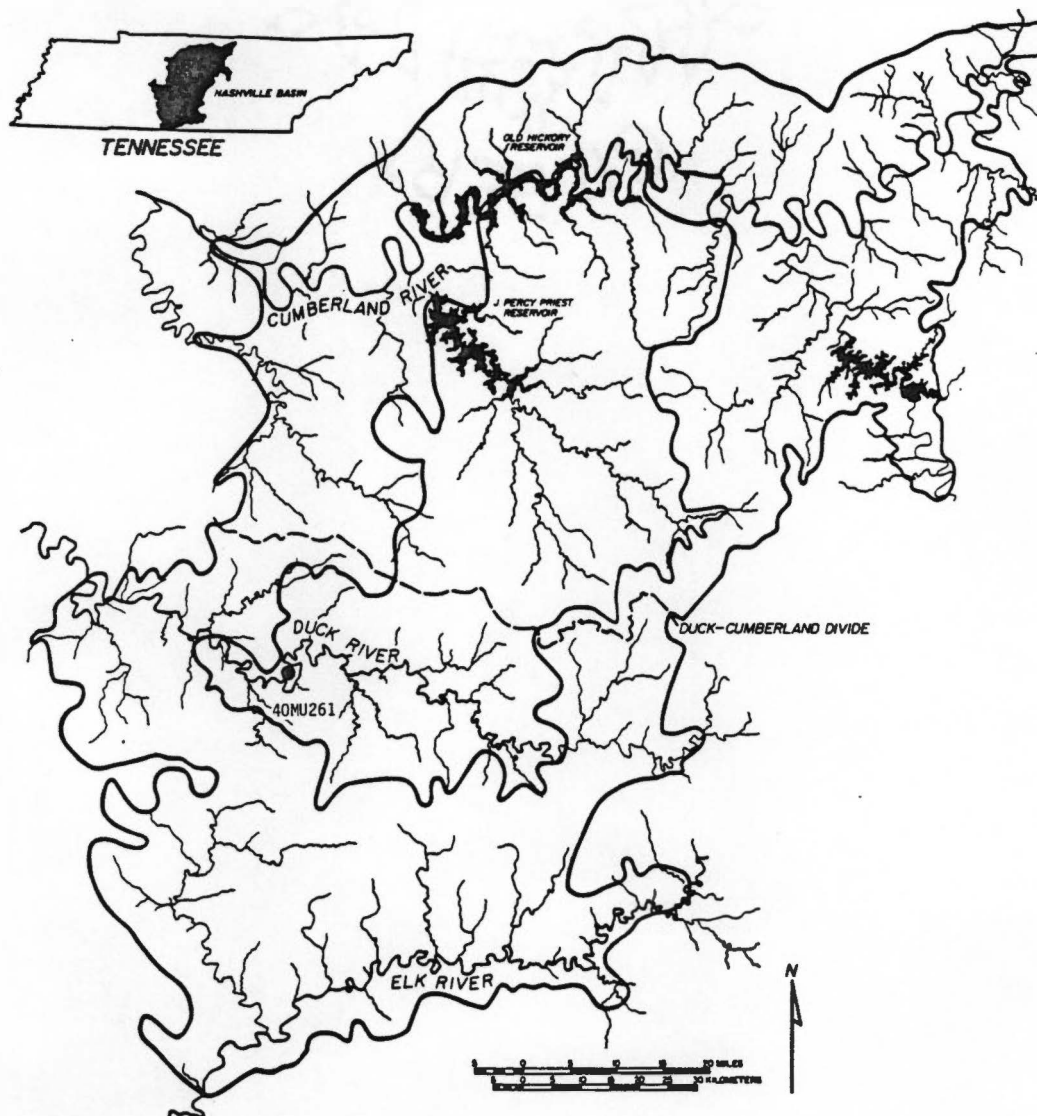


Fig. 2. The Nashville Basin in Tennessee. Cheek Bend Cave (40MU261) is located in the Inner Basin (delineated by the inner heavy line--after Edwards et al. 1974) (from Klippel and Parmalee, 1982a).

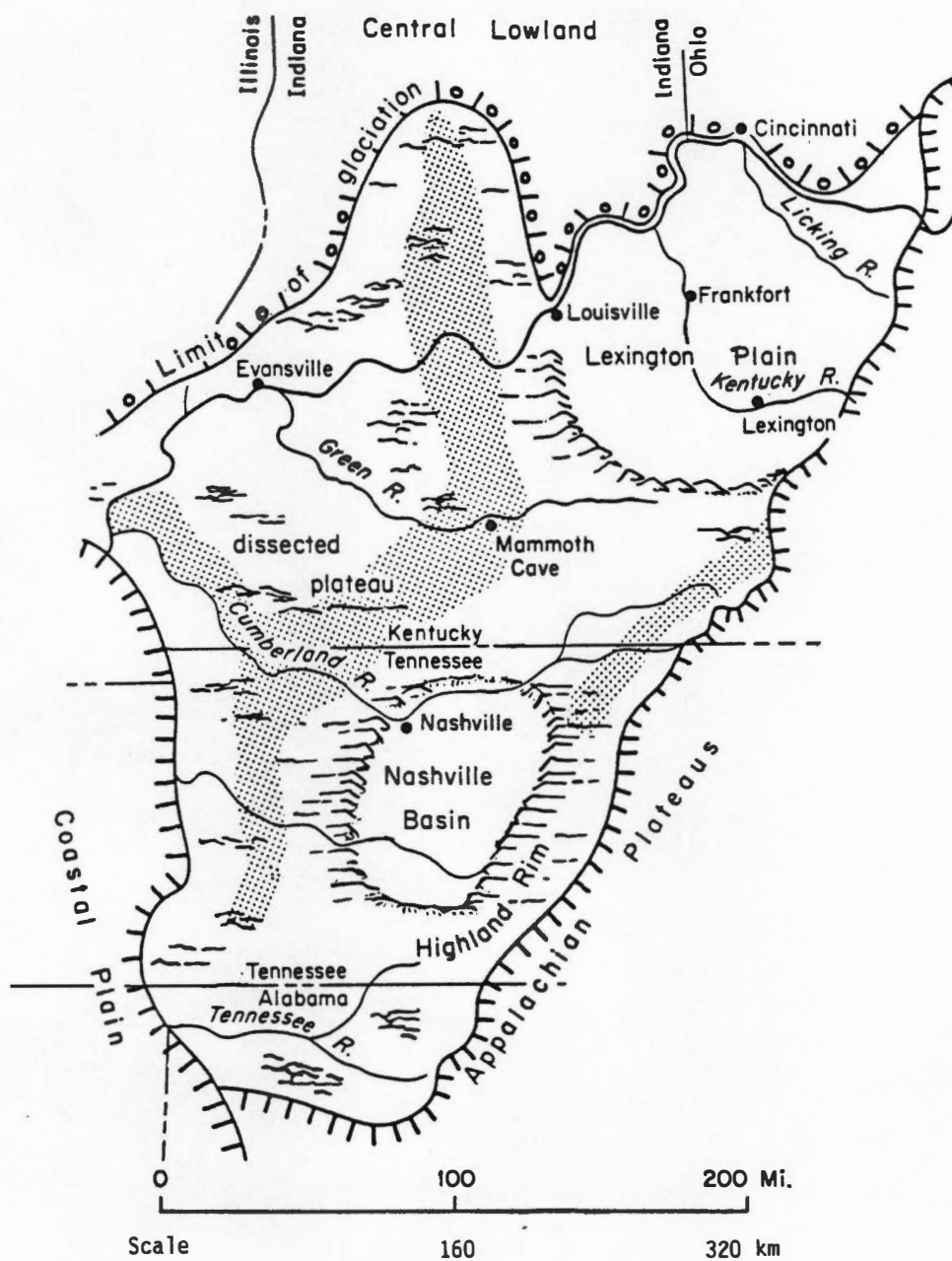


Fig. 3. Interior Low Plateaus physiographic province (diagrammatic representation) (after Hunt 1974).

Each section is characterized by distinctive bedrock geology, the Highland Rim being underlain by Mississippian limestones, while the limestones of the Nashville Basin are primarily of Ordovician age. The limestones are often cavernous and sinkholes in the land surface are not uncommon. Springs are numerous in this region; however, many of the weaker springs and smaller streams are seasonal (Bouchard 1972).

Eroded out of the surrounding Highland Rim, the elliptical-shaped basin occupies an area of approximately 15,300 km² with a north-south dimension of approximately 170 km and an east-west distance of about 104 km, according to Edwards et al. (1974). Surrounding infacing escarpments to approximately 120 m (Hunt 1974) form a physical boundary with a nearly level surface rising to altitudes of 290 to 335 m MSL; on the other hand, elevation near the center of the basin ranges from 152 to 229 m MSL (Edwards et al. 1974). Middle Ordovician limestones (Nashville and Stones River Groups) predominate in the bedrock geology of the basin (Edwards et al. 1974, Miller 1974), with Lebanon and Ridley limestones (Stones River) being the most prevalent underlying the immediate Cheek Bend Cave vicinity.

Most workers, including Edwards et al. (1974) (the source of much of the following discussion), have chosen to divide the basin into outer and inner regions, based largely on physical characters. The outer region (ca. 10,878 sq. km.) is almost completely underlain by phosphate-rich limestones, and is generally deeply

dissected with steep slopes between narrow, rolling ridgetops and valley floors. Surface drainage is dendritic with stream gradients that are moderate to moderately strong. Above the flood plains soils range from 0.6 to 3 m in thickness; approximately 99% of the soils in the outer basin are well drained (Edwards et al. 1974).

The inner portion of the Nashville Basin (ca. 4403 sq. km.) consists almost entirely of limestones poor in phosphates and has a smoother, undulating to rolling surface (relief generally less than 60 m) with a lower average elevation than that in the outer region. Soils in the area are characterized as moderately to poorly drained with surface drainage that is often rudimentary or lacking; karst areas are a common feature. Soil depth above bedrock is significantly less than that described for the outer basin and smooth surface areas largely occupied by limestone outcrops (cedar glades) are common (Edwards et al. 1974). Major rivers draining the basin include the Cumberland, Harpeth, and Stones (the latter two tributary to the Cumberland) in the northern region, while the Duck and Elk rivers (Tennessee River drainage) drain most of the southern basin.

Minimal clearing of vegetation had occurred in the basin prior to 1880, when dense, deciduous hardwoods (Western Mesophytic Forest) covered much of the land surface, particularly in the outer basin. Cedar glades (especially in the inner basin) existed as scattered patches in the hardwood forest wherever xeric outcrops of limestone were predominant surface features (Braun 1950, Edwards

et al. 1974). Presently, many steep areas in the outer basin are covered with secondary deciduous forests, while rolling hills and some steep areas are in pasture or cultivation. On the contrary, a substantial part of the inner basin is used for agricultural purposes.

Dominant plant communities in the immediate Cheek Bend Cave vicinity (< 1 km) are cedar and hardwood glades in various stages of succession that include grasses, herbs, shrubs, cedar, hackberry, elm, and oaks. These are gradually replaced by a more characteristic deciduous oak-hickory forest (Western Mesophytic Forest) in more outlying areas of deeper soils (Edwards et al. 1974, Klippel and Parmalee 1982a).

Duck River

The Duck River, originating in the uplands of northwestern Coffee County, Tennessee (ca. 420 to 430 m MSL) flows northwest along a course of approximately 468 km, terminating at its confluence with the lower Tennessee River (ca. 110 to 115 m MSL) in Humphreys County, Tennessee (Nieland 1983, Anonymous, TVA 1975). Draining portions of seven counties (Fig. 4), total watershed area (exclusive of its major tributary, the Buffalo River, near its mouth) is approximately 7,164 km² (Nieland 1983). Stream types range from small, swift spring-fed streams to the large, rather sluggish main channel.

Brakenridge (1984) considered the Duck River as an "ingrown" meandering river, characteristic of many rivers in the central

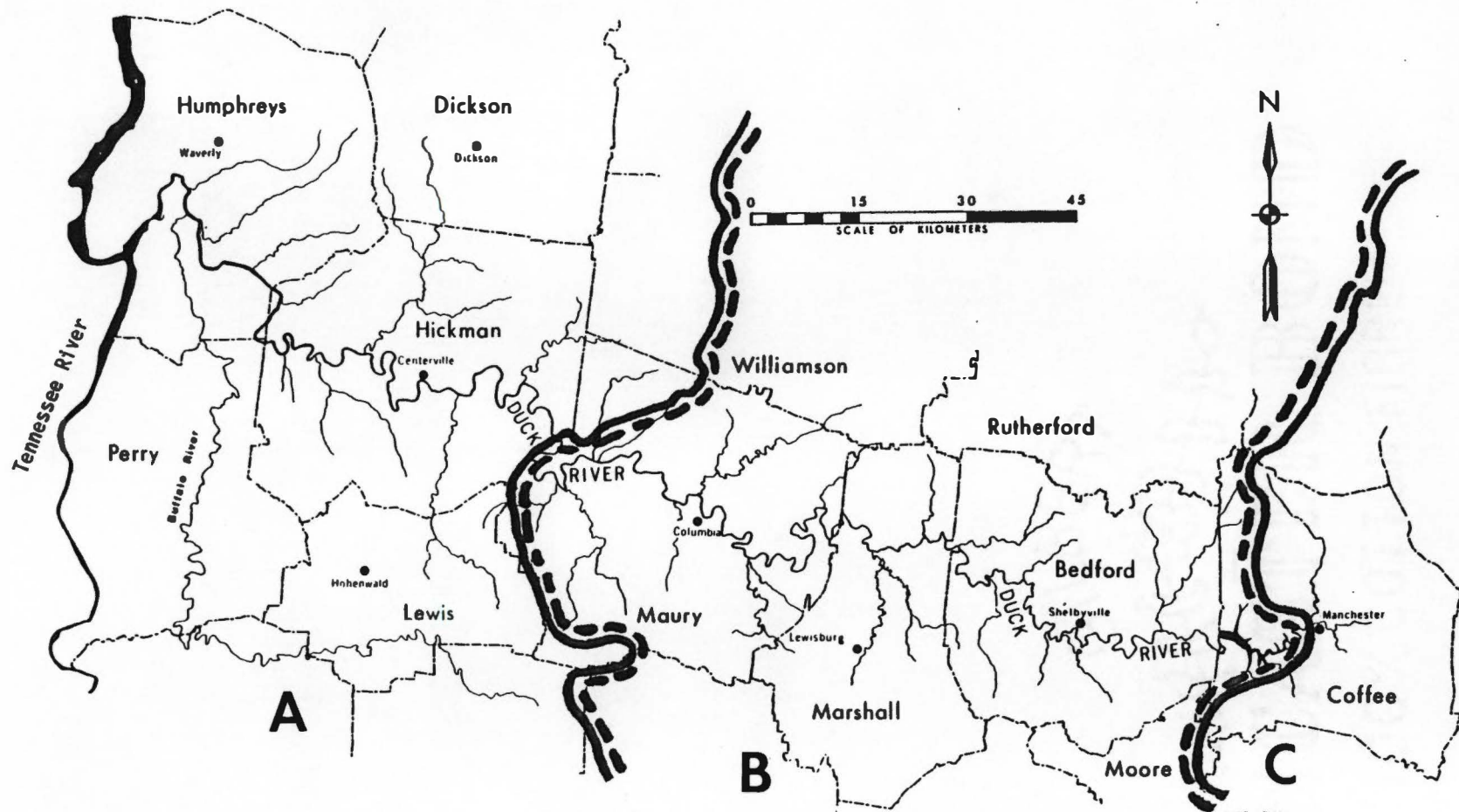


Fig. 4. Map of the Duck River system, Tennessee (after Nieland, 1983). The river drains three regions of the Interior Low Plateau: A. Western Highland Rim, B. Nashville (Central) Basin, and C. Eastern Highland Rim.

uplands of the United States that have typically formed relatively deep, narrow valleys in the resistant bedrock. He further noted that a stretch of river (RM 137 to 157) in the area of Cheek Bend Cave likewise ". . . is confined between steep or vertical bedrock slopes on the outside of bends and gradually sloping bedrock 'slip-off' slopes on the inside of bends . . .," resulting in the characteristic strongly asymmetrical river bed (cross section) profile and well expressed flood plain (1984, p. 10).

The Duck River is perhaps unique in that its headwaters originate in the Highland Rim physiographic province (Eastern), while the upper and middle reaches completely traverse the Nashville Basin province and the middle through lower reaches flow through the western portion of the Highland Rim (Fig. 4). Highland Rim streams generally have a moderate gradient with gravel substrates; however, bedrock substrates may be common, particularly in the pools of eastern rim streams. Nashville Basin streams distinctively have a lesser average gradient, with limestone bedrock as the predominant substrate and gravel substrates noted occasionally in streams adjacent to the rim (Nieland 1983). While many headwater streams in the eastern rim area are influenced by abundant spring flow, numerous basin streams become dry or nearly so during summer and early fall. Average September streamflow at Columbia (downstream from Cheek Bend ca. 29 km) was reported as 11.7 m³ per second but was noted as subject to apparent wide fluctuation (Anonymous, TVA 1975).

The lower reach of the Duck River (ca. 45 km) becomes a larger, free-flowing river impounded at the extreme lower portion by the Tennessee River (Kentucky Lake). Lengthy stretches of the main channel lower Duck (e.g., near the mouth of Hurricane Creek in Humphreys County) often have extensive gravel shoal areas that afford a variety of riffle, pool, and backwater habitats. Thus, fish species diversity may often be great (e.g., 90 known from the Hurricane Creek locality according to Etnier and Jenkins 1980). The Duck River System, as a whole, is considered to have possibly the most speciose fish fauna of any North American river (Jenkins and Burkhead 1984), with at least 136 known taxa (Fig. A-1).

Agricultural practices were introduced along areas of the middle Duck River by settlers in the early 1800s. A correlation between these practices and increased overbank sedimentation (flood plain accretion) was suggested in the study by Brakenridge (1984). Because of these practices, physical and biological changes in the Duck River and its ichthyofauna undoubtedly occurred during this time and to the present, but the nature and magnitude of these changes are largely unknown.

Additionally, changes in the fauna likely have been occurring (and continue to occur) as a result of impoundment within the system. Normandy Dam, constructed in the headwaters near the Coffee-Bedford County line (RM 248.6), was completed in 1976 with the resulting reservoir having an area of approximately 1,307 ha (Nieland 1983). The proposed Columbia Dam (RM 136.9) would create

a much larger impoundment (about 5,100 ha); however, its future is uncertain pending documentation of the status of endangered species (molluscs) and current review by various governmental agencies. Although an older small dam near Columbia (ca. RM 133.5) is still functional, its effects are minimal as compared with the proposed effects of the completed Columbia Dam which would result in a high-water level reaching near the entrance to Cheek Bend Cave (pers. comm., W. E. Klippel).

IV. METHODS OF INVESTIGATION

Excavation, Processing, and Dating of Cave Materials

The following work involving excavation, cleaning, and sorting of faunal material from Cheek Bend Cave was conducted largely by staff and students in the Department of Anthropology at The University of Tennessee, Knoxville. Initial funding was provided by the Tennessee Valley Authority (TVA) (Contract No. TVA TV-49244A and TVA TV-53013A).

Three 1x2 m columnar units were excavated along the east wall (near the entrance) to a depth of approximately 4.5 m (Fig. 5). Cave fill from the two outside units (104N/100E and 100N/100E) was removed in arbitrary 10 cm levels, while the middle column (102/100E) was excavated according to natural strata. Layers comprised of uniform deposits of silt, rock debris and faunal elements, or combinations of other naturally deposited materials were removed separately (Parmalee and Klippel 1981b). Subsequently, these natural depositional layers were correlated with the arbitrary levels from the other two columns to determine more precisely a sequential pattern of deposition. The two distinct episodes of aggradation (corresponding to Late Wisconsinan and Holocene times) mentioned earlier in the Introduction were further subdivided into eight major strata (Fig. 6), based on the physical nature of the deposits and preliminary faunal analysis (Klippel and Parmalee 1982a,b);



Fig. 5. Photograph depicting initial stages of excavation in Cheek Bend Cave (on file in Department of Anthropology, The University of Tennessee, Knoxville).

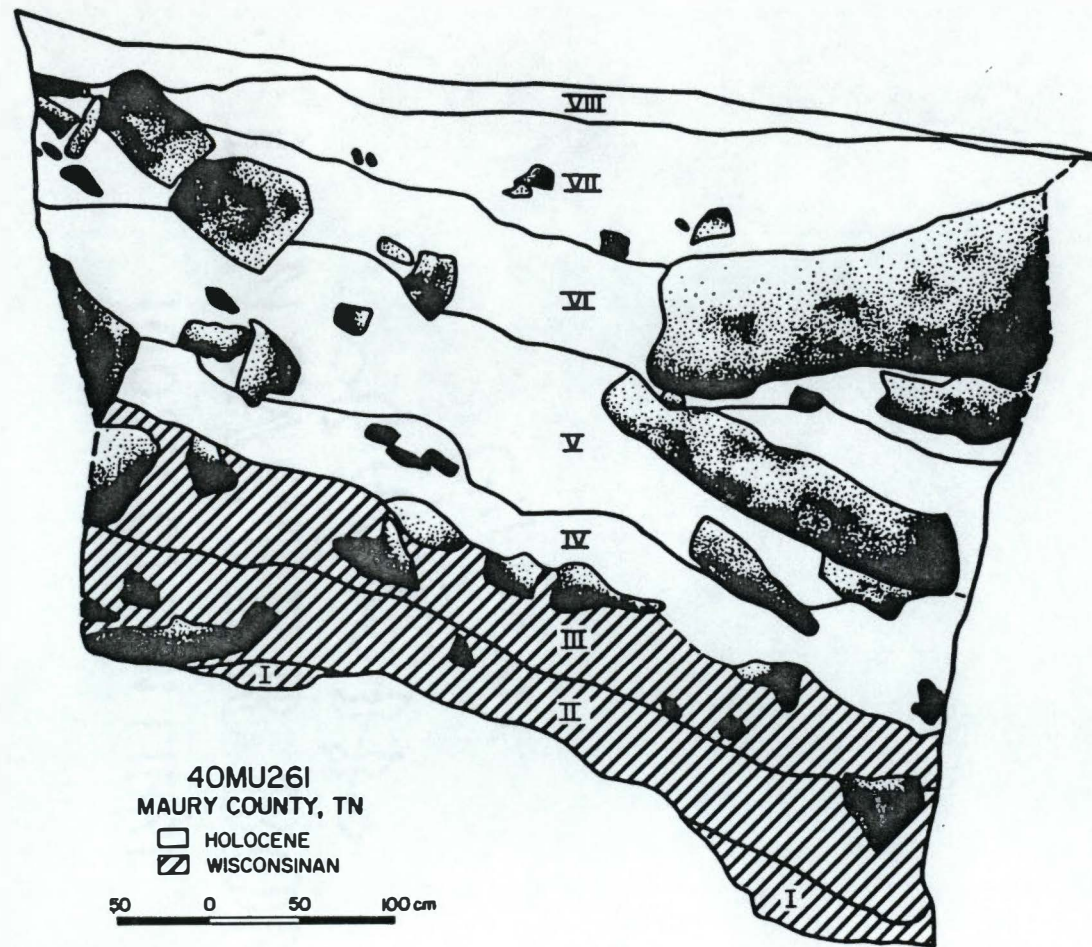


Fig. 6. Diagrammatic illustration of east-facing vertical profile (100N/100E-104N/100E) of Pleistocene and Holocene strata, Cheek Bend Cave (from Klippel and Parmalee 1982a).

strata I-III represent late Pleistocene deposition while strata IV-VIII denote Holocene fill.

All material was water screened at the cave site through a series of screens (12.5 to 1.5 mm mesh) after which the smaller material (e.g., bone, chert flakes, shell, charcoal) was bagged and transported to a field station near Columbia, Tennessee. Sorting of material was later conducted at the laboratory facilities of the field station and the Department of Anthropology at The University of Tennessee, Knoxville. Initial sorting of all faunal materials was undertaken by Paul W. Parmalee.

Aboriginal occupation of the cave was apparent from various sources of evidence in Strata V-VIII (e.g., chert flakes, scorched bone, mollusc shells, ceramic sherds), suggesting occasional human habitation for more than 7,000 years. Absolute dating (from charcoal) indicates that Stratum V was being deposited approximately $7,505 \pm 440$ YBP, while Strata VI and VII were aggrading at $4,655 \pm 75$ YBP and $2,630 \pm 255$ YBP, respectively (Klippel and Parmalee 1982a). Relative dating of the strata (for this study) follows biostratigraphic micromammal (insectivore) evidence from the cave as suggested by Klippel and Parmalee (1982a,b), which they found to be congruent with Late Wisconsin-Holocene paleovegetational chronology proposed by Delcourt (1979) for Middle Tennessee. Combined evidence from these studies is briefly summarized in Table 1.

Table 1. Dating of Cheek Bend Cave strata (based on combined evidence from Delcourt 1979 and Klippel and Parmalee 1982a,b).

Strata	Time Interval
VI-VIII	Late Holocene, ca. 5000 YBP - 200 YBP
V	Mid-Holocene, ca. 8000 - 5000 YBP
IV	Early Holocene, ca. 12,500 YBP - 8000 YBP
III	Late Glacial, ca. 16,500 YBP - 12,500 YBP
I-II	Full Glacial, ca. 18,000 YBP - 16,500 YBP

Identification and Analysis of Fish Remains

The initial problem at the outset of the investigation was that of discerning osteological features of various taxa (often requiring specimens from a range of size classes and localities) of pertinent families (e.g., Cyprinidae, Catostomidae, Ictaluridae). Also, it was sometimes necessary to consider not only modern Duck River taxa, but also relevant taxa from other drainage regions as well (e.g., Ozark Plateau, Ohio Valley, midwestern plains, south-eastern Coastal Plain).

The comparative material utilized in this study primarily consisted of the disarticulated fish research skeletal collection (hereafter designated as U.T.Z.C.) housed in the Zooarchaeology section of the Department of Anthropology at The University of Tennessee, Knoxville. This was supplemented, in part, by use of dry skeletal material from the author's personal collection. Processing of both collections was generally accomplished by microbial maceration in water, while a few skeletons were processed by dermestid beetles. Some study specimens prepared by "clearing and staining" preserved specimens following the technique established by Taylor (1967), as well as a few partially dissected specimens, were employed as well. The sources of this material were the author's personal collection and the research collection of fishes (U.T.R.C.F.), housed in the Department of Zoology at The University of Tennessee, Knoxville.

Additionally, several large series of cyprinid pharyngeal bones provided by J. T. Eastman (Ohio University, Athens, Ohio) and

some catostomid material provided by R. E. Jenkins (Roanoke College, Salem, Virginia) were utilized. Skeletal material examined at the University of Michigan Museum of Zoology and Paleontology included a single specimen of the extinct hare-lip sucker, Lagochila lacera (on loan from the U.S.N.M.), in addition to various other pertinent taxa from different regions of North America. In a few cases, only one or two comparative specimens of a taxon may have been available for use in identification; however, if possible, a series of specimens (or individual elements), usually from different localities, was used in order to better address the problems of intraspecific and geographic variation.

Although size estimation of original fish represented by the fragmentary remains was not the focus of the study, it was frequently attempted for the purpose of aiding identification within certain groups (e.g., Notropis), as well as to provide potential insight into the sources of deposition of the fishes (e.g., predators, aboriginals, flooding). The method employed usually involved direct comparison of one or more dimensional aspects of the fossil element with modern skeletal counterparts from specimens with known measurements, usually expressed in a conservative range.

Faunal material was identified by levels and summarized by strata. Assignment of identified taxa to the eight principal strata, as well as the smaller intermediate strata (e.g., VI-V), was accomplished with the use of the correlative levels provided in Appendix A.

Identified fish remains are stored (by levels within columns) in the Zooarchaeology Section of the Department of Anthropology at The University of Tennessee, Knoxville. Because of the large number of identified fragments and the pending identification of unsorted cave material (subsequently excavated), individual elements have not been assigned museum numbers or otherwise catalogued.

In addition to the original three columns, partial identification of one level (No. 42) near the bottom of a subsequently excavated (1983) fourth column (101N/99E) augmented the faunal diversity recorded from the late Pleistocene strata. Reconstruction of the mid-late Holocene Duck River ichthyofauna was enhanced by identification of some fish remains from two archaeological sites (40MU423 and 40ML139) in the vicinity of the cave (< 12 km).

It is assumed that the source of most of the fish remains in the cave deposits was the main channel of the Duck River in the local area. This seems likely not only because of its immediate proximity to the cave, but also because of the cave position relative to other river bends north and east (Fig. 2, page 22). Also, the nearest tributary of significant size (Silver Creek) is approximately 5 km south of the cave.

The list of extant Duck River fishes (Fig. A-1) was compiled from the following sources:

1. D. A. Nieland 1983, unpublished manuscript on Duck River fishes on file in the Fish Museum, Department of Zoology, The University of Tennessee, Knoxville.

2. Records from The University of Tennessee, Knoxville, Fish Museum collection files.
3. D. A. Etnier 1986, Fishes of Tennessee, manuscript.
4. Lee et al. 1980, Distributional Atlas of North American Fishes.

V. RESULTS

Before results of the study are presented, it is felt that a brief discussion of certain limitations pertinent to the nature of the data collected would be useful in its interpretation. The use of numbers of fish remains (elements) identified for a particular taxon or group of taxa should be done carefully, primarily for the following reasons. First, the large number and diversity of bones in most teleost skeletons (a few hundred or so in most forms) which may become scattered before, during, or following deposition, can render estimation of original number of fish specimens (minimum number of individuals or MNI) a very difficult task. Also, when one considers that some or all of these bones may become fragmented with time (in some cases they may already be broken because of predators, scavengers, or other factors), then attempting to estimate MNI from one or more samples of elements becomes even more complex and difficult. This is particularly true in dealing with deposits containing a large quantity of fragmentary material (as is the case with Cheek Bend Cave). Indeed, the bulk of the elements recovered from the cave deposits consisted of fragments of vertebrae, ribs, spines, rays, pterygiophores (fin supports), scales, and nondescript fragments of cranial bones.

Additional problems to consider are those of a taphonomic nature. Factors such as seepage of elements downward with time,

displacement of elements due to burrowing or digging animals, and differential deposition along the cave floor may further contribute to the problem of estimating original numbers of specimens. In Cheek Bend Cave no evidence of significant displacement of faunal remains due to burrowing activities or seepage was apparent from intensive biostratigraphic investigations conducted thus far (pers. comm., W. E. Klippel).

Differential deposition along the floor of the cave has resulted in a generally oblique downward pattern of stratigraphy from the entrance backwards into the cave (Fig. 3, page 23). Thus, as excavation proceeded vertically from the surface downward, frequently fill from adjacent strata was removed in a single excavation unit (e.g., a 10 cm level). The combination of these "mixed" excavation units between major strata constitute an intermediate stratum (e.g., III/II); intermediate strata, by themselves, are considered uninformative for the purpose of analyzing the biostratigraphy of the cave. However, they are used in combination with the primary strata in two of the time stratigraphical units used in the method of dating the cave material (Table 1, page 35). Additionally, all strata in unequivocal Pleistocene/Holocene contexts (all but the "mixed" Stratum IV/III) are used for the comparison of fish taxa identified from these two depositional zones.

The focus of the previous discussion is that the use of the "presence" or "absence" of a taxon or taxa in one or more strata may be more valid for the purpose of biostratigraphic analysis in

most situations than using numbers of elements of taxa. However, numbers of elements may be used (with caution) in certain situations, particularly where broad comparisons are involved (e.g., familial; Pleistocene vs. Holocene).

The results of the study are presented in six parts, the first five of which furnish information derived entirely from investigations of fish remains from the unequivocal Pleistocene/Holocene contexts of Cheek Bend Cave deposits (excavation units 100N/100E-104N/100E). The final part briefly discusses some additional records of fishes from subsequent excavation in the cave, as well as those from two archaeological sites in the cave vicinity. These additional records, as well as the results of investigations involving the original excavation, will be discussed in more detail in the following section. All tables referenced in the remainder of this section are located in Appendix B.

General Preview

Of an estimated 25-30,000 fish remains examined from the three excavated columns, 2876 were identified to or below the familial level. Identifiable remains were referred to 62 taxa (representing 11 families) of which 45 are unequivocal (distinctly different) (Tables B-1 and B-3).

The sucker family, Catostomidae, had the greatest number of identifiable elements (716), while the least represented families included the Anguillidae and Esocidae with three elements each

(Table B-2). The Catostomidae and the Centrarchidae (sunfishes) accounted for the highest percentages, by family, of the total elements identified for all families with 26.3% and 23.7%, respectively (Table B-2). Unequivocal taxa representing these two families totaled eight (Catostomidae) and three (Centrarchidae) (Table B-3). The Cyprinidae (minnows) and Ictaluridae (catfishes) had the greatest number of unequivocal taxa, 11 and 9, respectively, although they accounted for only 10.8% and 7.1% of the total of identified remains. Regarding similar information for the remaining families, refer to Tables B-1, B-2, and B-3.

Biostratigraphical Analysis

The number of unequivocal taxa, as well as the total number of identified elements, was highly variable among the eight major (principal) strata. The following brief table provides a comparison of number of unequivocal taxa, in addition to total number of identifiable elements, for all the principal strata.

Stratum	I	II	III	IV	V	VI	VII	VIII
Total No. of Taxa	3	21	13	13	30	14	11	6
Total No. of Identified Elements	3	407	120	91	953	196	289	16

Stratum V had the greatest number of identified elements, as well as unequivocal taxa. This stratum, however, contained the

largest number of elements for many vertebrate taxa (refer to tables in Klippel and Parmalee 1982a) and probably contained the largest volume of sediment of all the principal strata (Fig. 6, page 33). As might be expected, the least number of taxa and elements came from Stratum I, the deepest and presumably smallest (in volume of sediment) of the eight principal strata. Stratum II contained the second largest number of unequivocal taxa and total identified elements.

Distribution of fish families among the strata was also quite variable. Catostomid elements were present in virtually all principal and intermediate strata (Table B-1); likewise, lepisosteids, cyprinids, centrarchids, sciaenids (Aplodinotus grunniens), and ictalurids had nearly ubiquitous stratigraphic distributions, with representative elements in all but one to three of the total number of strata. Conversely, elements of the families Anguillidae and Esocidae occurred in only one and three strata, respectively. Intermediate in stratigraphic distribution between these two extremes were the remaining families Cottidae (sculpins), Cyprinodontidae (killifishes), and Percidae (perches).

Several unequivocal taxa, namely Lepisosteus sp., Moxostoma carinatum, Ambloplites rupestris, and Aplodinotus grunniens were broadly distributed stratigraphically, occurring in the majority of the total number of strata (absent in only 2-5 strata). On the other hand, 27 unequivocal taxa were identified from three or less strata (Table B-1). Five of these, Esox cf. masquinongy, Nocomis biguttatus, Notropis cornutus/chrysocephalus, Noturus cf.

nocturnus, and Cottus cf. bairdi occurred in only intermediate strata.

Distribution of taxa and their numbers of elements among the five time-stratigraphical units (e.g., late glacial) designated for the purpose of dating the cave material are the same as that just presented except for changes in the first (full glacial) and last (late Holocene) units. These obviously have greater numbers of elements and taxa due to the combination of several principal and intermediate strata. The distribution and numbers of elements of all taxa within and among these units are presented in Table B-4. The entire stratigraphical distribution (including intermediate strata) for each taxon is recorded in Table B-1.

Pleistocene/Holocene Analysis

The total number of elements identified from the late Pleistocene strata (I-III) was 773, while that for the Holocene strata (IV-VIII) was 1946. The family with the greatest number of identified elements from the late Pleistocene strata was the Catostomidae with 363, followed by the Centrarchidae with 168. These totals represented 50.7% and 26.1%, respectively, of the total elements identified for each of these two families (Table B-2). Contrasting somewhat with these totals and percentages were those of the Cyprinidae and Percidae. Although represented in the Pleistocene strata by fewer elements, 105 (Cyprinidae) and 78 (Percidae), these constituted 35.7% and 45.6%, respectively, of the total number of elements for

each of these two families. Pleistocene totals and percentages of elements for the other families are given in Table B-2.

Of the 11 total families identified, only Anguillidae was not represented in the Pleistocene strata. However, the Lepisosteidae, Cyprinodontidae, and Esocidae had only a marginal occurrence in the Pleistocene deposits, as the total number of representative elements for each was three, five, and two, respectively. Although 25 ictalurid elements were identified from the Pleistocene strata, these accounted for only 12.9% of the total ictalurid elements identified (Table B-2). The large percentage of Pleistocene esocid elements (66.7%) obviously reflects the low number of total elements (three) for that family. With a low percentage of total identified elements occurring in the Pleistocene strata (8.9%), the family Sciaenidae (i.e., Aplodinotus grunniens) was widely represented in the Holocene deposits; however, most of these elements, by far, were from late Holocene strata (Table B-1).

Regarding the Pleistocene occurrence of distinct taxa, a wide range of variability was found in number of taxa per family. Five cyprinid taxa (when Notropis sp. is included; see Tables B-1 and B-3) of 11 total were recorded from the Pleistocene. Of eight total catostomid species, seven were recorded from Pleistocene deposits; similarly, five of six total percid taxa were identified from these lower strata. However, in sharp contrast, of nine total ictalurid taxa known from the cave deposits, only one (Noturus cf. flavus) was identified from the Pleistocene. Altogether, 24

unequivocal taxa were identified from Pleistocene strata while 33 unequivocal Holocene taxa were listed (Table B-3).

Taxa identified from Pleistocene deposits only were: Esox cf. masquinongy, Nocomis biguttatus, Catostomus commersoni, Moxostoma anisurum, M. macrolepidotum, Lepomis cyanellus, Percina caprodes, Perca flavescens, Stizostedion canadense, S. vitreum, and Cottus cf. bairdi. Exclusive to the Holocene were 20 unequivocal taxa while 13 taxa were present in both Pleistocene and Holocene strata (Table B-3).

Several taxa, namely Lepisosteus sp., Fundulus catenatus, Lepomis sp., and Micropterus sp., although not exclusive to the Holocene strata, were concentrated in those strata. Numbers and percent occurrence in the Pleistocene of the total elements of all taxa are presented in Table B-5.

Comparison with Modern Duck River Fish Fauna

The fish fauna identified from the sediments of Cheek Bend Cave was found to have a high degree of overlap with the modern Duck River fish fauna, as well as with the faunas of most river systems in the Tennessee-Cumberland drainage realm of Middle Tennessee. All of the unequivocal taxa listed from the cave are known today to have valid natural (non-introduced) records from the Duck River except the following: Anguilla rostrata, Esox cf. masquinongy, cf. Dionda/Hybognathus, Nocomis biguttatus, N. effusus/micropogon (in part), Notropis cf. stramineus, Noturus flavater, Perca flavescens,

and Stizostedion vitreum. While some of these currently have natural ranges extending well into the Tennessee River System and are assumed to exist in the Duck River, others (Nocomis biguttatus, Noturus flavater, Perca flavescens and, to a great extent, Esox cf. masquinongy) have modern ranges that are outside of the Tennessee region. All of these will be discussed in the following section.

New Late Quaternary Fish Records

Based on the summary lists of late Cenozoic fishes provided in Smith (1981) and a survey of recent archaeological literature for eastern North America, a number of new late Quaternary records of fishes were listed as a result of the investigations of Cheek Bend Cave. Fifteen taxa were recorded from the Late Wisconsinan for the first time, while 18 fish taxa from the Holocene represent new records for that period. Of this total of 33, 17 represent the initial fossil occurrence recorded for those taxa (Table B-3). The cyprinid taxon designated cf. Dionda/Hybognathus and possibly the madtom catfish Noturus cf. flavus apparently represent heretofore unknown taxa and will be discussed later.

Additional Sources of Late Pleistocene/Holocene Fish Records for the Middle Duck River

While identification of fish remains from Cheek Bend Cave was in progress, additional excavation was being conducted at the cave site. Two additional columns (101N/99E and 102N/99E) were

excavated (as were the original columns) to the bottom of the cave. These columns were, however, excavated in 1x1 m units (rather than 1x2 m units) and although dug adjacent to the three previously excavated columns, they were located closer to the middle of the cave floor.

From column 101N/99E, one Pleistocene level (42) near the bottom was partially sorted and surveyed by the author. The list of taxa and elements identified are given in Fig. B-1. Two additional pharyngeal bones of Nocomis biguttatus were identified as well as several bone fragments of the muskellunge, Esox masquinongy. This provided an unequivocal identification of the latter species.

Also, during the latter part of the study, Dr. Paul Parmalee, while sorting through various remains from Pleistocene levels of 101N/99E and 102N/99E, recognized some sturgeon (Acipenseridae) fragments in these two units and turned them over to the author for further scrutiny. Thus, an additional family and species (Acipenser fulvescens) was added to the cave faunal list.

As previously mentioned, some fish remains from two archaeological sites in the vicinity of the cave were also examined. While sorting archaeological samples from the Hayes Site (40ML139), a Middle to Late Archaic midden site located at the confluence of Caney Creek and the Duck River in Marshall County, the author identified several fish taxa. Supplementing this list were a few records supplied by other investigators in the Department of Anthropology, University of Tennessee--namely, Darcy F. Morey and Bruce Manzano. The most

significant fish species recorded from this site (Fig. B-2) was the harelip sucker, Lagochila lacera, an extinct sucker apparently known from only two other sites (unpublished late Holocene records). To date, only a small fraction of fish remains from the Hayes Site have been examined as materials from the site are still under study.

Fish faunal remains from another archaeological site, the late Middle Woodland Edmondson Bridge Site (40MU423) in Maury County, were examined by the author and another investigator, Lynn Snyder, of the Department of Anthropology. Although no new records of fishes were obtained from this survey, additional records of some of the uncommon taxa occurring in Cheek Bend Cave were provided (Table B-6).

VI. DISCUSSION

The following discussion will focus on the characteristics of the fish fauna identified from Cheek Bend Cave, and discuss the results presented in the previous section. Comments on elements used for identification, biostratigraphy, and responses of taxa or groups of taxa to environmental change will accompany the brief, generalized accounts of distribution and habitat when pertinent to the discussion. Unless otherwise indicated, the discussion will concern taxa identified from the unequivocal Pleistocene/Holocene contexts of the originally excavated columns 100N/100E-104N/100E.

Acipenseridae--sturgeons

The lake sturgeon, Acipenser fulvescens, represented by several scute fragments (Fig. C-1A,B), occurred only in the Pleistocene deposits (units 101N/99E and 102N/99E). Three of the fragments appear to be nearly complete cranial elements. The large size and thickness of these and the other fragments were used in identification to the species level. Thickness of the elements ranged from 2.5 to 5.0 mm and they were at least as thick as the comparable scutes from the disarticulated cranial skeleton of a modern specimen of A. fulvescens. The comparative specimen had a recorded length of 6 ft. (ca. 1800 mm) and a weight of 66 lbs. (30 kg). The only other probable species of sturgeon in this region of North America likely were

the two species of Scaphirhynchus (platyrhynchus and albus), which range in maximum standard length to about 800 mm and 1100 mm, respectively (Lee 1980). The occurrence of a sturgeon this large in the cave deposits seems a bit unusual, particularly when presumed time of deposition apparently preceded known aboriginal occupation in the cave by several thousand years. Possibly a scavenger (e.g., bear, raccoon) transported the skull or a portion of it to the cave and subsequently abandoned it, or deposited its remains in the form of scat material.

The lake sturgeon usually inhabits lakes and deeper portions of large rivers, generally over rocky, gravel or mud bottoms (Gruchy and Parker 1980, Becker 1983); it was noted by Trautman (1981) to travel well upstream into many Ohio rivers to spawn. Largely extirpated from many parts of its range, the lake sturgeon is known from Alberta, Canada east across the Hudson Bay drainage to the St. Lawrence estuary, and from the Great Lakes, Ohio and Mississippi drainages as far south as Arkansas and Tennessee, with an isolated record from northern Alabama (Coosa River) (Gruchy and Parker 1980). Although not recorded from the Duck River, presumably it is an occasional inhabitant there, particularly in the lower portion.

Common in late Cretaceous deposits, sturgeon records are rare otherwise, with the exception of a few archaeological records. The Cheek Bend record is presumably the second Pleistocene record of A. fulvescens, the other coming from a Pennsylvania cave (Leidy 1889). Recently, however, the author has examined several sturgeon fragments

recovered by Dr. Gordon Bell from Pleistocene cave deposits in the Tennessee River bluffs in Colbert County, Alabama, and later sent to Dr. Paul Parmalee. The fragments, from a small specimen, have been temporarily assigned to Acipenser fulvescens, based on similarity in parasphenoid structure, contrasting more with that of specimens of Scaphirhynchus platyrhynchus.

Lepisosteidae--gars

All remains of gars were identified only to the generic level. Although one epihyal, a number of vertebrae, and several dentate fragments were identified, the majority of remains consisted of scute and scale fragments (Fig. C-1C). The thick, enameloid-like, often rhomboid scales, accicular teeth, finely-tuberculate scutes, and opisthocelous vertebrae are diagnostic for this group. A significant number of the above-mentioned elements from the late Holocene strata were scorched, indicating an aboriginal source for these remains.

The most likely species to which the remains might be referred are Lepisosteus oculatus and L. osseus. Although both species occur in the Duck River today, the latter species is more common in the cave vicinity. They are both more likely to be found in the less turbid, cooler, upland riverine habitats than the other gar species, although much of the range of L. oculatus overlaps with that of Atractosteus spatula and Lepisosteus platostomus, which tend to be found in more low gradient portions of larger streams (Lee 1980,

Lee and Wiley 1980, Wiley 1980). Lepisosteus osseus is the most widespread gar species, particularly in the Interior Low Plateaus region, extending somewhat farther north (SW Quebec) than L. oculatus.

The nearly ubiquitous distribution of gar remains from Stratum VIII downward into Stratum II (Table B-1) is of interest, particularly in light of the abrupt decline in number of elements following the peak number (139) in Stratum V. The only elements in the Pleistocene are three scales (two in Stratum III and one in Stratum II), less than 1.0% of all gar remains identified. It is at least possible that these elements are intrusive, due to filtering down from higher levels; thus, lepisosteids would appear, under those circumstances, to be absent from the Pleistocene. At any rate, there is a definite paucity of gar remains in the Pleistocene strata as well as from early Holocene Stratum IV.

It seems possible that Lepisosteus sp. may have been affected, at least locally, by the climatic effects of glaciation even as far south as Tennessee. Delcourt (1979) suggested that Middle Tennessee vegetation during the full glacial (corresponding to Stratum I-II) was probably most like forests of southern Manitoba today (Jack pine-spruce-fir). Similarly, she indicated that the late glacial (= Stratum III) mixed coniferous-deciduous forests in Middle Tennessee were similar to those today in northeast Minnesota. Today the northern limits of Lepisosteus (i.e., L. osseus) approximate the southern limit of the boreal coniferous forest (see vegetation map in Delcourt and Delcourt 1981).

Thus, if environmental factors (climatic or otherwise) associated with the northern boreal forest biome are limiting to the Lepisosteidae today, then similar limitations may have been imposed on this group of fishes (at least locally) in the region of Middle Tennessee during Late Wisconsinan time.

Anguillidae--eels

Anguilla rostrata, the freshwater eel, was identified from two premaxillary fragments and one dentary fragment, representing at least two individuals (Fig. C-1E,F); all three elements occurred in Stratum V, representing the mid-Holocene period. Diagnostic characters are the elongated premaxillary and dentary bones, which both have long, flat dentate surfaces bearing several irregular rows of tooth sockets, some of which are greatly enlarged.

The freshwater eel, a catadromous species, is common throughout the Atlantic and Gulf slopes of North America, but migrates far inland to the Great Lakes, midwestern, and some southwestern regions of the United States (Lee 1980). Medium to large riverine and lake habitats are typically occupied in these regions (Pflieger 1975, Becker 1983).

Eels are largely nocturnal and known to leave the water on warm, humid nights in search of frogs and other prey (Eddy and Underhill 1974). Possibly the cave fragments originated from specimens that had been taken as prey by an owl, mink, or some other predator and transported (at least in part) to the cave. Anguilla rostrata

is practically unknown in the fossil record and this occurrence is one of the few reported.

Esocidae--pikes

The only representative of this family identified from the cave was the muskellunge, Esox masquinongy. Two teeth from Pleistocene strata were referred to E. cf. masquinongy. The teeth were somewhat broad at the base, similar to those of E. lucius and E. masquinongy (pers. comm., G. R. Smith), but appeared to lack the compressed edges reportedly occurring in E. lucius teeth (Crossman and Harrington 1970). A single small vertebra occurring in Stratum VIII/VII was referred to Esox sp. The species E. masquinongy was identified without question after recovery of more diagnostic elements from Level 42 (Pleistocene; full glacial) of the subsequently excavated column 101N/99E by the author and Dr. Paul Parmalee. Although two additional teeth and vertebrae were identified, the most significant elements (for diagnosis) were two fragments of the anterior end of the palatine (representing two individuals). Cavender et al. (1970) discussed the use of this bone in identifying E. masquinongy. The significant character was the presence of one or two enlarged, specialized canine teeth at the anterior end of the palatine. These teeth are fixed rather than depressible and thus, when lost, an enlarged round socket is revealed. These sockets contrast with those of the depressible teeth (which appear more like semicircular "pedestals") (Cavender et al. 1970). The two palatine fragments

with the enlarged sockets and one enlarged tooth are illustrated in Fig. C-1D.

The original range of the muskellunge (extensive introduction has occurred for some time) is thought to have been west of the Appalachians from southeastern Canada, in the Great Lakes region, to Tennessee (Crossman 1980) (Fig. D-1). The modern distribution in Tennessee is mostly in the eastern portion, where populations in the headwater streams are presumed to be of natural origin. The record of this species from the Cheek Bend Cave deposits may represent a formerly more widespread range in Tennessee during the late Pleistocene. Habitat, as described by Crossman (1980), may be summarized as shallow, heavily vegetated water to much greater depths near rocky shorelines, usually in lakes, sluggish streams, and larger rivers.

Cyprinidae--minnows

Although the cyprinid family accounted for only 10.8% of the total number of identified fragments, it had the greatest number of unequivocal taxa (11). All but one of these (Campostoma sp.) were recorded from less than 10 remains; however, one equivocal taxon, Nocomis sp., was represented by 45 elements.

Campostoma sp. and Nocomis sp. were identified (as were the majority of cyprinids) mostly from trophic bones (e.g., pharyngeals, basioccipitals, dentaries) (Figs. C-2A and C-3D). In Campostoma sp. the dentaries are highly diagnostic for generic recognition. The stout, horizontal ramus is usually sharply curved mesially with

a large symphysial knob. The ventrolateral surface of the anterior portion of the dentary is expanded into a thick, wide prominence of bone which presumably supports the cartilaginous shelf along the lower jaw in living specimens.

Identification below generic level was not possible, largely because of the similarity in osteology among the species. Distribution was also of little help in identification because of increased taxonomic ambiguity recently created by the recognition of several new forms in the southeastern United States (Burr and Cashner 1983).

The genus Campostoma is one of the most widespread cyprinid groups in North America, routinely occurring in most streams throughout east-central United States from New York to Wyoming south into Mexico. All taxa in the genus seem to prefer riffles and swift runs in clear streams ranging from small creeks to medium-sized rivers, over bottoms of gravel or rocks (Burr and Cashner 1983).

Most elements of the chub genus Nocomis were identified only to that level; however, eight elements were referred to N. effusus/micropogon and one to the hornyhead chub, N. biguttatus. Although N. effusus and N. micropogon were inseparable osteologically (only limited material of N. effusus was available), N. biguttatus was easily distinguishable from the other two on the basis of dental formulae. Although dental formulae in certain cyprinids or groups of cyprinids are often highly variable, Nocomis is one group in which the opposite is apparently true (Lachner and Jenkins 1971a,b; Eastman and Underhill 1973). The presence of a minor tooth row

was observed in one pharyngeal from Stratum II/I and in two pharyngeals from the subsequently excavated column 101N/99E; these were all referred to N. biguttatus (Fig. C-3A).

Nocomis micropogon is not known from the Duck River today, but is known from a single locality in the Buffalo River (tributary to the lower Duck). However, it is widespread in the lower Tennessee River drainage (upstream from the mouth of the Duck) to its extreme upper reaches in eastern Tennessee. A few records also exist from the headwaters of the Big South Fork of the Cumberland River in Tennessee. Most of the overall range of the species, however, is north of Tennessee, from eastern Kentucky through northern Virginia into Pennsylvania and New York west to Lake Michigan and Illinois (Lachner and Jenkins 1971b, Jenkins and Lachner 1980).

Nocomis effusus is much more restricted in range, known from the Cumberland River drainage in Tennessee and Kentucky (below Cumberland Falls), headwaters of the Green River in these two states, and the Duck River in Tennessee. Distribution of this species in the Duck River is interesting in that, although several localities exist in the portion of the river draining the Highland Rim, no records for N. effusus are known from the middle Duck which flows through the Nashville Basin (Nieland 1983). Starnes and Etnier (1986) suggested that N. effusus is one of several species that apparently avoids the Nashville Basin in its distribution. Regional physiography, however, may not be the underlying factor responsible for the distributional hiatus in the range of this species. This

would seem to be the case when consideration is given to the presence of N. effusus/micropogon in the late Pleistocene-Holocene strata of Cheek Bend Cave which is located in the Nashville Basin.

If the present distribution of Nocomis micropogon in the Tennessee River is best explained by east to west dispersal (during Blancan times) via stream piracy in the headwaters (Lachner and Jenkins 1971b), then it would seem that the form occurring in the Late Wisconsinan-Holocene central Duck River was probably N. effusus. It should also be mentioned that 14 additional elements of N. effusus/micropogon were identified from the Edmondson Bridge archaeological site (dated ca. 1500 YBP) in the cave vicinity. Assuming that these likely represent N. effusus as well, then it would appear that its absence from the modern central Duck River fauna may be due to more recent (historic?) changes in that portion of the watershed, such as those that may be associated with increased agricultural practices during this time. Pflieger (1975) suggested that increased siltation and intermittent flow due to intensive agricultural practices, may have caused the decline in range of N. biguttatus in Missouri. Preferred habitat of all three species of Nocomis identified from the cave has been generally described as small- to medium-sized clear streams with gravel to rocky or boulder substrates (Jenkins and Lachner 1980). However, N. micropogon is more likely to be found in streams with faster gradient, while N. biguttatus is routinely found in slower runs and pools. Concerning the habitat of Tennessee Nocomis, Etnier (1976) pointed out that N. micropogon generally

prefers larger streams to small rivers with swift currents and cool waters, while N. effusus is generally found in somewhat smaller streams. Nieland (1983) mentioned the preference of N. effusus for slower currents or pools in medium-sized tributaries of the Duck River.

The presence of N. biguttatus remains in the cave deposits is far more unusual than that of N. effusus/micropogon. The present distribution of the hornyhead chub is outside the state of Tennessee (Fig. D-2), mostly in glaciated areas from New York to the Dakotas with a large, nearly disjunct population concentrated in the Missouri-Arkansas Ozarks and eastern Kansas Flint Hills regions (Jenkins and Lachner 1980). Isolated populations in the headwaters of the Platte and Cheyenne drainages in Colorado, Nebraska and Wyoming, as well as scattered records across the midwestern Plains, suggest a former more widespread range. The author has also identified this species from the Late Wisconsinan Prairie Creek Site (see Literature Review, page 9) in southwestern Indiana.

As indicated by their presence in the full glacial (Stratum I-II of the original excavation units and Level 42 of the Pleistocene from the subsequent excavation unit 101N/99E), Nocomis biguttatus and N. effusus/micropogon were possibly coexistent in the central Duck River during this time. However, this does not seem unusual considering the fact that N. biguttatus and N. micropogon are sympatric throughout much of their present ranges in the Great Lakes and upper Ohio River drainages.

Besides Campostoma sp. and representative taxa of the genus Nocomis, the only other unequivocal cyprinid taxon identified from Pleistocene strata (I-III) was Semotilus atromaculatus (one element) which will be discussed later. All other taxa representing this family were found in Strata IV through VI, with the majority of both taxa and elements occurring in Stratum V.

Of the cyprinid taxa occurring in Stratum V, all but Campostoma sp. was represented by only one or a few elements. The following discussion will focus on those unequivocal taxa in Stratum V that have not been previously discussed. They are cf. Dionda/Hybognathus sp., cf. Hybopsis amblops, Notropis cornutus/chrysocephalus, Notropis (Cyprinella) sp., N. cf. stramineus, Phenacobius cf. uranops, Pimephales notatus, and Semotilus atromaculatus.

The cyprinid taxon designated cf. Dionda/Hybognathus occurred in Stratum V (4 elements) and Stratum V/IV (2 elements). In addition, one element was identified from the Edmondson Bridge Site in the cave vicinity. All elements (except for one basioccipital) are fragments of pharyngeal bones only one of which is dentate, bearing a single tooth. Most of the pharyngeals, as well as the basioccipital are illustrated (Figs. C-4, C-5, and C-6).

The pharyngeals are unique in the structure of the upper (posterior) limb which has a large depression along most of the entire dorsal length, being the apparent attachment site for the fifth levator arcus branchialis muscle. The anterior and posterior angles are both well-defined which, in combination with the straight,

usually long upper limb, gives it an overall shape similar to that in the genera Dionda and Hybognathus. However, the upper limbs in all specimens of those genera examined were more compressed (particularly in Hybognathus) and lacked the long depression. The pharyngeals all had a single row of four (usually robust) tooth sockets. The single tooth on the one specimen was similar in structure to that observed in most detritivorous cyprinids (e.g., Pimephales notatus, Campostoma, Dionda) in having a moderately large grinding surface and reduced hooking at the apex. The ventral edge of the grinding surface had several tiny crenulations. Although a crenulate grinding surface on the teeth has not been reported (Eastman 1970) or observed by the author in Hybognathus species or Dionda (= Notropis) nubila from many parts of its range, it has been noted as occurring in some of the Mexican Dionda (Dionda sensu stricto) according to Hubbs and Miller (1977).

To the extent possible, as many east-central North American cyprinid species (including all but a few Notropis species) having a single row of pharyngeal teeth were examined for comparison, but none were in morphological agreement with the species in question. Dr. Gerald R. Smith at the Museum of Paleontology, University of Michigan, also studied the specimens, comparing them with several Mexican Dionda species; he concurred with the author that the specimens probably represent an extinct, undescribed form having affinities with modern Dionda or Hybognathus. The single basioccipital fragment was also postulated by Dr. Smith as referable to this taxon. The

tiny fragment has a ventral masticatory plate similar in shape (sub-oval) to those in other detritivorous cyprinid groups (e.g., Phoxinus, Hybognathus, Dionda) and its position with respect to the procenterum (sub-parallel in lateral view) is also typical of these trophically specialized cyprinids. The narrow, laterally compressed stem of the pharyngeal process of the basioccipital appears to be a unique feature absent in Hybognathus species, but present in some of the Mexican Dionda species examined (pers. comm., G. R. Smith).

Formal description of this presumably extinct cyprinid species (genus?) is not presented in this work, pending possible recovery of additional elements in the subsequent excavation material. From the author's viewpoint, the taxon presumably has greatest affinities with the southwestern Dionda group (Mexico and Texas) and not the more upland Dionda (recently included in Notropis) nubila of the Ozark upland and upper midwestern regions. Based on the shape and topography of the pharyngeal bones and the basioccipital, it is thought to have been a detritivore, probably with an elongated gut and black peritoneum. The small, nearly equal size of all six pharyngeal bones along with the high degree of bone sculpture suggests that it was probably a small species. Illustration of four of the pharyngeals, as well as pharyngeals of some Hybognathus and Dionda species, are presented in Fig. C-6.

The cyprinid taxon cf. Hybopsis amblops, the bigeye chub, was tentatively identified from one small, nearly complete pharyngeal bone (Fig. C-2B). This species generally occupies small streams

to moderately large rivers in Tennessee, with a preference for areas of slower current adjacent to riffles, usually over sand and gravel substrates (Etnier 1976, Nieland 1983). Its range extends from Lake Erie drainage in southwestern New York and southeastern Michigan south into the Tennessee and Cumberland River drainages and southwest through southeastern Illinois into the areas of southern Missouri, northwestern Arkansas, and northeastern Oklahoma.

Notropis cf. stramineus, the sand shiner, was also tentatively identified from one small pharyngeal fragment, based on dental formula and similarities in shape of the teeth and pharyngeal bone (Fig. C-2B). Although it appears that a tiny remnant of a minor row tooth socket is present, this was regarded as a small foramen. One or more of these foramina were often found at the base of the third and fourth major row teeth in several comparative specimens of Notropis stramineus and other Notropis species having uniserial teeth.

According to Gilbert (1980), habitat is extremely variable with populations known from streams as small as spring runs to large rivers, often over sandy bottoms. In Tennessee it is known from small, low-gradient streams of the upper Cumberland and Tennessee drainages in East Tennessee, while several records exist in West Tennessee from small direct tributaries to the Mississippi River (Etnier 1976 and pers. comm.). Outside Tennessee the overall range of the species is expansive, extending from New York and West Virginia west across most of the north-central United States as far as Montana to the north and New Mexico to the south. Scattered localities

are known in Canada and south-central Texas, while the species is lacking in Arkansas, Louisiana, and southeastern United States.

Phenacobius cf. uranops, the stargazing minnow, was identified from a single maxillary fragment (Fig. C-3B). This species is restricted to the Tennessee and Cumberland River drainages and Green River system (Kentucky) where it is found in moderate to swift currents in medium to large, clear streams over gravel to rock substrates (Jenkins 1980). Nieland (1983) collected several specimens from a few widely separated localities along the main channel of the Duck River.

Pimephales notatus, the blunt-nosed minnow, was identified on the basis of a single basioccipital fragment (Fig. C-2E). Widely distributed throughout much of eastern-central North America from southern Canada to the Gulf, P. notatus occupies a wide range of habitats from small creeks to large rivers and reservoirs. It was reported as the most common cyprinid species in the Central Basin streams of the Duck River system (Nieland 1983).

The creek chub, Semotilus atromaculatus, was represented by two elements in Stratum V and one element in the full glacial Stratum II/I. The distinctive dental formula on the left pharyngeal (2,5-) and the shape of the pharyngeal were diagnostic features (Fig. C-3C). Also, the teeth of this species tend to be more pointed, with reduced hooks and grinding surfaces, than those of many other forms. Like the bluntnose minnow, the creek chub is wide-ranging throughout much of eastern North America; however, as its name

implies, it is most frequently found in small clear streams and brooks (Lee and Platania 1980).

The only other unequivocal cyprinid taxa not discussed thus far are Notropis cornutus/chrysocephalus and Notropis (Cyprinella) sp. Osteological distinction of the closely related Notropis cornutus and N. chrysocephalus was not of the magnitude needed for separation of the two. Both species are widely distributed and are sympatric throughout much of the upper Midwest and Great Lakes regions. Notropis cornutus is the northern form which also has a greater east-west distribution, from Colorado and Wyoming east to Virginia and north to Nova Scotia. On the other hand, N. chrysocephalus is more vertically distributed in North America, from New York, Michigan, and southeastern Wisconsin in the north southward through Tennessee and Arkansas to the Louisiana Gulf Coast. Based on this distribution, as well as its common occurrence in the Duck River (Nieland 1983), the cave fragments are probably referable to N. chrysocephalus. The highly arched pharyngeal bone, dental formula, and large size (estimated standard length 130-140 mm) suggested by the size of the two fragments were diagnostic for this large Notropis species (Fig. C-2C).

Notropis (Cyprinella) sp. was identified from four pharyngeal bone fragments (three in Stratum IV/III, one in Stratum IV) (Fig. C-2D). This large wide-ranging subgenus of Notropis has several species that might be represented by the cave fragments; some likely possibilities are N. galacturus, N. spilopterus, and N. whipplei.

The low number of cyprinid elements in Strata III and IV (Table B-1) seems unusual, particularly when considering the much higher numbers in Strata V and II. Strata III and IV represent the late glacial and early Holocene times, respectively, and their low numbers of cyprinid elements may represent a negative adjustment for that group to environmental changes that may have occurred during those times. However, as noted before, Stratum V had the highest number of taxa and elements for many of the vertebrate groups, possibly because of the large amount of deposited material in that stratum.

Although Stratum II had far more cyprinid elements than III or IV, it should also be noted that all but one of the identifiable elements were referred to Campostoma sp. and taxa of the genus Nocomis. The elements from that stratum identified only to family may also have come mostly from the specimens represented by these few taxa. Thus, the total number of individuals represented may not be significantly different from the totals found in Strata III and IV (based on element numbers). The sharp drop in number of cyprinid elements in Strata VI through VIII is also unusual, and was noted to occur in other groups of small fishes, as well (e.g., darters, sculpins).

The paucity of Pimephales notatus elements in the deposits seems noteworthy, particularly since it is such a common species in the Duck River system today. However, examination of the distribution map for this species in the Duck River (Nieland 1983) indicates that most records are from tributaries to the main channel, which are not that close to the cave.

As far as southward displacement of cyprinid taxa during the Pleistocene is concerned, the only probable indication is the presence of the hornyhead chub, Nocomis biguttatus, in the full glacial deposits of the original and the subsequent excavation units. This is presumably the first documentation of this occurrence in eastern North America for the cyprinid family.

Catostomidae--suckers

Represented in all strata of the cave deposits, the catostomids accounted for the greatest percentage, by family, of the total number of identified elements for all families with 26.3%. Of the eight unequivocal taxa, all are known to occur in the Duck River system today. Size estimates of original specimens from a large number of elements indicated that a wide range of sizes (from ca. 75 to 650 mm) occurred in both Pleistocene and Holocene strata. For identification to genera and species, a variety of osteological elements were used. The most frequently used bones were the maxillary, premaxillary, dentary, and hyoid bones, while some of the lesser used skeletal elements were the supraethmoid, pharyngeal, and palatine bones (Figs. C-3E,F, C-7, C-8).

The white sucker, Catostomus commersoni, was represented by 15 elements, all from the Pleistocene strata (Fig. C-3E). The most widely distributed of all North American catostomid species, it ranges throughout much of Canada from the Arctic Circle south into New Mexico in the west and as far southeast as South Carolina.

In the northern United States it occupies a wide variety of habitats from small streams to large rivers and glacial lakes (Becker 1983, Trautman 1981). According to these authors, it is one of the most commonly collected fish species in Wisconsin and Ohio, respectively; they also pointed out the high degree of tolerance this species has for many types of environmental constraints. In more southern parts of its range (e.g., Missouri Ozarks, Tennessee) it tends to occupy small creeks and spring habitats (Etnier 1973a, Pflieger 1975). Only three specimens from two localities were reported from the Duck River by Nieland (1983); however, several specimens have been collected recently from Fountain Creek, tributary to the Duck River in the cave vicinity (pers. comm., W. E. Klippel). Six additional white sucker remains were identified from the subsequently excavated column 101N/99E (Level 42 from the Pleistocene).

Unlike the white sucker, another species, Hypentelium nigricans (northern hog sucker), was widely distributed in the cave strata although not abundantly (21 total remains) (Fig. C-7B). Widespread throughout much of the eastern United States, it occurs from Minnesota and Wisconsin south to Arkansas and east throughout the Tennessee and Ohio River valleys and much of the lower Great Lakes drainage (Buth and Murphy 1980). It also occurs in many Atlantic slope streams from southern New York to northern Georgia. Populations in the southern Mississippi-Louisiana area may indicate a more expansive range in the south during the Late Wisconsinan. Habitat has been described as riffles and pools in high gradient streams over gravel

to rock substrates (Pflieger 1975, Etnier 1973a). Nieland (1983) found that this species was the most common sucker in the Duck River and that in the Nashville Basin region it was collected mostly on gravel shoals of the main channel.

The only buffalo recorded from the cave deposits was the tentatively identified Ictiobus cf. niger, the black buffalo, which was known from only two nearly complete elements. The urohyal was the more diagnostic element used for identification (Figs C-3F and C-7A). Ictiobus niger and the very similar I. bubalus (the smallmouth buffalo) may be distinguished from the bigmouth buffalo (I. cyprinellus) using only the urohyal, if fairly complete. However, it was not possible to reliably distinguish the first two species using only this particular element.

The black buffalo occurs mostly in the Mississippi basin from Minnesota to West Virginia, south to the Louisiana Gulf coast and west into eastern Oklahoma, Kansas, and Nebraska. It is also known from the Great Lakes drainage in southern Michigan and scattered localities in southern and western Texas (Shute 1980). The more often collected I. bubalus has basically the same range, except for records in the Gulf drainage of Alabama and the upper Missouri River in Montana and the Dakotas (Lee 1980). Occurring mostly in large rivers, both species frequent areas of current, but may be found in more sluggish waters as well.

Recovered from only the Late Holocene Stratum VII in the cave, the Ictiobus remains, representing a fish approximately

400-500 mm in standard length, may have been deposited as a result of aboriginal activity. Both I. niger and I. bubalus have been collected from the Duck River near the cave site by personnel in the Department of Anthropology, University of Tennessee.

The extinct Lagochila lacera, the harelip sucker, although not officially recorded from Cheek Bend Cave, was identified from several specimens recovered from the Middle to Late Archaic Hayes site (40ML139) and was obviously a part of the middle Duck River fish fauna at that time. The author, however, found one very small urohyal in the subsequently excavated column 101N/99E (Level 42 of the Pleistocene) which may be eventually assigned to this taxon, pending further research.

The harelip sucker is poorly known as it was collected only between 1859 and 1893, but it appeared in numerous collections during this time (Etnier 1973a). The only prehistoric records of the species previous to the Duck River record are two late Holocene unpublished archaeological records from the upper Tennessee River drainage in East Tennessee. The species was formerly widely distributed in the Tennessee and Cumberland River drainages as well as in the Ohio River drainage in Kentucky, Indiana, and Ohio (Jenkins 1980). Records are also available for the upper White River system of Arkansas and from the Maumee River (Ohio), a tributary to Lake Erie. Preferred habitat is thought to have been pools and other areas of slower currents in moderate to large streams having moderate gradient and low turbidity (Jenkins 1980).

The most commonly identified catostomids from the cave were of the genus Moxostoma, the redhorses. Of the 267 sucker elements identified to generic level or below, 230 (86.1%) were in this genus. Of the five identified species, three were recorded from both late Pleistocene and Holocene deposits and all are part of the modern Duck River fauna as well. This large, diverse group of suckers is widespread throughout much of east-central North America and, according to Etnier (1973a), reach their greatest abundance in large, clear rivers.

Three of the Moxostoma species identified from the cave are very similar in external morphology and are often difficult to separate osteologically. The three, Moxostoma carinatum, M. duquesnei, and M. erythrurum, were separated using pharyngeal bones, maxillaries, premaxillaries, ceratohyals, and urohyals. Moxostoma carinatum, the river redhorse, is very distinct in the structure of the pharyngeal bone and teeth. The thick, robust pharyngeal bone and large molariform teeth (Fig. C-7D) easily distinguish this species from all other catostomids except, perhaps, the trophically similar M. hubbsi of the Great Lakes drainage. Besides these features, it is also distinctive in having a large, functional masticatory plate on the ventral surface of the basioccipital. Aside from the above mentioned characters, however, it is osteologically quite similar to the other two Moxostoma species. Examination of over 100 skeletons each of M. duquesnei, the black redhorse, and M. erythrurum, the golden redhorse, from the Duck River near Cheek Bend Cave revealed that ceratohyal, urohyal,

and maxillary bones are reliable for distinguishing these two similar species. Additionally, all of these bones are fairly solid and compact in structure and are often likely to be found preserved in nearly complete form (particularly the hyoid bones) in subfossil deposits. The more robust, compressed form of the ceratohyal of M. duquesnei contrasts with the relatively longer, more slender (hourglass-shaped) configuration of the M. erythrurum ceratohyal (Figs. C-8A and C-7F). Additionally, this bone in M. duquesnei (as well as in M. carinatum) often tends to be more oblique along the longitudinal axis as compared with the straighter form of the bone in M. erythrurum. Although urohyals of these three Moxostoma species are all similar fan-shaped bones, M. erythrurum again has the most distinctive form. Even though the stems of the urohyals appear to be somewhat variable (in length and thickness), the depressed lateral edges of the "fan" in M. erythrurum tend to give the sides of the bone a sinuate appearance as opposed to the nearly straight or gently curved sides of the urohyal in the other two species; in addition, the relative width of the bone in M. erythrurum is usually less than in the other two (Figs. C-7F and C-8C).

Maxillary bones were found to be useful in identifying all five species of Moxostoma. The general configuration of the entire bone, as well as features of the anterior end (shape of dorsal angle, shape of neck region, ventral process development), were found to be useful characters, particularly in combination, for demarcation of the species (Figs. C-7E and C-8B).

The two other species of Moxostoma identified from the cave deposits were M. macrolepidotum and M. anisurum. Represented by only two elements, the shorthead redhorse (M. macrolepidotum) was recorded only from the Pleistocene deposits; the elements were both dentaries and represented two individuals. The dentaries as well as several other cranial bones in this species appear to be compressed antero-posteriorly. The horizontal ramus is short and stout with a small, sub-quadrate notch near the midpoint of the dorsal surface. In addition, another distinctive character of the dentary is the wide medial process extending back obliquely from the symphysis past the mental foramen (Fig. C-7G,H). Among other bones of this species which distinguish it from the other four are the hyoid bones and maxillary bones (Fig. C-8A,B).

The silver redhorse, M. anisurum, represented by eight Pleistocene elements, was found to be the most distinctive, osteologically, of the five aforementioned species. A wide variety of cranial elements of this species differed (some strikingly) from the same elements in the other four Moxostoma species. Some of the more divergent bony elements were the urohyal, epihyal, ceratohyal, premaxillary, maxillary, supraethmoid, dentary, and interoperculum (Figs. C-7C and C-8A,B,C).

The striking differences in bone morphology exhibited in M. anisurum prompted the author to preliminarily investigate some of these osteological characters in other Moxostoma species. One or two specimens each of 11 other species in the genus (representing

all four subgenera) were examined with regard to the hyoid bones. It was found that only the similar sympatric species M. papillosum (a redhorse species restricted to the Atlantic Slope drainage in Virginia, North and South Carolina) had similar hyoid morphology to that of M. anisurum. All other species exhibited basically similar hyoid morphology to the other four Duck River Moxostoma species. Thus, considering the divaricate nature of the structure of the hyoid bone group in M. anisurum and M. papillosum on the one hand, and that of the same bones of the majority of Moxostoma species on the other, it seems possible that the former pair are sibling species and might be relegated to their own subgenus (or possibly genus?), although more study along these lines is essential.

All five species of Moxostoma have widespread, generally overlapping ranges, centered mostly in central and eastern United States. Moxostoma erythrurum, M. anisurum, and M. macrolepidotum have populations on the Atlantic slope, while the latter two range farther north into Canada (particularly M. macrolepidotum) (Jenkins 1980). Preferred habitat for the five is also similar in that usually pools in medium to large moderately clear rivers over various substrates, usually gravel and rocks, but often sand or silt (M. anisurum and M. erythrurum), are frequented. In Tennessee, M. carinatum and M. macrolepidotum tend to occupy faster waters in large, clear rivers, while M. anisurum is more common in large, sluggish waters. Moxostoma erythrurum and M. duquesnei seem to prefer large creeks to moderate-sized rivers, with M. erythrurum tending to be more adapted to streams

with low gradient and increased turbidity, while M. duquesnei is characteristic of cooler, clearer streams with higher gradients (Etnier 1973a).

Although approximately half (50.7%) of the total catostomid elements identified and seven of the eight catostomid species were recovered from Pleistocene deposits, few implications can be drawn from this group of fishes concerning Pleistocene environmental conditions or Pleistocene-Holocene faunal modification. However, the stratigraphic distribution of the white sucker, Catostomus commersoni, deserves additional attention at this point in the discussion. As previously mentioned, C. commersoni was identified from only the Pleistocene strata. It was also pointed out that, although it primarily occurs in small creeks and spring habitats in the southern part of its range, it is routinely found in much larger bodies of water (rivers and lakes) in the northern United States. Scott and Crossman (1973) alluded to its common occurrence in tributary rivers of larger lakes as well as warmer, shallow lakes and bays in Canada. Furthermore, the creek chub, Semotilus atromaculatus, which often is associated with the white sucker in small streams in Tennessee, is also known to occur in larger streams in more northern areas of its range (Scott and Crossman 1973, Trautman 1981, Becker 1983). With the assumption that most of the fish remains from the cave originated from the Duck River proper and not tributaries (page 38), then it might be postulated that C. commersoni and Semotilus atromaculatus were inhabiting the main channel of the Duck River,

suggesting an analogy, perhaps, with the wider range of habitats occupied by these species in more northern parts of their ranges. It may be possible that the populations of these two species represented by the cave specimens were from northern stock (by ancestry) which were more adapted to riverine conditions, a situation easily explained by presumed southward displacement during glacial maxima.

As in the case of the cyprinids, there were significantly lower numbers of catostomid elements in Strata III and IV as compared with Strata II and V. Similarly, it is only speculative as to whether or not the drop in element numbers may reflect a substantial decrease in the overall catostomid population in the middle Duck River during late glacial and early Holocene times.

Ictaluridae--catfishes

A total of 194 elements of catfishes was identified from the cave deposits, representing 7.1% of the total elements identified for all families. Osteological elements used for identification varied, but pectoral spines, dentaries, and premaxillaries were the most frequently used. Several works dealing with catfish osteology were helpful in discerning the various taxa, namely, Krause 1977, Lundberg 1975, 1982, Mundell 1975, Paloumpis 1963, and Taylor 1969.

The channel catfish, Ictalurus punctatus, was identified from two elements, one in Stratum V, the other in uppermost Stratum VIII. The scorched pectoral spine fragment in Stratum VIII was from a specimen estimated to have been 300-400 mm standard

length, while the spine fragment in Stratum V represented a much smaller specimen.

This catfish occurs commonly throughout much of the east-central United States from the Great Lakes into Florida, throughout Texas, and as far northwest as Montana (Glodek 1980). Habitat ranges from clear to very turbid medium to large rivers over substrates ranging from mud and sand to gravel and rock bottoms. Channel catfish have been taken in large numbers from the Duck River in the cave vicinity by personnel in the Department of Anthropology, University of Tennessee, Knoxville.

Ictalurus natalis, the yellow bullhead, was identified from two elements, one each from Strata V and VI. Like the channel catfish, it is widely distributed throughout eastern and central United States and occupies a variety of habitats, often in small, sluggish streams, particularly with vegetation (Glodek 1980). Although rarely collected by Nieland (1983) from the Duck River, he reported it from earlier records as being very common in tributaries to the Duck in the Central Basin, where it was associated with slower waters and emergent vegetation.

Madtoms, genus Noturus, account for the great majority of ictalurid remains from Cheek Bend Cave; however, most of these were referred to a single taxon, Noturus cf. flavus. Most of the remaining Noturus elements belonged to the subgenus Rabida. Members of this group characteristically have large, distinctive, often impressively armored pectoral spines with dentate anterior and posterior edges

(Taylor 1969). The posterior teeth (serrae) are large, recurved, and sharply pointed except for the basal, sometimes stubby, one or two teeth which are often antrorse. Anterior serrae are much smaller, finer teeth that are variable in size and distribution along the anterior edge of the spine (Taylor 1969). Sometimes they are wide basally with bifurcate tips (due to fusion of teeth). The distal half of the spine is characterized as having several diagonal grooves. Typically, species in the subgenus inhabit high gradient streams where they are associated with riffles (Taylor 1969).

The subgenus Schilbeodes contains all the other madtom species besides Noturus flavus, which belongs to the subgenus Noturus. Pectoral spines of the Schilbeodes group are not nearly as ornate as in the Rabida subgenus. There is more variation in the spines of this group, which may be short or long and can vary as to the degree of groove development. There are never anterior serrae, but notches or recurved hooks may be present. The posterior edge may be dentate, smooth, or slightly roughened. If posterior teeth are present, they are usually straight or individually variable, sometimes antrorse or retrorse.

Noturus cf. elegans, the elegant madtom, was identified from a single pectoral spine fragment (Fig. C-9A). The spine is referred to this taxon on the basis of comparison with the illustration of this species in Taylor (1969) and with several comparative specimens of N. elegans. Only two posterior serrae remained on the spine, but the specimen appeared to have had at least eight posterior serrae.

At least half of the slender spine shaft was present and the position and size of teeth on the anterior edge were also diagnostic.

Distribution of the species is largely concentrated in the Green River drainage of Kentucky and Duck River system in Tennessee. The few specimens collected by Nieland (1983) were all from Nashville Basin streams, where they were taken in gravel shoal areas of the main channel. Other localities for the species occur in the upper and lower Duck (Rohde 1980).

The mountain madtom, Noturus cf. eleutherus, was identified from two spine fragments from Stratum VI, which represents the early part of the late Holocene. The shape and number of posterior serrae as well as the size and distribution of anterior serrae and curvature of the spine shaft were in close agreement with comparative specimens of N. eleutherus (Fig. C-9A).

The species occurs in large streams from western Pennsylvania into Kentucky and Illinois (Ohio River drainage) and into the Tennessee River drainage where it is very common in upper East Tennessee. Additional records are known from southeastern Missouri and southern Arkansas, while a single record exists from the Mississippi River in West Tennessee. In Tennessee, the species is common in swift water (riffles) over coarse gravel (Etnier 1973b) and has been taken in considerable numbers from the main channel Duck River in Maury County (Anonymous, TVA 1975).

The slender madtom, Noturus exilis, was identified from three spine fragments, one from Stratum V/IV and two from Stratum V.

Although the first two madtom species discussed were members of the subgenus Rabida, the slender madtom belongs to Schilbeodes. The spine shaft is short, only slightly curved, and bears up to 10 long posterior teeth that are usually straight or slightly retrorse (some occasionally antrorse) and sometimes bifurcate. The anterior distal edge of the spine has several distinct irregular notches, while the remaining edge is devoid of teeth (Fig. C-9B).

East of the Mississippi River, the range of the slender madtom is concentrated in the Tennessee and Cumberland drainages and Green River system in Kentucky and Tennessee, although scattered records are known from Indiana and north-central Illinois. The range west of the Mississippi is more expansive, extending from the uplands of Arkansas, eastern Oklahoma, Missouri, and Kansas to southern Minnesota and Wisconsin. Habitat has been described as gravel to rock substrates in riffles of small- to medium-sized streams (Etnier 1973b, Pflieger 1975, Rohde 1980).

Two pectoral spine fragments (one each from Strata V and V/IV) were assigned to Noturus flavater, the checked madtom. The fragments, measuring 5.5 mm and 6.4 mm in length, both comprised approximately the central portion of the spine shaft (Fig. C-9C) and were obviously representative of the subgenus Rabida because of the well-developed anterior and posterior dentations.

Comparison with spines from measured large Noturus flavipinnis, as well as other Rabida species, indicated that lengths of the unknown Rabida specimens were in the 100-125 mm standard length range.

The large size of the specimens greatly reduced the number of possible

species which they may represent. The three likely possibilities were N. flavipinnis, N. stigmosus, and N. flavater. Although no spines of N. flavater were available, one was dissected from a preserved specimen (UTRCF 48.132) and compared, along with spines from the other two species, with the cave fragments. Three large spines of N. flavipinnis and three smaller spines of N. stigmosus were used in the comparison, along with the excellent illustrations in Taylor (1969). It was found that the cave fragments were closest in morphology to N. flavater, primarily because of the similarities in the posterior teeth. The large posterior teeth along the center of the spine shaft appear to be more uniformly similar in size and shape and are less attenuate and retrorse than the same posterior teeth in both N. flavipinnis and N. stigmosus (Fig. C-9C). Because of this, the spaces between these four or five serrae have a characteristic shape (narrow near the spine base and more vertical) that the author has not been able to find in any other Rabida species. Noturus flavater is the only madtom species mentioned by Taylor (1969, p. 206) as having a pectoral spine with ". . . large uniformly recurved posterior serrae. . . ."

The checkered madtom occurs in the southern Missouri Ozarks from the upper White River system to the Current River (Pflieger 1975). Habitat was described as pools or sluggish waters where substrate is largely organic detritus in clear rivers with steep gradients and permanent flow (Pflieger 1975).

The apparent occurrence of this Ozarkian madtom in the middle Duck River during mid-Holocene time (ca. 8,000-5,000 YBP) does not

seem to be quite so unusual when the present distribution of N. flavater and its close proximity to the lowland Mississippi alluvial valley to the east (Fig. D-3) are considered. According to Baker (1983), the Mississippi River eroded through Crowley's Ridge at the Bell City-Oran Gap in Late Wisconsinan time (ca. 17,000 YBP). Presumably this resulted from increased flow during outwash that accompanied ice sheet ablation. Following this major change in course of the Mississippi River was the complete erosion through Thebes Gap near the southern tip of Illinois (ca. 9,000 YBP), the outcome of which resulted in the present course (or nearly so) of the lower Mississippi River. Assuming N. flavater had a similar distribution in the early Holocene (ca. 8-12,000 YBP) as its present distribution, then it probably would have had close access to that portion of the Mississippi River that was eroding through Thebes Gap which was close to the present mouth of the Tennessee River (Fig. D-3), thus providing a possible route to the Duck River. Speculation about the extirpation of this species in the Duck River is difficult, but considering the extreme diversity of fish species (particularly madtoms) in the modern Duck River, it is easy to suggest that competition may have led to its disappearance there. Taylor (1969) indicated that N. flavipinnis may have been replaced in the North Fork of the Holston River, just above Saltville, Virginia, by the recently established population of N. insignis.

The stonecat, Noturus cf. flavus, was the most common catfish taxon identified (50 total elements). A member of the subgenus

Noturus, this largest of all madtom species was identified by a variety of elements. Due to the extreme size of this madtom (estimated size based on some fragments was 200-250 mm), in some cases there was more of a problem in distinguishing it from other genera (e.g., Ictalurus-bullheads) than from congeneric forms (Fig. C-10A). Some of the elements utilized for identification were the pectoral spine, urohyal, premaxillary, and quadrate.

Although the large madtom taxon from the cave was referred to Noturus cf. flavus, there was some doubt as to whether it is conspecific with modern Noturus flavus. The suggestion that the taxon has greatest affinities with N. flavus is certain. Besides the extreme size and the close similarity of the bones to those of comparative specimens of N. flavus, the cave specimens have some of the diagnostic characters of the stonecat as well. One example is the large premaxillary bone with its posterolateral extensions (Taylor 1969) (Fig. C-10C). Another bone that is distinctive for N. flavus is the pectoral spine (Taylor 1969) (Fig. C-9D). The straight, rather blunt spine is characterized as having only a few very small, irregular (sometimes antrorse) posterior dentations or is only slightly roughened on the posterior edge. The anterior edge is essentially edentate except for the very low recurved hooks that may extend from the distal tip to at least the midpoint of the spine shaft (Taylor 1969). In addition, the angle between the dorsal articulating surface (head of spine) and the dorsal surface (Fig. C-10A) is about 90°. In all other

ictalurid spines examined (including some of juvenile N. flavus), this angle was acute. The other spines also had a larger, thinner dorsal articulating surface (head) unlike the shorter, thicker head of N. flavus. Finally, the characteristic dentary that has a thick, sub-quadrate anterior end (in lateral view) is peculiar to both N. flavus and the cave form.

Although both forms agree in having these characters, there are some differences as well. For example, the angle between the dorsal articulating surface and the dorsal surface of the pectoral spine is sometimes obtuse in the cave form (Fig. C-10B). The pre-maxillary bone (anterior end) is usually more symmetrical than that observed in N. flavus (Fig. C-10C). Finally, the dentary of the cave form does not have the degree of medial curvature or symphyseal process development as do the comparative N. flavus specimens (Fig. C-10D). There are also other bones of the N. flavus type that do not seem to be completely in the expected range of variation of that species.

Comparative specimens used were from Ohio River drainage (5), Illinois (?) (1), Cumberland River (2), and upper Tennessee (Copper Creek, Virginia) (1). The three Tennessee specimens did not demonstrate any more similarity to the cave form than the Ohio drainage specimens. This was of particular interest as LeGrande and Cavender (1980) suggested that, based on their genetic studies of N. flavus, upper Tennessee N. flavus may represent a distinct chromosomal race. Thus, the cave form of N. flavus is tentatively

identified as N. cf. flavus; it is hoped that additional, more complete specimens may be recovered from the 1983 excavation material.

It is interesting to note that this taxon was the only ictalurid taxon occurring in Pleistocene strata. Noturus flavus is very widespread from the Great Lakes-St. Lawrence River drainage west to the extreme headwaters of the Missouri River in Montana, south as far as northeastern Oklahoma and east into the Tennessee-Ohio River drainages (Rohde 1980). Preferred habitat is riffles or swift currents in large streams or rivers over gravel, sand, or rocks (Etnier 1973b, Pflieger 1975, Rohde 1980). According to Branson (1985), it is more adapted to cooler waters than most other Noturus species. Maximum size reportedly is 312 mm (ca. 12.5 in.) total length (Rohde 1980); however, the largest Tennessee specimens rarely exceed 7 inches (ca. 175 mm) (Etnier 1973b). Larger specimens (larger than the Tennessee specimens) have been reported from Canada (Scott and Crossman 1973) and from Ohio (Trautman 1981). The largest size estimated for any cave specimen was approximately 200-250 mm total length. Nieland (1983) reported a collection of 26 individuals collected in a 6 mile stretch of the main channel Duck River in Maury County by TVA rotenone crews.

Noturus cf. nocturnus, the freckled madtom, was identified from a single small, nearly complete pectoral spine (specimen not illustrated) occurring in Stratum V/IV. The spine was in excellent agreement with the two comparative specimens. However, due to the small size of the spine, it has been only provisionally referred to N. cf. nocturnus.

The range of the freckled madtom is mostly in the lower Mississippi River basin; however, it is also found in several southwestern tributaries to the Gulf and in the lower Ohio River basin (Rohde 1980). Habitat has been described as clear to somewhat turbid medium- to large-sized streams with low to moderate gradients over gravel to rock bottom. Fourteen specimens from three sites in the lower Duck River (main channel) in Humphreys and Hickman counties were reported by Nieland (1983).

Pyiodictis olivaris, the flathead catfish, was represented by one element in Stratum V and four elements from two strata of the late Holocene. Of these, the three premaxillary elements in VII/VI are probably from the same specimen. Of the three fragments, the largest is illustrated (Fig. C-11C). Diagnostic features of the premaxillary are the extreme width, the posterolateral extension (broken off in illustrated specimen), and the numerous fine teeth. The fragment in Stratum VII was a small piece of scorched pectoral spine, indicating a probable aboriginal origin for that fish. The flathead catfish, one of the largest species in North America, is an inhabitant of large, deep pools near logs and other debris in the larger rivers in the Mississippi, Missouri, and Ohio basins (Glodek 1980).

In summary, perhaps the most interesting aspect of the biostratigraphy of the Cheek Bend Cave catfishes is the paucity of elements and taxa in the Pleistocene strata. After studying distribution maps of all North American species (Lee et al. 1980), it seems

apparent that just a few species range (only marginally) into Canada and thus as a group represent a somewhat analogous situation to that of the gars (Lepisosteus osseus in particular) in possibly having a complementary distributional association with the boreal coniferous forest biome. Perhaps, as with the gars, some limiting factor(s) of the more northern climatic regime negatively affected ictalurid diversity or distribution (at least locally) during Late Wisconsinan time in Middle Tennessee.

Cyprinodontidae--killifishes

Remains of killifishes, genus Fundulus, were identified from all strata from III/II upwards through VI/V, with a single element coming from Stratum VIII/VII. Of the 181 total fragments, 151 were referred to Fundulus catenatus, the northern studfish. Types of bones identified were the infrapharyngeal, suprapharyngeal, quadrate, premaxillary, dentary, basioccipital, articular-angular, ceratohyal, and others (Fig. C-11D,E). Fundulus catenatus was identified not only on the basis of similar morphology of cave elements to that of comparative specimens, but also on the large size of most of the elements. Many of them compared well in morphology and size with a large series of comparative specimens in the 100-125 mm total length range. Some cave specimens were estimated to have come from fishes approximately 150 mm in total length. This size is well out of the range of most inland Fundulus species, with the most likely other possibility (based on size and distribution) being

another large form of the subgenus Xenisma, the Barrens topminnow, F. julisia. This species is known to reach a total length of approximately 100 mm, although the normal size range is considerably less (pers. comm., P. R. Rakes). The two species appear to be nearly identical osteologically and the possibility exists that some of the cave elements may have originated from this species. However, F. julisia, which is restricted to springs and headwater streams strongly charged by groundwater, occurs only in the upper Duck River, the upper portion of the Caney Fork River (Cumberland drainage), and the upper Elk River (Tennessee drainage) (Starnes and Etnier 1986). Dispersal of this species across the main channel Duck River was likely improbable for a spring form and it would seem that additional populations would occur along the Duck where appropriate habitat existed, according to Starnes and Etnier (1986). They proposed that the area of dispersal (between river systems) was in the low areas of the Barrens Plateau on the Eastern Highland Rim.

Fundulus catenatus is distributed west of the Mississippi throughout the Ozark and Ouchita mountain regions, while east of the Mississippi River it is concentrated mostly in the Tennessee and Cumberland drainages in Tennessee and the Green River system of Kentucky (Shute 1980). Disjunct populations are known from Indiana (Wabash River system) and from the lower Mississippi and Gulf Coastal drainages in the region of southwestern Mississippi (Bart and Cashner 1980), the latter of which may be relicts of the last glaciation (Pflieger 1971).

Habitat has been described as usually being upland streams of various sizes with moderate to high gradient and clear permanent flow over sandy, gravel, or rock bottoms (Shute 1980, Pflieger 1975). The northern studfish most often occurs in sluggish water adjacent to pools and riffles. Nieland (1983) reported this species as widespread and often abundant throughout the Duck River system in clear pools or backwaters in a variety of stream sizes.

Of the 181 total killifish remains, only five (2.8%) were recovered from late Pleistocene deposits. Although the killifish are not distributed throughout the late Holocene strata, they are otherwise similar to the lepisosteids in having a large peak number of elements in Stratum V, followed by a rather striking progressive drop in number of elements downward into the Pleistocene strata. It may be possible that some or all of the five elements in the Pleistocene strata could be intrusive from the Pleistocene-Holocene mixed Stratum IV/III. However, one cyprinodontid element was found in the subsequently excavated column 101N/99E (Level 42 of the Pleistocene full glacial). This would suggest that killifish occurred in the middle Duck River during glacial maxima, but perhaps only marginally. As mentioned earlier, the southern Mississippi-Louisiana populations may be evidence of southward displacement during the Wisconsinan and perhaps the species was at that time more widespread in the coastal plain in the proximity of the Mississippi River. Like the gars and catfishes, killifishes scarcely penetrate the boreal forest biome of North America (accomplished to a small extent by F. diaphanus,

the most northern of this temperate-subtropical genus of fishes). Presumably, it is possible that these three groups were displaced farther south than the Middle Tennessee region, or were at least locally displaced during the full glacial period. One can only speculate as to whether the primary environmental factor underlying this displacement was physical (e.g., temperature, physiography) or biological (e.g., increased competition due to amalgamation of more cool adapted northern populations and tolerant southern conspecifics) or more likely, perhaps both.

Centrarchidae--sunfishes

The 644 centrarchid elements accounted for 23.7% of the total remains identified for all families of fishes. Of the taxa identified below family level, the majority of the remains (157) were referred to Ambloplites rupestris, the rock bass, and were distributed in all but three strata. The taxa Micropterus sp. and Lepomis sp. were next in abundance of identified elements with 30 and 26, respectively.

A large variety of elements was used in identification of these groups. Some of the more frequently used bones included the dentary, maxillary, premaxillary, vomer, palatine, pterygoid, mesopterygoid, hyomandibular, ceratohyal, and articular-angular (Fig. C-12A,B).

Ambloplites rupestris may be distinguished from Lepomis and Micropterus with the use of several elements. For example, the

large, oval tooth patch on the mesopterygoid bone of the rock bass is absent in all Lepomis and Micropterus (except L. gulosus, in which it is much reduced). Also, the L-shaped pterygoid bone has a longitudinal tooth patch extending through the angle on to the shorter arm, whereas in Micropterus the tooth patch is developed along the longer arm only. The much reduced Lepomis pterygoid bone never has teeth. The premaxillary is another bone that may be used for separating these groups. In A. rupestris there is a distinctive inner shelf under the vertical articulating processes of the distal end. Also diagnostic is a horizontal, external groove behind a small pore near the middle of the bone. The moderately wide ventral tooth patch extends only slightly along the medial surface. Contrasting with this, the dental arrangement in Micropterus includes a tooth patch that expands progressively on to the medial surface towards the anterior end, where the widened asymmetrical patch becomes lateral in position. Additionally, Micropterus tends to have teeth that are finer and more uniform in size (on all the dentate bones) than those of the other two genera. A narrow ventral tooth patch bearing enlarged lateral teeth is usually distinctive of the premaxillary in Lepomis (except sometimes in L. gulosus, particularly in smaller specimens).

Ambloplites rupestris is widespread from approximately the Tennessee River drainage northeast to Quebec, across southern Ontario and the Great Lakes region to Minnesota and southern Manitoba, south through the Mississippi basin to southern Illinois (Cashner 1980).

Habitat is described as small cool lakes or shallows of larger lakes and permanently flowing, clear, cool streams with clean, rocky substrate and considerable bank cover (Cashner 1980).

Lepomis cyaneus, the green sunfish, was identified from a single dentary element (not illustrated), which came from Stratum II. The original range of this widely-introduced species, as discussed in Lee (1980), was east-central North America from Lake Ontario to the Gulf coast of Mississippi, Louisiana, and Texas, west to New Mexico, Colorado, and Wyoming and northeast to Lake Superior. Although the green sunfish tolerates a wide variety of ecological conditions, according to Pflieger (1975), it seems to thrive in habitats where few other sunfish occur.

The taxon Lepomis sp. was distributed in all strata from IV through VIII, with the exception of VIII/VII. Although specific identification was not possible, a few elements (e.g., dentaries) were determined to belong to the "short-jawed" Lepomis, which excludes L. cyaneus and L. humilis. However, there are still several other possible species to which the fragments might be referred and the material was too fragmentary to be of use in making any determination.

The species of Lepomis have geographical ranges that are often widespread in the east-central United States, although some are coastal plain forms. They generally do not range farther north than the Great Lakes region, with the exception of L. gibbosus which extends into New Brunswick and southeastern Manitoba. It usually inhabits cooler water than most other Lepomis (Lee 1980) and is

the only Lepomis species that is generally northern in distribution (Lee 1980).

The smallmouth bass, Micropterus dolomieu, was known from five fragments, one in Stratum V/IV, three in Stratum V, and one in Stratum VI. Also, one vomer in the Pleistocene Stratum II/I was referable to M. dolomieu/punctulatus. Twenty-five fragments were referred to Micropterus sp. of which only one occurred in Pleistocene strata (II); most of these, however, were recorded from Stratum V. The majority of all fragments identified to the genus Micropterus and below represented small specimens (estimated less than 150 mm in standard length). Micropterus dolomieu is an inhabitant of clear, cool streams generally over clean rocky or gravel substrates. The original distribution was described as the Great Lakes region from southern Quebec and Minnesota south to Tennessee and eastern Oklahoma (Lee 1980).

An examination of the centrarchid stratigraphic distribution in the cave as well as ecological preferences of this group does not provide much information about Pleistocene-Holocene faunal shifts or climatic changes, with the exception, perhaps, of the Lepomis sp. stratigraphical distribution. This taxon has a somewhat similar distribution in the cave deposits as the Cyprinodontidae and Lepisosteidae and all but one unequivocal taxon of the Ictaluridae (Noturus cf. flavus) (i.e., it is concentrated in the Holocene deposits). Considering the fact that its geographical distribution is concentrated mostly in the temperate latitudes of North America, the group as

a whole may have been concentrated somewhat farther south than the Middle Tennessee region during the last glacial maximum. The occurrence of L. cyanellus in the full glacial Stratum II (one element) seems a bit unusual if this line of reasoning concerning the other Lepomis is accepted. As was pointed out, however, this species does well in a large variety of environmental conditions, particularly in the absence of other Lepomis.

Percidae--perches

Percids accounted for only 6.3% of the total elements identified for all families. Of the 171 percid elements identified, 78 (45.6%) occurred in the Pleistocene strata. Although six unequivocal taxa were identified, most of the Pleistocene elements (66) represented only two of those, Etheostoma blennioides and Perca flavescens.

The greenside darter, Etheostoma blennioides, was identified mostly from trophic elements (Fig. C-13A,B), but other fragments (e.g., cleithrum, nasals) were utilized, as well. The large size of most of the elements facilitated identification. However, this large darter species has rather distinctive cranial osteology, particularly in the structure of the trophic elements (maxillary, premaxillary, dentary, and articular-angular). All of these bones seem to be compressed antero-posteriorly and have a somewhat stout, robust appearance when compared with the same bones from most other darter species in all three genera. The deltoid-shaped articular-angular is particularly diagnostic (Fig. C-13A,B).

The greenside darter is widespread east of the Mississippi River from the Great Lakes, Potomac, and Susquehanna drainages throughout much of the Ohio River basin, to the Tennessee and Cumberland River drainages where it is extremely widespread and abundant (Denoncourt 1980). West of the Mississippi it is also widespread and abundant throughout the Ozark uplands region and the upper Red River drainage of Arkansas. Preferred habitat was characterized as moderate to fast clear rivers and streams over rubble to small boulders, although it is also known from various other habitats (Denoncourt 1980). According to Pflieger (1975, p. 313), it is ". . . often observed foraging over boulders or submerged logs in pools having slight current." Nieland (1983) reported that E. blennioides occurred most often in the main channel and larger tributaries in the Duck River system.

Etheostoma (Nothonotus) sp. was represented by a single very small dentary fragment (not illustrated), which occurred in Stratum V. After comparison with all darter species in the skeletal collection, dentaries of Etheostoma rufilineatum and E. camurum were found to be excellent comparisons. The slight ventral deflection of the anterior end, the overall shape and size of the bone, and the narrow dentigerous surface were all in close agreement. Nieland (1983, p. 69) reported that E. rufilineatum, the redline darter, was ". . . the most common member of the subgenus Nothonotus in the Duck River" Furthermore, he reported it as largely restricted to the river proper in the Central Basin drainage. Etheostoma rufilineatum

is restricted to the Tennessee and Cumberland drainages in its overall distribution (Etnier 1980). The bluebreast darter, E. camurum, is known from a few Duck River localities in the vicinity of Cheek Bend Cave (Anonymous, TVA 1975, pers. comm., D. A. Etnier). It is widespread, but often localized in the Ohio River basin, including the Tennessee and Cumberland drainages. Both E. camurum and E. rufilineatum generally prefer areas of moderate to swift current over clean, rocky substrate in clear streams and small rivers (Etnier 1980, Stauffer 1980).

The logperch, Percina caprodes, was identified from two articular-angular bones (apparently from the same specimen) which were recovered from the full glacial Stratum II (Fig. C-13C). One diagnostic feature used by the author was the presence of a small notch in the lateral portion of the socket of the articular-angular bone (Fig. C-14). This notch was observed in nine of the 10 specimens examined as well as in two specimens of the closely-related blotchside logperch, Percina burtoni. The notch was not observed in any other darters examined. Presumably it functions in some part of the feeding mechanism of these two species, which are somewhat specialized in their habit of flipping small stones in search of food.

The logperch is perhaps the most widespread of all darters, ranging from Louisiana up the Mississippi basin into the Great Lakes drainage and well into Canada (Thompson 1980). It may be found in various stream habitats ranging from creeks to rivers and lakes. According to Thompson (1980, p. 719), it prefers ". . . clean riffles

and runs over mixed sand and gravel" Although P. burtoni also compared well with the fossil elements, they were assigned to P. caprodes on the basis of its more widespread distribution (P. burtoni is an uncommon species restricted to the Tennessee-Cumberland drainage) and the slightly better morphological comparison.

The darter fragments from Cheek Bend Cave represent only the second fossil record of this group. The initial record was that of two species, Percina cf. copelandi and Etheostoma exile, from the Ree Heights Wisconsin deposits of South Dakota (Ossian 1973). Approximately 10 skeletons (seven complete) were preserved in fine-grained diatomite lake sediments in Hand County, South Dakota.

The yellow perch, Perca flavescens, was identified from 46 fragments, all in the Pleistocene strata. A variety of elements including fragments of articular-angulars, preopercles, dentaries, and premaxillaries were identified (Fig. C-15A,B). The fragmentary elements appeared to represent specimens of small to medium size (ca. 150 mm or less). The yellow perch appears to be the species with greatest affinities with the boreal environment that was identified from Cheek Bend Cave.

Its natural range reportedly extended from approximately southern Illinois northward, through the Great Lakes, into the Dakotas and throughout much of Canada into the Yukon Territory and east to Great Slave Lake (Lee 1980) (Fig. D-4). It also occurs from Nova Scotia to the Santee River drainage in South Carolina. The unusual records of Perca flavescens from Florida (Appalachicola

drainage) and Alabama (Choctawhatchee and Mobile Bay drainages) which are listed in Smith-Vaniz (1968) are apparently questionable (introductions?). They are not included in range maps of several recent works (Pflieger 1975, Lee 1980). Also, Scott and Crossman (1973) refer to the recent expansion of range for the yellow perch from South Carolina to Florida and Alabama.

According to Becker (1983), in Wisconsin the yellow perch is tolerant of a variety of habitats but prefers lake, backwater, and slough areas with at least some vegetation in moderately fertile waters. As Perca flavescens does not occur in Tennessee (except where introduced), the record from the Pleistocene of Cheek Bend Cave has some significance and will be further discussed in the Conclusions.

Stizostedion canadense, the sauger, and S. vitreum, the walleye, were represented by a single element each in the Pleistocene strata (Fig. C-15C). Also, four additional elements referred to the genus Stizostedion were identified from Pleistocene strata, while one element occurred in Stratum V. The S. vitreum element is a large epiphyal bone examined by the author and Dr. G. R. Smith and referred to this species (rather than S. canadense) on the basis of its large size and greater similarity to the comparative material of S. vitreum. The single fragment referred to S. canadense was a premaxillary (anterior end) which was referred to this species (by G. R. Smith) by the presence of the external horizontal groove near the base.

Stizostedion canadense occurs from Alberta to Quebec in Canada and south throughout the Great Lakes and Mississippi basins as far south as the Tennessee River drainage to the east, and west to northern Louisiana and eastern Oklahoma (Scott and Crossman 1973). The walleye has much the same range as the sauger except that it occurs further north into Canada, particularly in the northwest where it reaches the Arctic Circle. Presumably it is also native to the central Atlantic seaboard (Scott and Crossman 1973). The walleye and sauger both occur in large streams, rivers, and lakes but the walleye tends to be found in deeper pools while the sauger frequents areas of current and is more tolerant of turbidity.

Sciaenidae--drums

Most of the elements of drum, Aplodinotus grunniens, occurred in the late Holocene strata. Only 9 elements of the total identified for that family (101) were from Pleistocene deposits. Of all the elements identified, the majority were pharyngeal teeth or pieces of them. However, in the upper Holocene strata a few large pterygiophores, fin spines, otoliths (Fig. C-16A), and one epihyal, in addition to other cranial fragments, were present. Some of the elements were scorched, indicating their presence in the cave as likely due to human occupation. This species routinely occurs in archeological deposits throughout much of the eastern United States.

Several unique skeletal features of this monotypic genus facilitated identification, namely, the enlarged saccular otoliths,

the fused infrapharyngeals with their sub-globose teeth, the greatly enlarged second anal spine, and the unusual strutted appearance of the skull (Scott and Crossman 1973), apparently the result of the greatly enlarged lateralis openings.

The freshwater drum inhabits large, shallow aquatic habitats in lakes and rivers ranging from clear to very turbid (Scott and Crossman 1973, Fremling 1980). Distribution is widespread, extending from the Hudson Bay to Mexico that includes a large area between the Rocky Mountains and the Atlantic slope (Fremling 1980). It has been collected extensively in the Duck River in the Cheek Bend Cave vicinity by personnel in the Department of Anthropology, University of Tennessee, Knoxville.

Cottidae--sculpins

Sculpins were recorded in the cave deposits from 30 elements. Twenty of these were referred to the genus Cottus, while nine were assigned to C. carolinae and one to C. cf. bairdi. The sculpins represented the only family, besides the Esocidae, that were found in both Pleistocene and Holocene strata, but not in the mixed Stratum IV/III lying between them.

Elements frequently used in identification were the dentary, palatine, suboperculum, and premaxillary (Fig. C-16B), although others were encountered as well. The rather long, slender dentary has a large lateral fossa and the nearly ventral lateralis openings are widely elongated. Dentary and premaxillary bones have several rows of teeth which are usually enlarged in the mesial row.

The more complete palatine bones were referred to C. carolinae because of the large dentate surface with two or three rows of teeth, as opposed to the reduced tooth-bearing surface in C. bairdi which has either a single row of weak teeth or none (in specimens observed by the author). The single element identified as C. cf. bairdi was a large epihyal. Dr. Gerald R. Smith examined the specimen and found close agreement with large C. bairdi from available skeletal material; however, he had no large specimens of C. carolinae for comparison (pers. comm., G. R. Smith). The author, having available large sculpin material of C. carolinae only, felt that acceptable comparison of the fossil with these forms was somewhat marginal. Therefore, the epihyal was referred tentatively to C. cf. bairdi. Distribution of Cottus carolinae, the banded sculpin, is centered largely in uplands and montane stream habitats throughout the Ozark Highland region and the Tennessee and Cumberland river drainages from the extreme lower to upper portions (Lee 1980). Additionally, it is widespread in the eastern Mobile Bay drainage (Alabama and Georgia); it is also known from streams in the upper and lower Ohio River system.

Cottus bairdi, the mottled sculpin, is more widespread but greatly fragmented in its range across North America. In the east, it ranges from northern Georgia and Alabama throughout much of the Ohio, Great Lakes, and upper Mississippi River drainages with scattered localities throughout much of eastern Canada. West of the Mississippi, it is concentrated in the Ozark Highland region, while

widely disjunct populations are known farther west, particularly concentrated in the Northwest.

Habitat preferences for the two species are similar and they are often syntopic (Pflieger 1975), generally preferring cool, clear streams over a sand and gravel or rocky substrate. However, C. bairdi tends to be less tolerant of warmer, downstream habitats (Lee 1980, Pflieger 1975). It may be found in lakes in more northern regions.

Nieland (1983) reported Cottus carolinae as extremely widespread and abundant throughout the Duck River system. On the other hand, C. bairdi rarely occurs in the system as the only available record reported by Nieland was seven specimens from Hurricane Creek, Humphreys County, in the lower Duck system.

Origins of Fish Bones in the Cave Deposits

There are presumably several means by which fish remains were deposited in the sediments of Cheek Bend Cave. These methods of accumulation are basically the same as those that have been succinctly discussed in Parmalee and Oesch (1972) and this discussion largely focuses on that work.

That humans have been the source of some of the remains in the cave deposits has been mentioned previously. The presence of various artifacts, charcoal, scorched bone fragments, mollusc shells, pottery sherds, and chert flakes attests to some aboriginal use of the cave, whether or not lengthy periods of habitation were

involved. Presumably the fish specimens used in the cave were caught or trapped in the main channel of the river not far from the cave site, but in some cases certain fish may have been transported for some distance from more productive areas of the river. The most commonly scorched bones were those of freshwater drum, Aplodinotus grunniens, and gars, Lepisosteus sp. However, a few scorched catfish (Ictaluridae) spine fragments were noted and, although very few catostomid cranial elements appeared to have been burned, some scorched vertebral fragments and fin rays were thought to represent fish of this group.

Evidence of prehistoric human occupation was found from Stratum VIII down into Stratum V (mid-Holocene). Thus, some of the remains in Stratum V (which contained the maximum number of elements and taxa for all strata) may have come from this source, although no scorched fish bones were recovered from this stratum. Presumably, these remains would represent mostly moderately large specimens rather than some of the smaller fish (e.g., sculpins, madtoms, darters, minnows, killifish) that comprised a substantial portion (in numbers of elements) of the identified material from that stratum. However, it is difficult to determine to what extent small fishes such as these may have been consumed or otherwise used by prehistoric populations. Nearly all the fishes identified from the aboriginal fire pit and adjacent area of the Edmondson Bridge Site (Table B-6) were small fishes consisting mostly of the groups mentioned above, and in large part were not represented by burned elements. Two

important sources of information concerning fish remains in archaeological context and the fishing methods used by aboriginals are Rostlund (1952) and Cleland (1966); others of related significance are listed in the comprehensive bibliographies in Bogan and Robison (1978) and Lyman (1979).

Another possible method of accumulation of fish remains is by direct deposition, either from periodic underground stream flow or by flooding from the main channel of the Duck River. These events could have left isolated pools with trapped fish which would have been left stranded after drying up of the pools. No apparent indication of flooding (e.g., fluvial sediments) has been discovered in Cheek Bend Cave (pers. comm., W. E. Klippel); however, the main channel of the Duck River has been observed to have risen to approximately 25-30 ft. (8-10 m) below the cave entrance during recent flooding (pers. comm., D. F. Morey).

Fish remains may be deposited in caves or crevices as a result of the activities of mammals (e.g., bear, raccoon, otter, mink) which might transport fish (from hunting or scavenging activities) to the cave, possibly resulting in deposition directly, by fecal material, or by their dying in the cave with fish bones in their digestive tracts. Gilbert and Nancekivell (1982) listed five species of fish consumed by mink and otter in northeastern Alberta, Canada. Casson and Klimstra (1983) reported sunfishes, minnows (mostly 2 - 4 cm long), suckers, and shad from a study of winter foods of mink in southern Illinois. The author has examined fish remains from

river otters introduced into local streams in east Tennessee and identified species of minnows, suckers, and sunfishes of small-to-medium size.

Avian fish predators or scavengers are another potential source of the fish remains in Cheek Bend Cave deposits. A large number of bird species worldwide (330 in 60 families) are known to produce pellets (regurgitated undigestible material) which frequently include animal bone remains (Burton 1973). Among those listed were kingfishers, herons, and some passerine birds. However, raptorial species (owls, hawks, eagles, kites) are known to produce pellets on a regular basis (Burton 1973).

Although a number of different avian species may have been contributors to the accumulation of fish remains in Cheek Bend Cave via pellet material, the most likely source among these are the owls which often roost in caves and crevices and within twilight areas. The majority of the many thousands of small mammal remains in the cave are attributed to this source (Klippel and Parmalee 1982a,b).

Even though fish are not reported as common in the diets of North American owl species, they have been reported as prey of some species: barred owl (Errington 1932, Smith et al. 1983), screech owl (Bent 1938, Turner and Dimmick 1981, Prescott 1985), and snowy owl (Bent 1938). Additionally, the author has identified several species of fish from great horned owl pellets collected in the vicinity of Cheek Bend Cave by W. E. Klippel and other personnel in the

Department of Anthropology, University of Tennessee, Knoxville.

Thus far, eight taxa of fishes ranging from small minnows to moderately large suckers (estimated standard length at least 300 mm) are represented.

Although it is easy to realize the possibility of owls capturing small surface-dwelling fish (e.g., killifish, some minnows) that are known from Cheek Bend Cave deposits, the occurrence of other small fish in the cave (e.g., madtoms, darters, sculpins) that are more benthic in habits is less easily explained by raptor predation. Perhaps in times of low water, some fish became trapped in shallow pools and were taken by owls nocturnally. On the other hand, active hunting of darters and other stream fishes by common mergansers (Merqus merganser) has been reported by Englert and Seghers (1983).

It is felt that the majority of the fish remains (particularly those representing small specimens) occurring in the deposits of Cheek Bend Cave were there as a result of predatory and scavenging activities of various piscivorous animals, notably raptorial birds. Even the large Moxostoma specimens represented in the pre-Holocene strata could be the result of scavenging activities by owls on spent individuals following spawning activities in shallow water. Judging by the fact that 27 of the taxa identified from the cave deposits were represented by only one or a few elements, and that most of the fish fragments surveyed were vertebrae, fin rays, pterygiophores, spines, and ribs (serially numerous elements in most fishes), it

is postulated (with caution) that probably no more than 200 or so specimens are represented in the three originally excavated columns. If this is true, then fish deposition was probably a rather slow, passive process throughout much of the span of time (at least the last 16,000 years) that is represented by the Cheek Bend Cave deposits. Perhaps future identification and analysis of remains from the subsequently excavated columns in the cave will provide additional insight into this question.

VII. CONCLUSIONS

Climatic inference, based on present distribution of fishes known from fossils, has basically been limited to studies west of the Mississippi River, primarily those of Illinoan glacial deposits in Meade County, Kansas, and adjacent Beaver County, Oklahoma (Hibbard and Taylor 1960; Schultz 1965, 1967; C. L. Smith 1954, 1958, 1964; G. R. Smith 1963; Taylor 1965). In these studies the investigators associated the fossil faunas with modern regions where the same species occur and suggested that southwestern Kansas had cooler summers and a wetter climate during Illinoan time than what exists there today, according to Cross (1970).

Attempts to infer climatic change using fossil fishes in the eastern United States are practically unknown, probably due to the scarcity of Wisconsinan or older sites in this region that have large quantities of fish remains and/or the failure to recover potential indicator species (those not found in the region of the fossil deposit today). The fish faunal information derived from investigations of Cheek Bend Cave does appear, however, to offer certain possibilities for inferring, at least, environmental change in the riverine environment of the middle Duck River in central Tennessee.

Instead of contrasting the entire Pleistocene fish fauna as a group with the complete Holocene list of taxa, a more plausible approach might be to evaluate each time-stratigraphical unit (regarding numbers of elements and taxa) and compare it with adjacent units

(Tables 1, B-4). The reasoning here is that because in both the unequivocal Pleistocene and Holocene contexts, several thousands of years of deposition are recorded and the amalgamation of taxa in each of these zones would presumably result in a combination of at least some taxa that were not contemporaneous. It is also felt that only taxa in Strata I-IV should be compared. This is due to evidence pointing to aboriginal occupation in the cave at various times throughout the period that Strata V through VIII were aggrading. It is felt that the aboriginal influence would not only result in additional taxa, but would also interfere with the natural mechanisms of cave biotic deposition both directly and indirectly.

The full glacial environment in Middle Tennessee was probably not unlike that in southern Manitoba today (Delcourt 1979). During this time Middle Tennessee mean annual temperatures may have been as much as 15 degrees (C) cooler and annual precipitation about 75 cm less than today (Delcourt 1979, p. 270). Delcourt (1980) suggested that the boreal-deciduous forest ecotone was in an area along 34° N latitude, east of the Mississippi Valley. Thus, Cheek Bend cave was located within the presumed boreal environment, but was not far from the ecotonal area in northern Alabama.

The most northern-ranging of the fish taxa represented in the full glacial depositional unit (Strata I-II) are the muskellunge, Esox masquinogy and the yellow perch, Perca flavescens. Smith (1964) characterized these two species as "northern" and "cold-water-dwelling" forms whose presence in the Illinoian deposits of the Oklahoma Panhandle

indicated a climate in that part of Oklahoma more like that in southern Wisconsin today.

Perca flavescens is one of the most commonly recorded taxa from late Pleistocene sites in North America west of the Mississippi River (Smith 1981). Habitat of the yellow perch and the muskellunge are somewhat similar in that they both prefer lakes and sluggish waters of rivers, and both are usually associated with vegetation. Crossman (1978) mentioned that in the southern part of its range, the muskellunge is limited to rivers and survived glaciation in these environments.

Nearly all the other species represented in the full glacial unit (Table B-4) seem to "fit" into the inferred boreal forest environment of Middle Tennessee, as modern ranges for most of them extend at least marginally into various areas of Canada or at least into the boreal/temperate ecotonal regions of the northern United States. The exceptions are Nocomis effusus and Cottus carolinae. Nocomis effusus would likely be able to exist in boreal stream conditions (assuming temperature is the primary limiting factor) as it does extend well into the uplands of the upper Cumberland drainage of Tennessee. Also, Jenkins and Lachner (1980) suggested that it may have affinities for streams heavily influenced by springs. Cottus carolinae, although fairly tolerant of high temperatures, would also seem to adapt to lower temperatures as well, as it extends far into the upper Tennessee River headwaters.

The presence of a large specimen of Acipenser fulvescens, as well as Esox masquinongy and Perca flavescens, in the full glacial central Duck River would seem to suggest moderately large, sluggish areas of riverine habitat there. This would also be suitable habitat for Stizostedion canadense (from Stratum II of the cave deposit), although perhaps not optimal because of sluggish current.

Nocomis species, Campostoma species, Percina caprodes, and Etheostoma blennioides could probably exist in such a stream environment, particularly if there were peripheral areas of stronger currents with at least some gravel or rock substrate. Although the presence of Semotilus atromaculatus and Catostomus commersoni would contradict the suggestion of this type of riverine environment (based on modern habitat preferences in the Tennessee area), more northern populations of these two species would probably have been more adaptable. All five Moxostoma species present in the cave deposit would find adequate habitat in the areas of swifter water with some suitable substrate, although M. anisurum and M. erythrurum would probably do well in the yellow perch-muskellunge habitat as well.

One should use caution, however, in suggesting a certain type of riverine environment based mostly on the presence of yellow perch and muskellunge, as both of these species are fairly adaptable to a range of conditions. This may be seen when considering their success as introductions and the presence of Perca flavescens in Atlantic coastal plain environments as far south as South Carolina.

Boreal (or boreal-like) conditions in the full glacial were followed by late glacial mixed coniferous-deciduous forests (ca.

16,500 YBP to 12,500 YBP) in Middle Tennessee (Delcourt 1979).

The forest biome region suggested as a modern analog for this period was northeastern Minnesota. In Cheek Bend Cave, deposits in Stratum III have been correlated with the late glacial period (Klippel and Parmalee 1982b) based on micromammal faunas. For the fishes, the most obvious change from Stratum II to Stratum III is the sharp drop in numbers of elements and taxa for most families. The scarcity of taxa and their low numbers of elements makes it very difficult to infer river habitat during the late glacial. Fundulus sp. (killifishes) is known from a few remains in these deposits, but there are few hints as to why it appears at this point. The presence of Stizostedion vitreum (with only one element representing this species), as well as a few remaining Perca flavescens elements suggests, perhaps, a fairly large, low gradient stream. Supporting this view is the presence of freshwater drum elements. However, the overall drop in numbers of elements and taxa seems to outweigh the significance of the few taxa represented, and this may be related to a Late Wisconsinan event.

The beginning of the late glacial, as proposed by Delcourt (1979) (i.e., the onset of deposition represented by Stratum III), is nearly synchronous with the first major diversion of the lower Mississippi River channel (ca. 17,000 YBP) when the Mississippi River completely eroded through the Bell City-Oran Gap in southeastern Missouri and shifted the zone of outwash deposition east to its present valley (Baker 1983). The deeply entrenched Mississippi

River began to aggrade quickly with tremendous volume of meltwater discharge that flowed toward the Gulf of Mexico. Perhaps the back-up effects or some other anomaly in flow regime of the lower Tennessee-Ohio River junction (due to the significant change in the Mississippi River) indirectly affected the flow regime of the Duck River during much of the time that Stratum III was aggrading. Thus, the paucity of taxa and numbers of elements in this stratum may be a reflection of possible changes in the river flow regime.

Delcourt (1979) suggested that the early Holocene (ca. 12,500 - 8,000 YBP) in Middle Tennessee was characterized by a cool-temperate mixed mesophytic forest environment. During this time Stratum IV was being deposited in Cheek Bend Cave. Examination of the fish fauna from this stratum again indicates low diversity and even fewer elements than in the previous stratum. The scattered taxa, represented by only one or a few elements each, makes it difficult to speculate on the nature of the fish fauna as a whole. Perhaps some major event in the drainage pattern farther north caused another anomaly in the Duck River flow pattern.

Baker (1983) suggested that a sudden change occurred around 13,000 YBP as the Saginaw ice lobe retreated from Michigan, causing Lake Erie meltwater to enter glacial Lake Chicago. According to Baker (1983, p. 118), ". . . further influxes of meltwater, over-spillings, downcutting, and uplift of northern outlets due to isotatic rebound produced a series of shorelines and adjustments that extended into the Holocene." Again, modification of the flow regime (e.g.,

influxes of meltwater, sediment build-up) in the major rivers could have influenced the tributaries such as the Duck River (e.g., by impoundment or temporary diversion of the lower channel). Moreover, as major Late Wisconsinan events such as these probably significantly affected the Mississippi River, there were apparently fairly continuous adjustments of the river's flow pattern occurring throughout much of the period from about 17,000 to 9,000 YBP in response to deglaciation (Saucier 1974, Baker 1983).

When the Mississippi River made its final major diversion (Thebes Gap, near Cairo, Illinois, ca. 9000 YBP), it began to establish its meandering course (Baker 1983). Perhaps this set the stage for stabilization of the Duck River flow regime during mid-Holocene time (represented by Stratum V), because while this stratum was being deposited, maximum numbers of elements and taxa were being deposited with it. As previously mentioned, however, Stratum V probably contained the largest volume of fill which could have been the primary factor in causing the resulting increased numbers of elements and diversity.

In summary, indirect evidence of a changing fish fauna in the central Duck River during late Pleistocene-Holocene time is suggested by the concentration of certain families or taxa of fishes in the Holocene deposits. These groups are the families Lepisosteidae, Ictaluridae, and Cyprinodontidae, and the genus Lepomis. More direct evidence of changing fish faunas during this time comes from the presence of Esox masquinongy, Nocomis biguttatus, and Perca flavescens in the Pleistocene deposits. Their presence tends to

support the concept of range adjustment of eastern North American fishes to climatic oscillations in late Quaternary times, an idea that has frequently been postulated on the basis of modern fish zoogeography but rarely demonstrated.

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LITERATURE CITED

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APPENDICES

APPENDIX A

Table A-1. Correlative levels (40MU261 -- 100N/100E).

Strata	Level (Catalog Number)
VIII	
VIII/VII	1(81-78), 2(83-78), 3(82-78) 1, 2, or 3(58-78)
VII	
VII-VI	4(79-78), 5(78-78), 6(77-78)
VI	7(76-78), 8(75-78), 9(74-78)
VI/V	10(73-78), 11(57-78)
V	12(48-78), 13(47-78), 14(56-78), 15 (55-78), 16(80-78)
V/IV	17(53-78), 18(67-78), 19(52-78), 20(69-78)
IV	21(46-78), 22(61-78)
IV/III	23(25-78), 24(35-78), 25(34-78), 26(32-78)
III	27(33-78), 28(54-78), 29(24-78)
III/II	30(26-78), 31(27-78), 32(28-78)
II	33(29-78), 34(51-78)
II/I	35(22-78), 36(30-78), 37(21-78)

Table A-2. Correlative levels (40MU261 -- 102N/100E).

Strata	Level (Catalog Number)
VIII	1A(229-79), 1B(230-79), 2A1(228-79)
VIII/VII	2A2(227-79)
VII	3A(226-79), 3B(225-79), 4A(224-79), 4B(223-79), 5A(222-79), 6A(221-79), 7A(219-79), 8A(217-79), 8C(215-79)
VII/VI	
VI	7B(218-79), 8B(216-79), 9A(214-79), 10A(213-79), 11A(211-79), 12A(210-79), 13A(208-79), 14A(206-79), 15A(203-79)
VI/V	
V	11B(212-79), 12B(209-79), 13B(207-79), 14B(205-79), 15B(204-79), 16(202-79), 17(201-79), 18(196-79, 197-79, 198-79), 19(195-79, 199-79, 200-79), 23A(185-79), 26A(166-79), 27A(161-79)
V/IV	20(193-79), 20(194-79), 21(192-79), 26C-1X(170-79)
IV	22B(191-79), 23B1(186-79), 23B2(101-79), 23B2X(188-79), 24B1(109-79), 24B2(116-79), 25A(177-79), 25B1(178-79), 25B2(179-79), 26B(168-79), 26B1(167-79), 26B2(168-79), 27B1(162-79), 27B2(165-79), 28B1(156-79), 28B2(157-79), 29B1(126-79)
IV/III	25C-1X(180-79)
III	23C1(189-79), 24C1(), 24C-1X(118-79), 24C-1Y(119-79), 24C2Y(121-79), 24C2Z(122-79), 25C-1X(180-79), 25C1Y(181-79), 25C2(182-79), 25C2X(184-79), 26C1(169-79), 26C2(171-79, 172-79, 173-79, 174-79, 175-79), 26C-2N(171-79), 27C1(163-79), 27C2(164-79, 176-79), 28C1(159-79), 28C2(155-79, 158-79), 29C1(124-79), 29C2(115-79, 125-79), 29C-2N(125-79), 29C-2S(115-79), 30C(114-79), 31C(130-79), 31E(133-79), 32C(131-79), 32E(133-79), 33C(134-79), 33E(136-79), 34C(129-79), 34E(111-79), 35E(139-79), 36E(106-79), 36E(140-79), 37E(107-79), 37E(143-79)
III/II	34E(111-79)

Table A-2 (continued).

Strata	Level (Catalog Number)
II	28D(160-79), 29D(127-79), 30D(113-79), 31D(132-79), 32D(1-79), 32D(100-79), 33D(135-79), 34D(112-79), 35D(138-79), 36D(141-79), 37D(142-79), 38D(104-79), 38D(144-79), 39D(102-79), 39D(145-79), 41D(147-79)
II/I	40D(103-79), 40D(146-79), 41D(147-79), 42D(149-79)
I	34A(128-79), 35A(137-79), 42F(150-79), 43D(151-79), 43F(152-79), 44G(153-79), 45G(154-79)

Table A-3. Correlative levels (40MU261 -- 104N/100E).

Strata	Level (Catalog Number)
VIII	1(50-78)
VII	2(68-78), 3(17-78), 4(45-78), 5(43-78), 6(44-78), 7(42-78)
VII/VI	8(41-78), 9(40-78), 10(38-78)
VI	11(37-78), 12(36-78), 13(16-78), 14(70-78), 15(71-78)
VI/V	16(72-78), 17(66-78), 18(20-78)
V	19(63-78), 20(31-78), 21(49-78), 22(62-78), 23(15-78), 24(18-78), 25(60-78), 26(12-78)
V/IV	27(23-78), 28(11-78)
IV	29(39-78)
IV/III	30(10-78), 31(65-78), 32(64-78)
III	33(14-78), 34(19-78), 35(1-78)
III/II	36(2-78), 37(3-78), 38(4-78)
II	39(5-78), 40(6-78), 41(7-78), 42(8-78), 41-42(9-78)
II/I	43(13-78), 44(84-78)
I	45(85-78)

Petromyzontidae

Ichthyomyzon castaneus--Chestnut lamprey
Lampetra aepyptera--Least brook lamprey

Lepisosteidae

Lepisosteus oculatus--Spotted gar
L. osseus--Longnose gar

Clupeidae

Alosa chrysochloris--Skipjack herring
Dorosoma cepedianum--Gizzard shad
D. petenense--Threadfin shad

Hiodontidae

H. tergisus--Mooneye

Salmonidae

Salmo gairdneri--Rainbow trout

Esocidae

Esox americanus--Grass pickerel
E. niger--Chain pickerel

Cyprinidae

Campostoma anomalum--Stoneroller
Clinostomus funduloides--Rosyside dace
Cyprinus carpio--Carp
Hemitremia flammea--Flame chub
Hybopsis aestivalis--Speckled chub
H. amblops--Bigeye chub
H. dissimilis--Streamline chub
H. insignis--Blotched chub
H. storeriana--Silver chub
Nocomis effusus--Redtail chub
Notemigonus crysoleucas--Golden shiner
Notropis ardens--Rosefin shiner
N. ariommus--Popeye shiner
N. atherinoides--Emerald shiner
N. blennius--River shiner
N. boops--Bigeye shiner
N. chrysocephalus--Striped shiner
N. galacturus--Whitetail shiner
N. heterolepis--Blacknose shiner
N. leuciodus--Tennessee shiner
N. lirus--Mountain shiner
N. photogenis--Silver shiner
N. rubellus--Rosyface shiner

Fig. A-1. Fishes of the Duck River system.

Cyprinidae (continued)

N. sp. cf. spectrunculus
N. spilopterus--Spotfin shiner
N. telescopus--Telescope shiner
N. volucellus--Mimic shiner
N. whipplei--Steelcolor shiner
N. wickliffi--Channel mimic shiner
Opsopoeodus emiliae--Pugnose minnow
Phenacobius mirabilis--Suckermouth minnow
P. uranops--Starazing minnow
Phoxinus erythrogaster--Southern redbelly dace
Pimephales notatus--Bluntnose minnow
P. promelas--Fathead minnow
P. vigilax--Bullhead minnow
Rhinichthys atratulus--Blacknose dace
Semotilus atromaculatus--Creek chub

Catostomidae

Carpiodes carpio--River carpsucker
C. cyprinus--Quillback
Catostomus commersoni--White sucker
Erimyzon oblongus--Creek chubsucker
Hypentelium nigricans--Northern hog sucker
Ictiobus bubalus--Smallmouth buffalo
I. cyprinellus--Bigmouth buffalo
I. niger--Black buffalo
Minytrema melanops--Spotted sucker
Moxostoma anisurum--Silver redhorse
M. carinatum--River redhorse
M. duquesnei--Black redhorse
M. erythrurum--Golden redhorse
M. macrolepidotum--Shorthead redhorse

Ictaluridae

Ictalurus melas--Black bullhead
I. natalis--Yellow bullhead
I. punctatus--Channel catfish
Noturus elegans--Elegant madtom
N. sp. cf. N. elegans
N. eleutherus--Mountain madtom
N. exilis--Slender madtom
N. flavus--Stonecat
N. miurus--Brindled madtom
N. nocturnus--Freckled madtom
N. stanauli--Pygmy madtom
Pylodictis olivaris--Flathead catfish

Fig. A-1 (continued).

Cyprinodontidae

- Fundulus catenatus--Northern studfish
- F. notatus--Blackstripe topminnow
- F. olivaceus--Blackspotted topminnow
- F. julisia--Barrens topminnow

Poeciliidae

- Gambusia affinis--Mosquitofish

Amblyopsidae

- Chologaster agassizi--Spring cavefish

Aphredoderidae

- Aphredoderus sayanus--Pirate perch

Percichthyidae

- Morone chrysops--White bass
- M. mississippiensis--Yellow bass

Atherinidae

- Labidesthes sicculus--Brook silverside

Centrarchidae

- Ambloplites rupestris--Rock bass
- Lepomis cyanellus--Green sunfish
- L. gulosus--Warmouth
- L. humilis--Orangespotted sunfish
- L. macrochirus--Bluegill
- L. megalotis--Longear sunfish
- L. microlophus--Redear sunfish
- Micropterus dolomieu--Smallmouth bass
- M. punctulatus--Spotted bass
- M. salmoides--Largemouth bass
- Pomoxis annularis--White crappie
- P. nigromaculatus--Black crappie

Percidae

- Etheostoma atripinne--Cumberland snubnose darter
- E. aquali--Coppercheek darter
- E. blennioides--Greenside darter
- E. blennius--Blenny darter
- E. caeruleum--Rainbow darter
- E. camurum--Bluebreast darter
- E. chlorosomum--Bluntnose darter
- E. cinereum--Ashy darter
- E. crossopterum--Fringefin darter

Fig. A-1 (continued).

Percidae (continued)

- E. duryi--Blackside snubnose darter
- E. flabellare--Fantail darter
- E. sp. cf. duryi--Golden snubnose darter
- E. gracile--Slough darter
- E. histrio--Harlequin darter
- E. kennicotti--Stripetail darter
- E. luteovinctum--Redband darter
- E. neopterum--Lollypop darter
- E. nigripinne--Blackfin darter
- E. nigrum--Johnny darter
- E. rufilineatum--Redline darter
- E. smithi--Slabrock darter
- E. spectabile--Orangethroat darter
- E. stigmaeum--Speckled darter
- E. striatulum--Striated darter
- E. tippecanoe--Tippecanoe darter
- E. zonale--Banded darter
- Percina burtoni--Blotchside logperch
- P. caprodes--Logperch
- P. evides--Gilt darter
- P. macrocephala--Longhead darter
- P. phoxocephala--Slenderhead darter
- P. sciera--Dusky darter
- P. shumardi--River darter
- P. vigil--Ouachita darter
- Stizostedion canadense--Sauger
- S. vitreum--Walleye

Sciaenidae

- Aplodinotus grunniens--Freshwater drum

Cottidae

- Cottus bairdi--Mottled sculpin
- C. carolinae--Banded sculpin

Fig. A-1 (continued).

APPENDIX B

Table B-1. Cheek Bend Cave ichthyofauna (40MU261--excavation units 100N/100E - 104N/100E).
(Numerical entries indicate numbers of elements identified for each taxon.)

Taxa	Strata ^{a,b}															Total
	I	II/I	II	III/II	III	IV/III	IV	V/IV	V	VI/V	VI	VII/VI	VII	VIII/VII	VIII	
LEPISOSTEIDAE																
<u>Lepisosteus</u> sp.			1		2	3	6	19	139	9	81	15	97	8	5	385
ANGUILLIDAE																
<u>Anguilla</u> <u>rostrata</u>									3							3
ESOCIDAE																
<u>Esox</u> cf. <u>masquinongy</u>		1		1												2
<u>Esox</u> sp.														1		1
Total Esocidae		1		1										1		3
CYPRINIDAE																
<u>Campostoma</u> sp.	2		6	1		2	7		8	33		2				61
cf. <u>Dionda</u> / <u>Hybognathus</u> sp.									2	4						6
cf. <u>Hybopsis</u> <u>amblops</u>										1						1
<u>Nocomis</u> <u>biguttatus</u>	1															1
<u>Nocomis</u> <u>effusus</u> / <u>micropogon</u>			5			1	1			1						8
<u>Nocomis</u> sp.	15		16						4	5		5				45
<u>Notropis</u> <u>cornutus</u> / <u>chrysocephalus</u>									2							2
<u>Notropis</u> (<u>Cyprinella</u>) sp.						3	1						1			5
<u>Notropis</u> cf. <u>stramineus</u>										1						1
<u>Notropis</u> sp.		1	1						1	2						5
<u>Phenacobius</u> cf. <u>uranops</u>										1						1
<u>Pimephales</u> <u>notatus</u>										1						1

Table B-1 (continued).

Taxa	Strata ^{a,b}															Total
	I	II/I	II	III/II	III	IV/III	IV	V/IV	V	VI/V	VI	VII/VI	VII	VIII/VII	VIII	
(CYPRINIDAE)																
<u>Semotilus atromaculatus</u>			1						2							3
Cyprinidae sp.	1	14	27	10	2	10	6	14	76	2	8	3	2			175
Total Cyprinidae	1	34	55	11	4	21	8	31	127	2	15	3	3			315
CATOSTOMIDAE																
<u>Catostomus commersoni</u>		5	9		1											15
<u>Hypentelium nigricans</u>		3	3		2	1		1	8			2		1		21
<u>Ictiobus cf. niger</u>												2				2
<u>Moxostoma anisurum</u>			8	1												9
<u>Moxostoma carinatum</u>		3	3	1	7	4				1	7		10	4	1	41
<u>Moxostoma duquesnei</u>			3				1	2	1				1	1		9
<u>Moxostoma erythrurum</u>		1	3	2			1		5							12
<u>Moxostoma macrolepidotum</u>			1			1										2
<u>Moxostoma</u> sp.		6	38	5	4	14	6	9	34	1	8	5	25	18	3	176
Catostomidae sp.	1	39	128	45	41	27	21	25	69	4	21	13	36	3	3	476
Total Catostomidae	1	57	196	54	55	47	29	37	117	6	36	18	76	27	7	763
ICTALURIDAE																
<u>Ictalurus punctatus</u>									1						1	2
<u>Ictalurus natalis</u>									1		1					2
<u>Ictalurus</u> sp.						1			1							2
<u>Noturus cf. elegans</u>									1							1
<u>Noturus cf. eleutherus</u>											2					2

Table B-1 (continued).

Taxa	Strata ^{a,b}															Total
	I	II/I	II	III/II	III	IV/III	IV	V/IV	V	VI/V	VI	VII/VI	VII	VIII/VII	VIII	
(ICTALURIDAE)																
<u>Noturus exilis</u>									1	2						3
<u>Noturus flavater</u>									1	1						2
<u>Noturus</u> cf. <u>flavus</u>		2	12	3			2	1	8	23		1				52
<u>Noturus</u> cf. <u>nocturnus</u>									1							1
<u>Noturus</u> (<u>Rabida</u>) sp.									2	7	1	2		1		13
<u>Noturus</u> sp.					1				4	11	1					17
<u>Pylodictis olivaris</u>										1		3	1			5
Ictaluridae sp.		3	4				7	4	22	51	1	8	1		1	102
Total Ictaluridae		5	16	3		1	10	5	39	100	3	14	4	2	1	204
CYPRINODONTIDAE																
<u>Fundulus catenatus</u>							3		32	117	1			1		154
<u>Fundulus</u> sp.				1	4	6	6		5	14						36
Total Cyprinodontidae				1	4	9	6		37	131	1			1		190
CENTRARCHIDAE																
<u>Ambloplites rupestris</u>		9	14	3	11	20	6	8	66		5		33	1	1	177
<u>Lepomis cyaneus</u>			1													1
<u>Lepomis</u> sp.							1	2	15	2	3	1	1		1	26
<u>Micropterus dolomieu</u>								1	3		1					5
<u>Micropterus dolomieu</u> / <u>punctulatus</u>		1														1

Table B-1 (continued).

Taxa	Strata a,b															Total
	I	II/I	II	III/II	III	IV/III	IV	V/IV	V	VI/V	VI	VII/VI	VII	VIII/VII	VIII	
(CENTRARCHIDAE)																
<u>Micropterus</u> sp.			1			5	2	3	17				1	1		30
Centrarchidae sp.	21	69	6		32	34	25	53	148	11	34	16	9	5		463
Total Centrarchidae	31	85	9		43	59	34	67	249	13	43	17	44	7	2	703
PERCIDAE																
<u>Etheostoma blennioides</u>	10		8	1		1	3	1	11	56		4				95
<u>Etheostoma (Nothonotus)</u> sp.										1						1
<u>Percina caprodes</u>			2													2
Percidae sp. (darter)			4				1		4	13		1				23
<u>Perca flavescens</u>	1	14	28		3											46
<u>Stizostedion canadense</u>			1													1
<u>Stizostedion vitreum</u>					1											1
<u>Stizostedion</u> sp.			3	1					2							6
Total Percidae	1	24	46	2	5	4	1	15	72		5					175
SCIAENIDAE																
<u>Aplodinotus grunniens</u>	4		2		3	4	1	1	2		1		67	19	1	105

Table B-1 (continued).

Taxa	Strata ^{a,b}															Total
	I	II/I	II	III/II	III	IV/III	IV	V/IV	V	VI/V	VI	VII/VI	VII	VIII/VII	VIII	
COTTIDAE																
<u>Cottus carolinae</u>		2	3		1				2		1					9
<u>Cottus cf. bairdi</u>				1												1
<u>Cottus sp.</u>		1	3	2	2		1		11							20
Total Cottidae		3	6	3	3		1		13		1					30
TOTAL BY STRATUM	3	159	407	84	120	157	91	246	953	34	196	57	289	64	16	2876

^aStrata I-VIII (including intermediate strata).

^bI-III = Late Pleistocene, IV-VIII = Holocene.

Table B-2. Summary of fish families identified from Cheek Bend Cave (40MU261), including percentage occurrence in Pleistocene Strata. (Numerical entries indicate numbers or percentages of elements identified.)

Family	Number of Elements Identified from Unequivocal Pleistocene/Holocene Contexts (all strata excluding IV/III)	Percentage of Total Elements for All Families Identified from Unequivocal Pleistocene/Holocene Contexts	Number of Elements in Pleistocene Strata (I-III)	Percentage Occurrence of Elements in Pleistocene Strata (I-III)
Lepisosteidae	382	14.0	3	0.8
Anguillidae	3	0.1	0	0.0
Esocidae	3	0.1	2	66.7
Cyprinidae	294	10.8	105	35.7
Catostomidae	716	26.3	363	50.7
Ictaluridae	194	7.1	25	12.9
Cyprinodontidae	181	6.7	5	2.8
Centrarchidae	644	23.7	168	26.1
Percidae	171	6.3	78	45.6
Sciaenidae	101	3.7	9	8.9
Cottidae	30	1.1	15	0.5

Table B-3. Unequivocal fish taxa identified from Pleistocene/Holocene deposits of Cheek Bend Cave (40MU261). (Excavation units 100N/100E--104N/100E; 101N/99E^a; 102N/99E^a).

Taxa	Recorded from Late Pleistocene Strata (I-III)	Recorded from Holocene Strata (IV-VIII)
ACIPENSERIDAE		
<u>Acipenser fulvescens</u> ^{a,b}	X	
LEPISOSTEIDAE		
<u>Lepisosteus</u> sp.	X	X
ANGUILLIDAE		
<u>Anguilla rostrata</u> ^b		X
ESOCIDAE		
<u>Esox masquinongy</u> ^{a,b}	X*	
CYPRINIDAE		
<u>Campostoma</u> sp.	X	X
cf. <u>Diionda/Hybognathus</u> sp. ^b		X*,**
cf. <u>Hybopsis amblops</u>		X*,**
<u>Nocomis biguttatus</u> ^b	X*	
<u>Nocomis effusus/micropogon</u>	X*,**	X*
<u>Notropis cornutus/chrysocephalus</u>		X*
<u>Notropis (Cyprinella)</u> sp.		X*,**
<u>Notropis</u> cf. <u>stramineus</u> ^b		X*
<u>Phenacobius</u> cf. <u>uranops</u>		X*,**
<u>Pimephales notatus</u>		X*,**
<u>Semotilus atromaculatus</u>	X	X

Table B-3 (continued).

Taxa	Recorded from Late Pleistocene Strata (I-III)	Recorded from Holocene Strata (IV-VIII)
CATOSTOMIDAE		
<u>Catostomus commersoni</u>	X	
<u>Hypentelium nigricans</u>	X*	X
<u>Ictiobus</u> cf. <u>niger</u>		X
<u>Moxostoma anisurum</u>	X*	
<u>Moxostoma carinatum</u>	X*	X
<u>Moxostoma duquesnei</u>	X*	X
<u>Moxostoma erythrurum</u>	X*	X
<u>Moxostoma macrolepidotum</u>	X*	
ICTALURIDAE		
<u>Ictalurus punctatus</u>		X
<u>Ictalurus natalis</u>		X
<u>Noturus</u> cf. <u>elegans</u>		X*,**
<u>Noturus</u> cf. <u>eleutherus</u>		X*,**
<u>Noturus exilis</u>		X*,**
<u>Noturus flavater</u> ^b		X*,**
<u>Noturus</u> cf. <u>flavus</u>	X*,**	X*
<u>Noturus</u> cf. <u>nocturnus</u>		X*,**
<u>Pylodictus olivaris</u>		X
CYPRINODONTIDAE		
<u>Fundulus catenatus</u>		X*,**

Table B-3 (continued).

Taxa	Recorded from Late Pleistocene Strata (I-III)	Recorded from Holocene Strata (IV-VIII) ^a
CENTRARCHIDAE		
<u>Ambloplites rupestris</u>	X*	X
<u>Lepomis cyanellus</u>	X	
<u>Micropterus dolomieu</u>		X
PERCIDAE		
<u>Etheostoma blennioides</u>	X*,**	X*
<u>Etheostoma (Nothonotus) sp.</u>		X*,**
<u>Percina caprodes</u>	X*,**	
<u>Perca flavescens</u> ^b	X	
<u>Stizostedion canadense</u>	X*	
<u>Stizostedion vitreum</u>	X	
SCIAENIDAE		
<u>Aplodinotus grunniens</u>	X	X
COTTIDAE		
<u>Cottus carolinae</u>	X*,**	X*
<u>Cottus cf. bairdi</u>	X	

^aDenotes subsequently excavated units partially surveyed and/or taxa identified only from those units.

^bDenotes taxa for which there are no modern records from the Duck River System.

*Denotes apparent initial record of taxon for Late Wisconsinan and/or Holocene time.

**Denotes apparent initial fossil occurrence ever recorded for taxon.

Table B-4. Distribution of Cheek Bend Cave fish taxa within and among time-stratigraphical units used in dating the fish remains.^a (Numerical entries indicate numbers of elements identified for each taxon.)

Taxa	Full Glacial Strata I-II	Late Glacial Stratum III	Early Holocene Stratum IV	Mid-Holocene Stratum V	Late Holocene Strata VI-VIII
LEPISOSTEIDAE					
<u>Lepisosteus</u> sp.	1	2	6	139	206
ANGUILLIDAE					
<u>Anguilla</u> <u>rostrata</u>				3	
ESOCIDAE					
<u>Esox</u> cf. <u>masquinongy</u>	1				
<u>Esox</u> sp.					1
Total Esocidae	1				1
CYPRINIDAE					
<u>Campostoma</u> sp.	8	2		33	2
cf. <u>Dionda</u> / <u>Hybognathus</u> sp.				4	
<u>Nocomis</u> <u>biguttatus</u>	1				
<u>Nocomis</u> <u>effusus</u> / <u>micropogon</u>	5		1	1	

Table B-4 (continued).

Taxa	Full Glacial Strata I-II	Late Glacial Stratum III	Early Holocene Stratum IV	Mid-Holocene Stratum V	Late Holocene Strata VI-VIII
<u>Nocomis</u> sp.	31			5	5
<u>Notropis cornutus/chrysocephalus</u> ^b					
<u>Notropis (Cyprinella)</u> sp.			1		1
<u>Notropis</u> cf. <u>stramineus</u>				1	
<u>Notropis</u> sp.	1			2	
<u>Phenacobius</u> cf. <u>uranops</u>				1	
<u>Pimephales</u> <u>notatus</u>				1	
<u>Semotilus</u> <u>atromaculatus</u>	1			2	
Cyprinidae sp.	42	2	6	76	13
Total Cyprinidae	89	4	8	127	21
CATOSTOMIDAE					
<u>Catostomus commersoni</u>	14	1			
<u>Hypentelium nigricans</u>	6	2		8	3
<u>Ictiobus</u> cf. <u>niger</u>					2

Table B-4 (continued).

Taxa	Full Glacial Strata I-II	Late Glacial Stratum III	Early Holocene Stratum IV	Mid-Holocene Stratum V	Late Holocene Strata VI-VIII
<u>Moxostoma anisurum</u>	8				
<u>Moxostoma carinatum</u>	6	7			22
<u>Moxostoma duquesnei</u>	3		1	1	2
<u>Moxostoma erythrurum</u>	4		1	5	
<u>Moxostoma macrolepidotum</u>	1				
<u>Moxostoma</u> sp.	44	4	6	34	59
Catostomidae sp.	168	41	21	69	76
Total Catostomidae	254	55	29	117	164
ICTALURIDAE					
<u>Ictalurus punctatus</u>				1	1
<u>Ictalurus natalis</u>				1	1
<u>Ictalurus</u> sp.				1	
<u>Noturus</u> cf. <u>elegans</u>				1	
<u>Noturus</u> cf. <u>eleutherus</u>					2

Table B-4 (continued).

Taxa	Full Glacial Strata I-II	Late Glacial Stratum III	Early Holocene Stratum IV	Mid-Holocene Stratum V	Late Holocene Strata VI-VIII
<u>Noturus exilis</u>				2	
<u>Noturus flavater</u>				1	
<u>Noturus</u> cf. <u>flavus</u>	14		1	23	1
<u>Noturus</u> cf. <u>nocturnus</u> ^b					
<u>Noturus</u> (<u>Rabida</u>) sp.				7	3
<u>Noturus</u> sp.		1		11	
<u>Pylodictus olivaris</u>				1	4
Ictaluridae sp.	7	0	4	51	10
Total Ictaluridae	21	1	5	100	22
CYPRINODONTIDAE					
<u>Fundulus catenatus</u>				117	1
<u>Fundulus</u> sp.		4	6	14	
Total Cyprinodontidae		4	6	131	1

Table B-4 (continued).

Taxa	Full Glacial Strata I-II	Late Glacial Stratum III	Early Holocene Stratum IV	Mid-Holocene Stratum V	Late Holocene Strata VI-VIII
CENTRARCHIDAE					
<u>Ambloplites rupestris</u>	23	11	6	66	40
<u>Lepomis cyanellus</u>	1				
<u>Lepomis</u> sp.			1	15	6
<u>Micropterus dolomieu</u>				3	1
<u>Micropterus dolomieu/punctulatus</u>	1				
<u>Micropterus</u> sp.	1		2	17	2
Centrarchidae sp.	90	32	25	148	64
Total Centrarchidae	116	43	34	249	113
PERCIDAE					
<u>Etheostoma blennioides</u>	18	1	1	56	4
<u>Etheostoma (Nothonotus)</u> sp.				1	
<u>Percina caprodes</u>	2				

Table B-4 (continued).

Taxa	Full Glacial Strata I-II	Late Glacial Stratum III	Early Holocene Stratum IV	Mid-Holocene Stratum V	Late Holocene Strata VI-VIII
Percidae sp. (darter)	4			13	1
<u>Perca flavescens</u>	43	3			
<u>Stizostedion canadense</u>	1				
<u>Stizostedion vitreum</u>		1			
<u>Stizostedion</u> sp.	3			2	
Total Percidae	71	5	1	72	5
SCIEANIDAE					
<u>Aplodinotus grunniens</u>	6	3	1	2	88
COTTIDAE					
<u>Cottus carolinae</u>	5	1		2	1
<u>Cottus</u> cf. <u>bairdi</u> ^b					

Table B-4 (continued).

Taxa	Full Glacial Strata I-II	Late Glacial Stratum III	Early Holocene Stratum IV	Mid-Holocene Stratum V	Late Holocene Strata VI-VIII
<u>Cottus</u> sp.	4	2	1	11	
Total Cottidae	9	3	1	13	1
TOTAL	568	120	91	953	622

^aRefer to Table 1, page 35, for method of dating fish remains.

^bIndicates taxa not occurring in the time-stratigraphical units.

Table B-5. Occurrence of fish taxa in the Pleistocene of Cheek Bend Cave (40MU261). (Numerical entries indicate numbers or percentages of elements identified.)

Taxa	Number of Elements Identified from Unequivocal Pleistocene/Holocene Contexts (all strata except IV/III)	Number of Elements Identified from Pleistocene Strata (I-III)	Percentage Occurrence of Elements in Pleistocene Strata
LEPISOSTEIDAE			
<u>Lepisosteus</u> sp.	382	3	0.8
ANGUILLIDAE			
<u>Anguilla rostrata</u>	3	0	0.0
ESOCIDAE			
<u>Esox</u> cf. <u>masquinongy</u>	2	2	100.0
<u>Esox</u> sp.	1	0	0.0
CYPRINIDAE			
<u>Campostoma</u> sp.	54	11	20.4
cf. <u>Dionda/Hybognathus</u> sp.	0	0	0.0
cf. <u>Hybopsis amblops</u>	1	0	0.0

Table B-5 (continued).

Taxa	Number of Elements Identified from Unequivocal Pleistocene/Holocene Contexts (all strata except IV/III)	Number of Elements Identified from Pleistocene Strata (I-III)	Percentage Occurrence of Elements in Pleistocene Strata
<u>Nocomis biguttatus</u>	1	1	100.0
<u>Nocomis effusus/micropogon</u>	7	5	71.4
<u>Nocomis</u> sp.	45	31	68.9
<u>Notropis cornutus/chrysocephalus</u>	2	0	0.0
<u>Notropis (Cyprinella)</u> sp.	2	0	0.0
<u>Notropis</u> cf. <u>stramineus</u>	1	0	0.0
<u>Notropis</u> sp.	5	2	40.0
<u>Phenacobius</u> cf. <u>uranops</u>	1	0	0.0
<u>Pimephales notatus</u>	1	0	0.0
<u>Semotilus atromaculatus</u>	3	1	33.3
Cyprinidae sp.	166	54	32.5

Table B-5 (continued).

Taxa	Number of Elements Identified from Unequivocal Pleistocene/Holocene Contexts (all strata except IV/III)	Number of Elements Identified from Pleistocene Strata (I-III)	Percentage Occurrence of Elements in Pleistocene Strata
CATOSTOMIDAE			
<u>Catostomus commersoni</u>	15	15	100.0
<u>Hypentelium nigricans</u>	20	8	40.0
<u>Ictiobus</u> cf. <u>niger</u>	2	0	0.0
<u>Moxostoma anisurum</u>	9	9	100.0
<u>Moxostoma carinatum</u>	37	14	37.8
<u>Moxostoma duquesnei</u>	9	3	33.3
<u>Moxostoma erythrurum</u>	12	6	50.0
<u>Moxostoma macrolepidotum</u>	1	1	100.0
<u>Moxostoma</u> sp.	162	53	32.7
Catostomidae sp.	449	254	56.6
ICTALURIDAE			
<u>Ictalurus punctatus</u>	2	0	0.0

Table B-5 (continued).

Taxa	Number of Elements Identified from Unequivocal Pleistocene/Holocene Contexts (all strata except IV/III)	Number of Elements Identified from Pleistocene Strata (I-III)	Percentage Occurrence of Elements in Pleistocene Strata
<u>Ictalurus natalis</u>	2	0	0.0
<u>Ictalurus</u> sp.	1	0	0.0
<u>Noturus</u> cf. <u>elegans</u>	1	0	0.0
<u>Noturus</u> cf. <u>eleutherus</u>	2	0	0.0
<u>Noturus</u> <u>exilis</u>	3	0	0.0
<u>Noturus</u> <u>flavater</u>	2	0	0.0
<u>Noturus</u> cf. <u>flavus</u>	50	17	34.0
<u>Noturus</u> cf. <u>nocturnus</u>	1	0	0.0
<u>Noturus</u> (<u>Rabida</u>) sp.	13	0	0.0
<u>Noturus</u> sp.	17	1	5.9
<u>Pylodictus</u> <u>olivaris</u>	5	0	0.0
Ictaluridae sp.	95	7	7.4

Table B-5 (continued).

Taxa	Number of Elements Identified from Unequivocal Pleistocene/Holocene Contexts (all strata except IV/III)	Number of Elements Identified from Pleistocene Strata (I-III)	Percentage Occurrence of Elements in Pleistocene Strata
CYPRINODONTIDAE			
<u>Fundulus catenatus</u>	151	0	0.0
<u>Fundulus</u> sp.	30	5	16.7
CENTRARCHIDAE			
<u>Ambloplites rupestris</u>	157	37	23.6
<u>Lepomis cyanellus</u>	1	1	100.0
<u>Lepomis</u> sp.	26	0	0.0
<u>Micropterus dolomieu</u>	5	0	0.0
<u>Micropterus dolomieu/punctulatus</u>	1	1	100.0
<u>Micropterus</u> sp.	25	1	4.0
Centrarchidae sp.	429	128	29.8
PERCIDAE			
<u>Etheostoma blennioides</u>	92	20	21.7

Table B-5 (continued).

Taxa	Number of Elements Identified from Unequivocal Pleistocene/Holocene Contexts (all strata except IV/III)	Number of Elements Identified from Pleistocene Strata (I-III)	Percentage Occurrence of Elements in Pleistocene Strata
<u>Etheostoma</u> (<u>Nothonotus</u>) sp.	1	0	0.0
<u>Percina caprodes</u>	2	2	100.0
<u>Percidae</u> sp. (darter)	22	4	18.2
<u>Perca flavescens</u>	46	46	100.0
<u>Stizostedion canadense</u>	1	1	100.0
<u>Stizostedion vitreum</u>	1	1	100.0
<u>Stizostedion</u> sp.	6	4	66.7
SCIAENIDAE			
<u>Aplodinotus grunniens</u>	101	9	8.9
COTTIDAE			
<u>Cottus carolinae</u>	9	6	66.7
<u>Cottus</u> cf. <u>bairdi</u>	1	1	100.0
<u>Cottus</u> sp.	20	8	40.0

Table B-6. Fish remains identified from the Middle Woodland (ca. 1500 YBP) Edmondson Bridge Site (40MU423) near Fountain Creek, in Maury County, Tennessee.¹

Taxa	Number of Elements Identified ²
LEPISOSTEIDAE	
<u>Lepisosteus</u> sp.	1
CYPRINIDAE	
<u>Campostoma</u> sp.	30
cf. <u>Dionda/Hybognathus</u> sp.	1
<u>Nocomis effusus/micropogon</u>	14
<u>Notropis</u> sp.	1
<u>Pimephales notatus</u>	4
<u>Semotilus atromaculatus</u>	1
Cyprinidae sp.	28
CATOSTOMIDAE	
<u>Moxostoma duquesnei</u>	1
<u>Moxostoma duquesnei/carinatum</u>	11
<u>Moxostoma erythrurum</u>	1
Catostomidae sp.	11
ICTALURIDAE	
<u>Ictalurus</u> cf. <u>melas</u>	2
<u>Ictalurus</u> cf. (bullhead)	5
<u>Noturus exilis</u>	9
<u>Noturus</u> sp.	19
Ictaluridae sp.	8

Table B-6 (continued).

Taxa	Number of Elements Identified ²
CENTRARCIDAE	
<u>Ambloplites rupestris</u>	11
<u>Lepomis</u> cf. <u>cyanellus</u>	1
<u>Lepomis</u> sp.	42
<u>Micropterus</u> sp.	3
Centrarchidae sp.	46
PERCIDAE	
<u>Etheostoma blennioides</u>	11
cf. <u>Percina</u> sp.	1
Percidae sp. (darter)	8
COTTIDAE	
<u>Cottus</u> sp.	1
SCIAENIDAE	
<u>Aplodinotus grunniens</u>	7

¹Site consists of an excavated earth oven pit and surrounding fill area located on second terrace above upper Fountain Creek, about 10 km upstream from the Duck River. Radiocarbon date reported as ca. 1500 YBP (Bentz, 1986). Identification by W. C. Dickinson, 1985. Data presented with permission of C. Bentz.

²Number of elements consists of total from oven pit and surrounding fill area.

ACIPENSERIDAE

Acipenser fulvescens - scute fragments - 7 (two complete)

ESOCIDAE

Esox masquinongy - palatine fragments - 2, teeth - 2,
vertebrae - 4

CYPRINIDAE

Nocomis biguttatus - lower pharyngeal bone fragments - 2

Nocomis effusus/micropogon - lower pharyngeal bone fragment - 1

Nocomis sp. - fragments of: dentary (2), basioccipital - 5,
lower pharyngeal - 4

Campostoma sp. - fragments of: basioccipital - 1, lower
pharyngeal - 1

Cyprinidae sp. - fragments of: quadrate - 1, dentary - 2, lower
pharyngeal - 5, articular-angular - 1, maxillary - 1, basioccipi-
tal - 1

CATOSTOMIDAE

Catostomus commersoni - ceratohyal - 4, hypohyal - 1, art-angular - 1

Hypentelium nigricans - epihyal fragment - 1

Moxostoma anisurum - ceratohyal - 1 (nearly complete)

Moxostoma cf. duquesnei - maxillary fragment - 1

Moxostoma cf. erythrurum - maxillary fragment - 1

Moxostoma sp. - fragments of: premaxillary - 1, articular-
angular - 2, ceratohyal - 1, epihyal - 1, hypohyal - 1, dentary - 2,
maxillary - 3

Catostomidae sp. - lower pharyngeal - 2, urohyal - 1 (small)

Fig. B-1. Preliminary results of identification of partial samples from some lower levels (late Pleistocene) of subsequently excavated deposits in Cheek Bend Cave (40MU261). (Excavation units 101N/99E and 102N/99E. Most faunal elements are from 101N/99E--level 42.)

Catostomidae sp. - fragments of: sphenotic - 2, palatine - 2, rib - 1, quadrate - 1, maxillary - 1

ICTALURIDAE

Ictaluridae sp. (cf. Noturus flavus?) - cleithrum fragment - 1

CYPRINODONTIDAE

Fundulus sp. - articular-angular - 1

CENTRARCHIDAE

Ambloplites rupestris - fragments of: dentary - 3, articular-angular - 1, maxillary - 1, vomer - 2, premaxillary - 3, palatine - 1, quadrate - 2

Micropterus sp. - premaxillary fragment - 1

Centrarchidae sp. - supracleithrum fragment - 1

PERCIDAE

Percidae sp. (darter) - cleithrum fragments - 2, premaxillary fragment - 1

COTTIDAE

Cottus sp. - fragments of: subopercle - 1, vomer - 1, dentary - 2

Osteichthys sp. - miscellaenous unidentified fragments of: lower pharyngeal - 1, dentary - 1, preopercle - 1, maxillary - 1, vertebrae - 57, spines - 2

Lepisosteus sp.--gar
Campostoma sp.--stoneroller minnow
Nocomis effusus/micropogon--orange fin chub/river chub
Cyprinidae sp.--minnow
Lagochila lacera--harelip sucker
Moxostoma carinatum--river redhorse
Moxostoma duquesnei--black redhorse
Moxostoma macrolepidotum--shorthead redhorse
Moxostoma sp.--redhorse
Catostomidae sp.--sucker
Ictalurus punctatus--channel catfish
Pylodictis olivaris--flathead catfish
Ictaluridae sp.--catfish
Ambloplites rupestris - rock bass
Micropterus sp.--black bass
Aplodinotus grunniens--freshwater drum
Cottus sp.--sculpin

Fig. B-2. Fish taxa identified during sorting of some archaeological material from the Middle Archaic Hayes Site (40ML139) near the Duck River (ca. RM 177), Marshall County, Tennessee. (Numbers of elements are not recorded; elements are not catalogued.) Material from the site excavated and presently under investigation by personnel in the Department of Anthropology, University of Tennessee, Knoxville.

APPENDIX C

Fig. C-1. Representative fish elements from Cheek Bend Cave and comparative skeletal material: Acipenseridae, Lepisosteidae, Anguillidae and Esocidae. (Scale marks in each illustration represent millimeters.)

A. Acipenser fulvescens, scutes: (left) specimen from cave (Pleistocene); (right) comparative specimen.

B. A. fulvescens, miscellaneous scutes from cave (Pleistocene).

C. Lepisosteus sp., from cave (late Holocene): (left to right) vertebra, scorched scute fragments, scorched scale fragments.

D. Esox masquinongy, from cave (Pleistocene): (upper left) vertebra, (lower left) teeth; (center) anterior end of right palatine showing enlarged, fixed canine tooth adjacent to large socket; (right) right palatine of another specimen showing enlarged, empty sockets.

E. Anguilla rostrata, premaxillaries: (top) from cave (mid-Holocene); (center) comparative specimen UTZC 1474; (bottom) larger specimen from cave.

F. Anguilla rostrata, dentaries: (upper) right dentary from UTZC 1474; (lower) anterior end of dentary from cave (mid-Holocene).

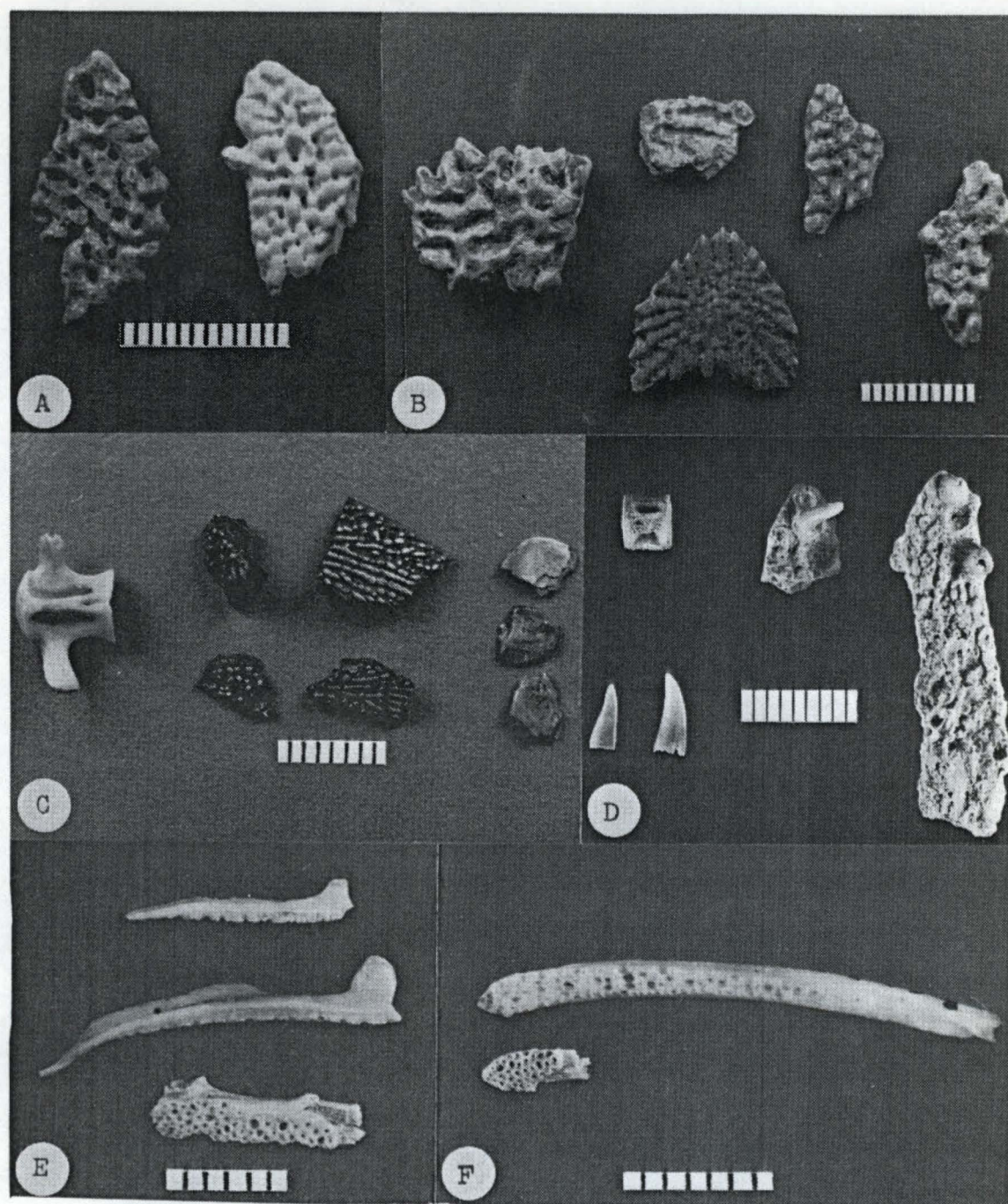


Fig. C-1.

Fig. C-2. Representative fish elements from Cheek Bend Cave and comparative skeletal material: Cyprinidae. (Scale marks in each illustration represent millimeters.)

A. CamPostoma sp., from cave (mid-Holocene): (at left) pharyngeal bone (left); (upper center) basioccipital fragment (lateral view); (lower center) articular-angular; (upper right) dentary (right); (lower right) maxillary fragment.

B. (Upper) cf. Hybopsis amblops, right pharyngeal bones: (left) from cave (mid-Holocene); (right) comparative specimen. (Lower) Notropis cf. stramineus, left pharyngeal bones: (left) from cave (mid-Holocene); (right) comparative specimen.

C. Notropis cornutus/chrysocephalus: (upper left) pharyngeal bone (left) of comparative specimen; (upper right) pharyngeal bone fragment from cave (Holocene); (lower left) quadrate from comparative specimen; (lower right) quadrate from cave (Holocene).

D. Notropis (Cyprinella) sp., left pharyngeal bone fragments from cave (Pleistocene/Holocene mixed Stratum IV/III).

E. Pimephales notatus, basioccipitals (ventral view): (left) comparative specimen UTZC 2571; (right) specimen from cave (mid-Holocene).

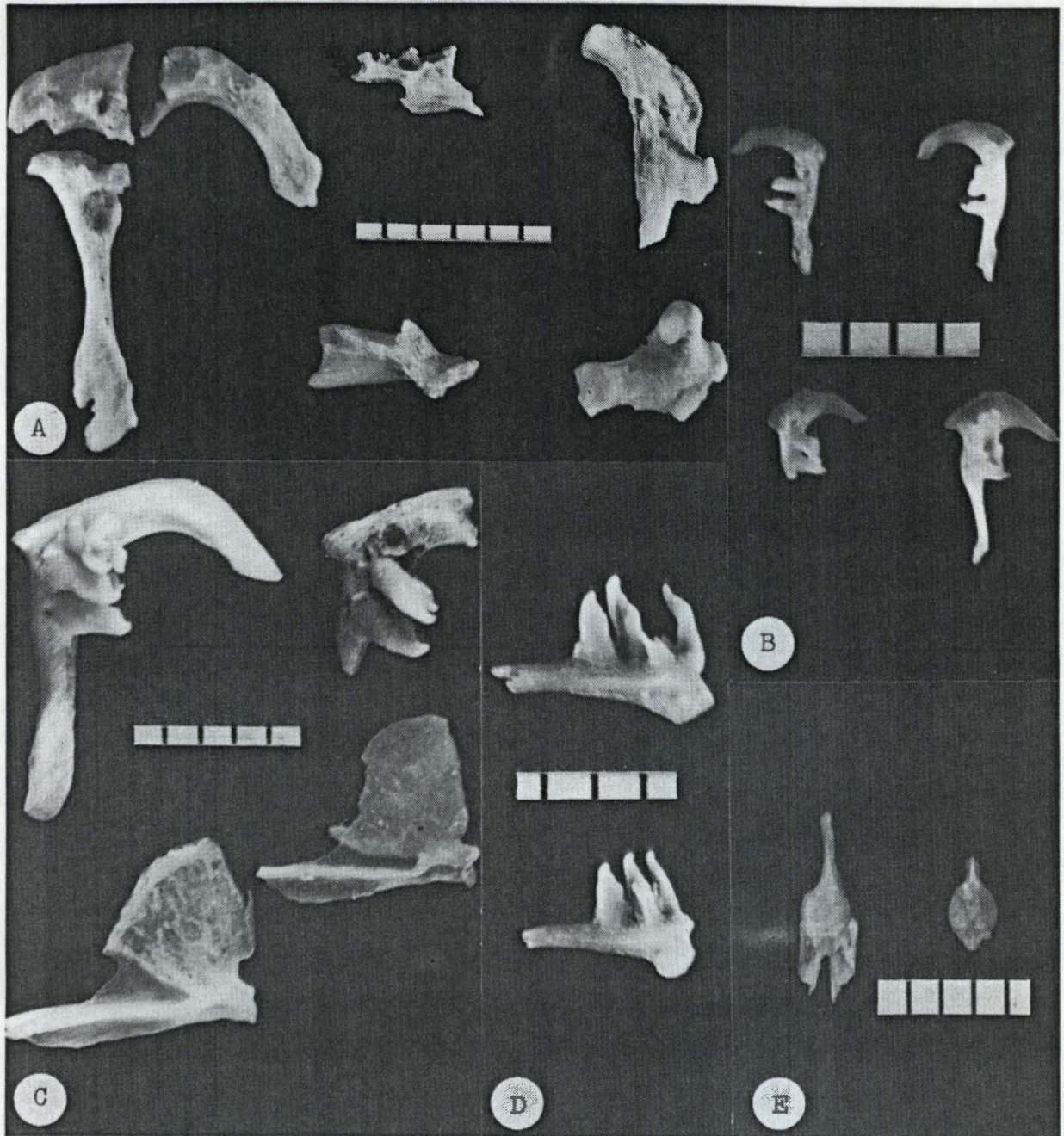


Fig. C-2.

Fig. C-3. Representative fish elements from Cheek Bend Cave and comparative skeletal material: Cyprinidae and Catostomidae. (Scale marks in each illustration represent millimeters.)

A. Nocomis biguttatus, pharyngeal bones: (left to right) comparative specimen (dorsolateral view) followed by two fragments from cave (Pleistocene) and comparative specimen (mediolateral view).

B. Phenacobius cf. uranops, maxillaries: (left) comparative specimen; (right) cave specimen (mid-Holocene).

C. Semotilus atromaculatus, pharyngeal bones: (upper) left pharyngeal from cave (mid-Holocene); (lower) left pharyngeal from comparative specimen.

D. Bone fragments of Nocomis sp. from cave (Pleistocene): (extreme left) pharyngeal bone; (left center) pharyngeal bone (upper limb) fragments; (right center) basioccipital fragments followed by dentary fragments (extreme right).

E. Catostomus commersoni, miscellaneous elements from cave (Pleistocene): (upper row, left to right) two dentary fragments (ventral view) followed by articular-angular (lateral view) and hypohyal (far right); (lower row) ceratohyals (representing four individuals).

F. Ictiobus cf. niger, urohyals: (left) from cave (late Holocene); (right) UTZC 2293.

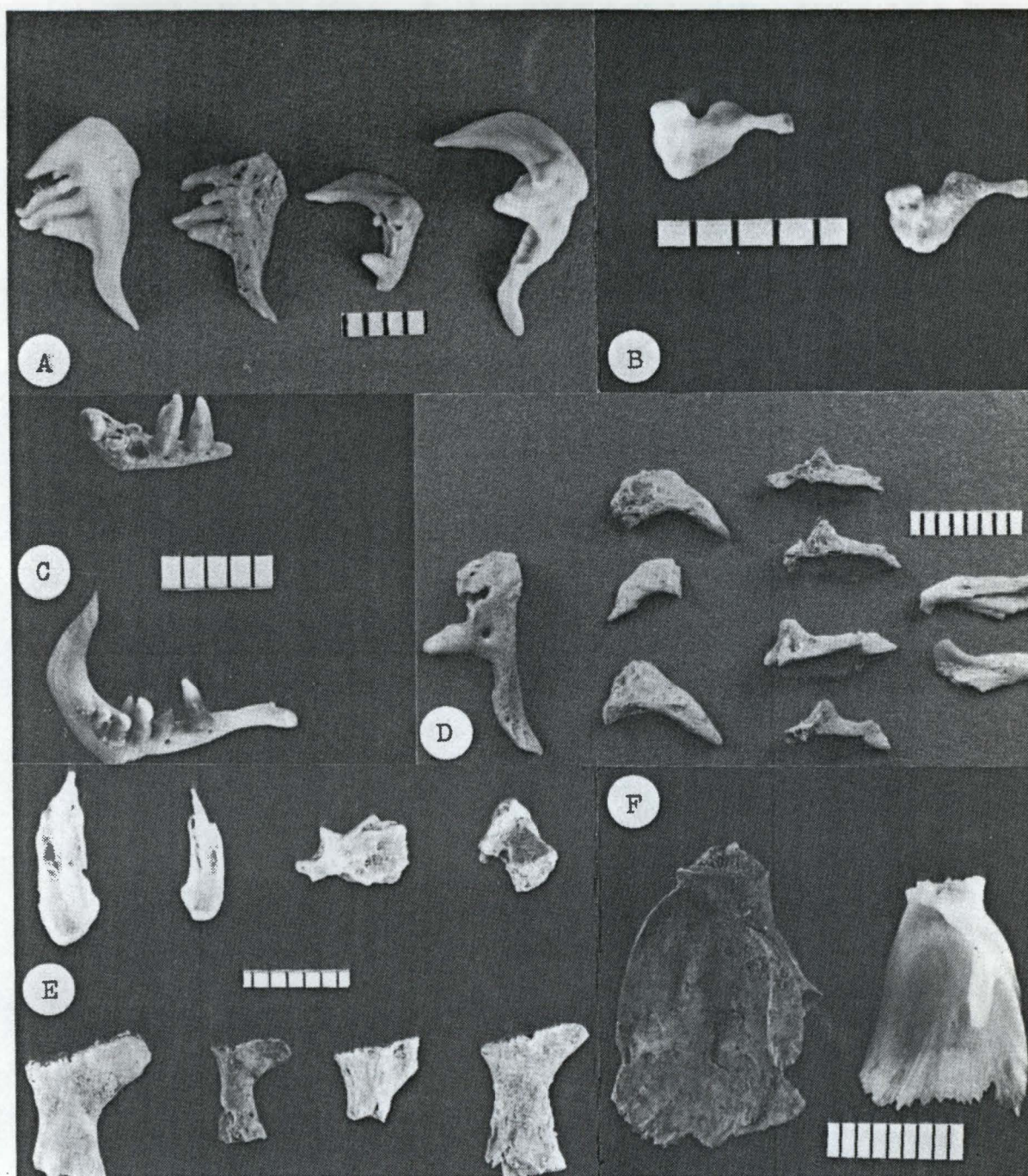
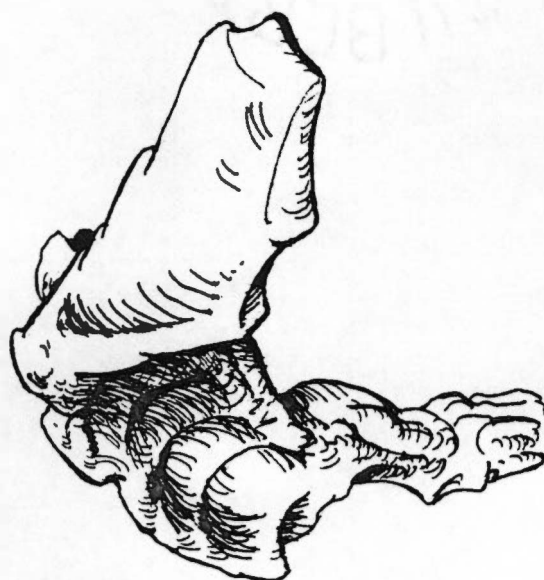
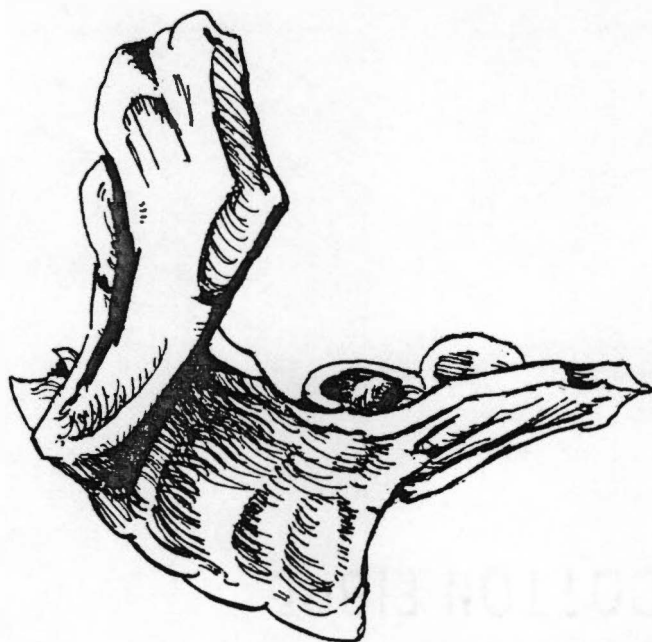


Fig. C-3.

Fig. C-4. cf. Dionda/Hybognathus sp., fragments of right pharyngeal bones (lateral view) from cave (mid-Holocene). Left specimen from Level 18(196-79) of excavation unit 102N/100E; right specimen from Level 22A(190-79) of excavation unit 102N/100E. Note large depression along length of upper limb.



1 mm

Fig. C-4.

Fig. C-5. cf. Dionda/Hybognathus sp., fragment of basioccipital bone (lateral view) from cave (mid-Holocene), Level 22A(190-79) of excavation unit 102N/100E.

PA = proatlas

PP = remaining portion of pharyngeal process (anterior region)

S = stem of pharyngeal process

MP = masticatory plate.

(Note laterally-compressed form of stem S.)

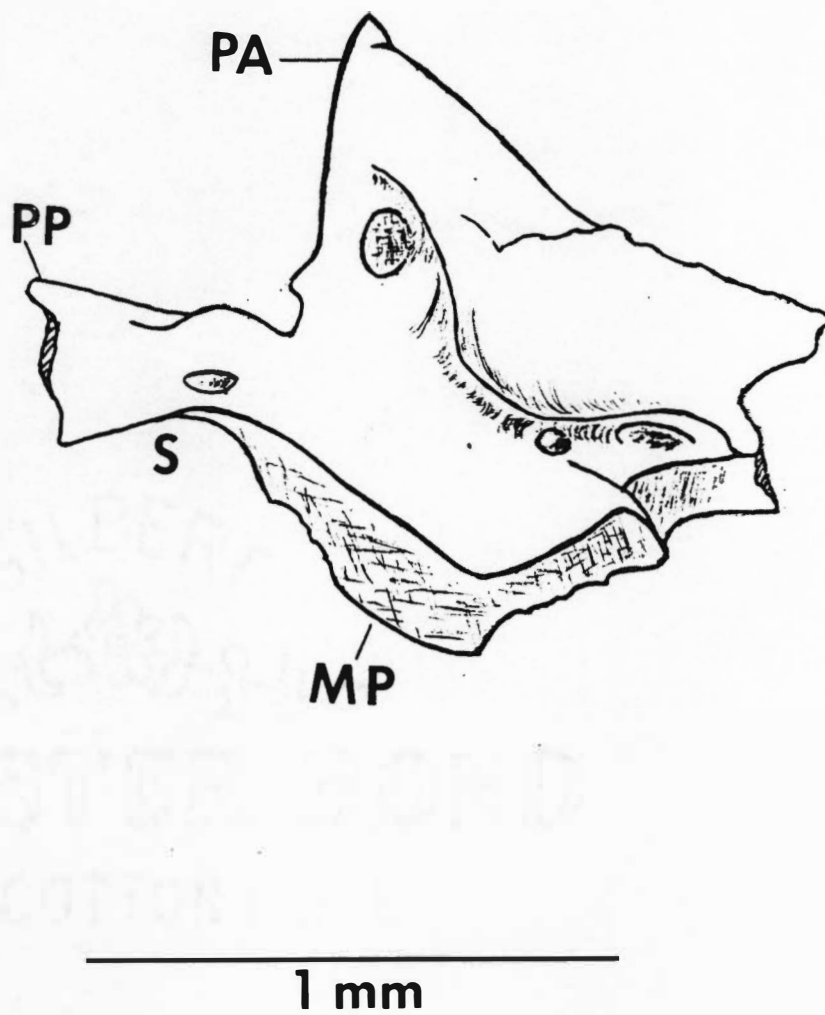


Fig. C-5.

Fig. C-6. Pharyngeal bones of cf. Dionda/Hybognathus sp. and representative species of the genera Dionda and Hybognathus. (Scale marks in each illustration represent millimeters.)

A. cf. Dionda/Hybognathus sp., pharyngeal bones (mediolateral view).

B. Right pharyngeal bones (mediolateral view) of comparative specimens of (left to right): Dionda (= Notropis) nubila, D. episcopa, Hybognathus hankinsoni, H. placitus.

C. cf. Dionda/Hybognathus sp., same bones as in (A) above, but in dorsolateral view. (Depression along upper limb can be seen in two specimens at left.)

D. Comparative specimens (same bones as shown in (B) above, but in dorsolateral view.)

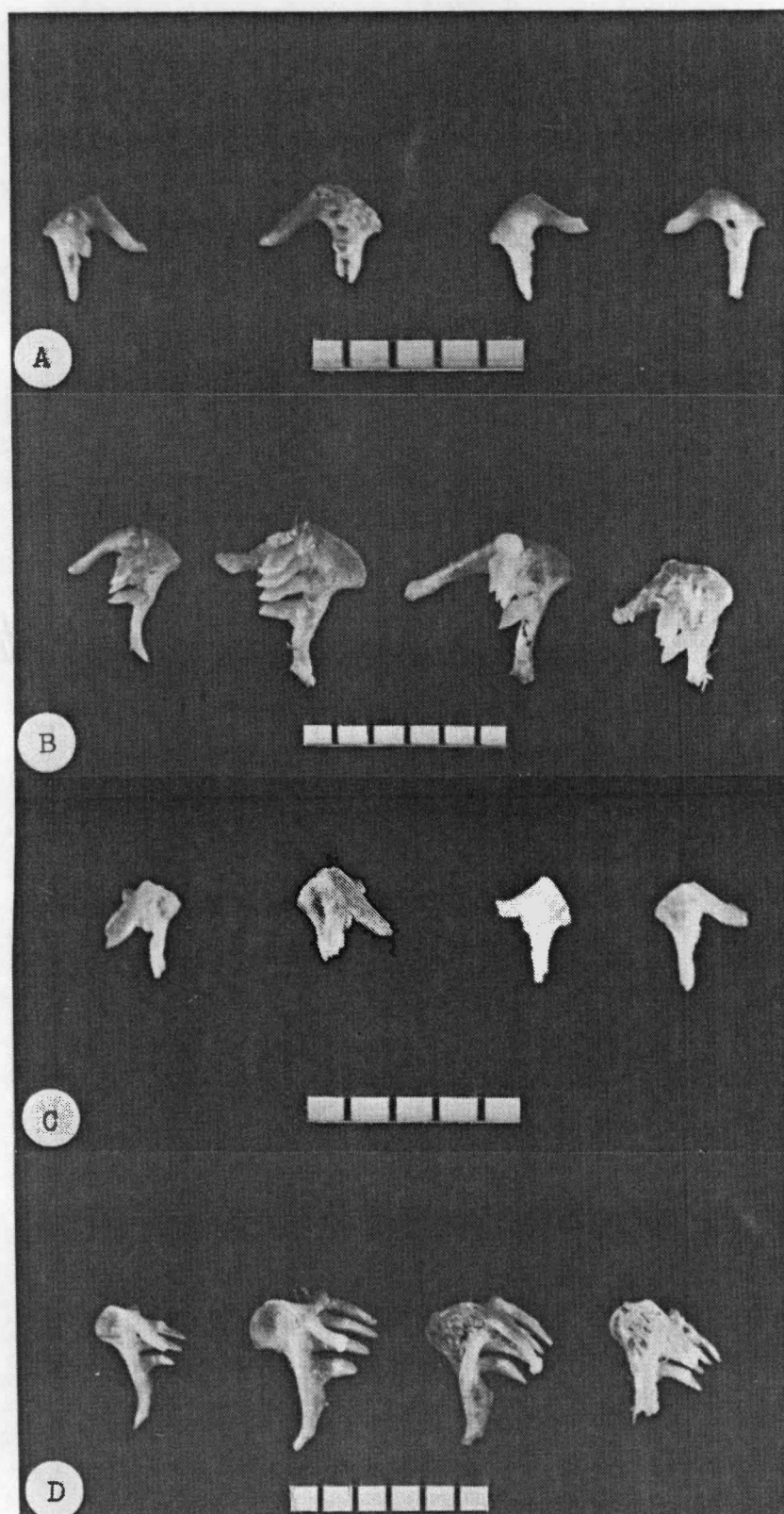


Fig. C-6.

Fig. C-7. Representative fish elements from Cheek Bend Cave and comparative skeletal material: Catostomidae. (Scale marks in each illustration represent millimeters.)

A. Ictiobus cf. niger, urohyals (dorsal view): (left) UTZC 2293; (right) cave specimen (late Holocene).

B. Hypentelium nigricans: (Left) epihyal (top) and urohyal (bottom) from UTZC 3107; (right) epihyal (top) and urohyal fragment (bottom) from cave (Pleistocene).

C. Moxostoma anisurum, miscellaneous elements from cave (Pleistocene): (upper row, left to right) ceratohyal, smaller ceratohyal, epihyal; (lower row, left to right) articular-angular fragment, maxillary fragment (anterior end), dentary fragment (ventral view).

D. Moxostoma carinatum, fragment of pharyngeal bone (mediolateral view) and single, molariform tooth (lateral view) from cave (late Holocene).

E. Moxostoma duquesnei, right maxillary fragment from cave (late Holocene).

F. Moxostoma erythrurum: (left) ceratohyal fragment from cave (early Holocene); (right) urohyal from cave (Pleistocene).

G. Moxostoma macrolepidotum, right dentaries (lateral view, dorsal surface down): (left) from cave (Pleistocene); (right) comparative specimen.

H. Moxostoma macrolepidotum, right dentaries (ventral view): (left) from cave (Pleistocene); (right) comparative specimen.

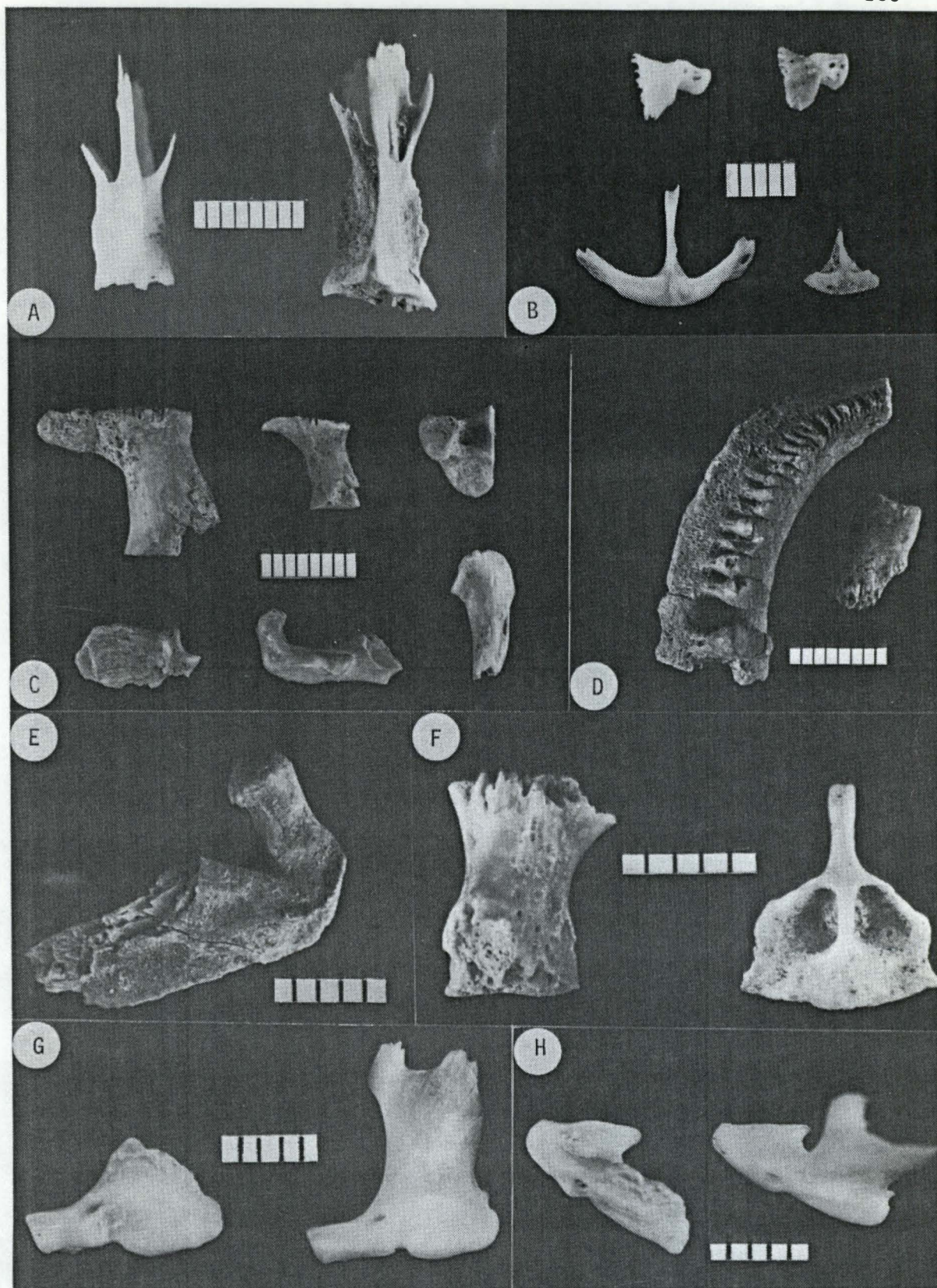


Fig. C-7.

Fig. C-8. Bones of Moxostoma (comparative specimens) representative of species from Cheek Bend Cave. Comparative material mostly from specimens collected from Duck River, near Cheek Bend Cave. All specimens are deposited in UTZC. Standard length range for all specimens is 310-410 mm. (Scale marks in each illustration represent millimeters.)

A. Ceratohyals from: (top, left to right) Moxostoma duquesnei, M. erythrurum, M. carinatum; (bottom, left) M. anisurum, (bottom, right) M. macrolepidotum.

B. Maxillaries (specimens slightly tilted dorsad): (top, center) Moxostoma anisurum; (top, left) M. duquesnei; (bottom, left) M. carinatum; (top, right) M. macrolepidotum; (bottom, right) M. erythrurum.

C. Urohyals: (top, left) Moxostoma erythrurum; (top, right) M. duquesnei; (bottom) M. anisurum.

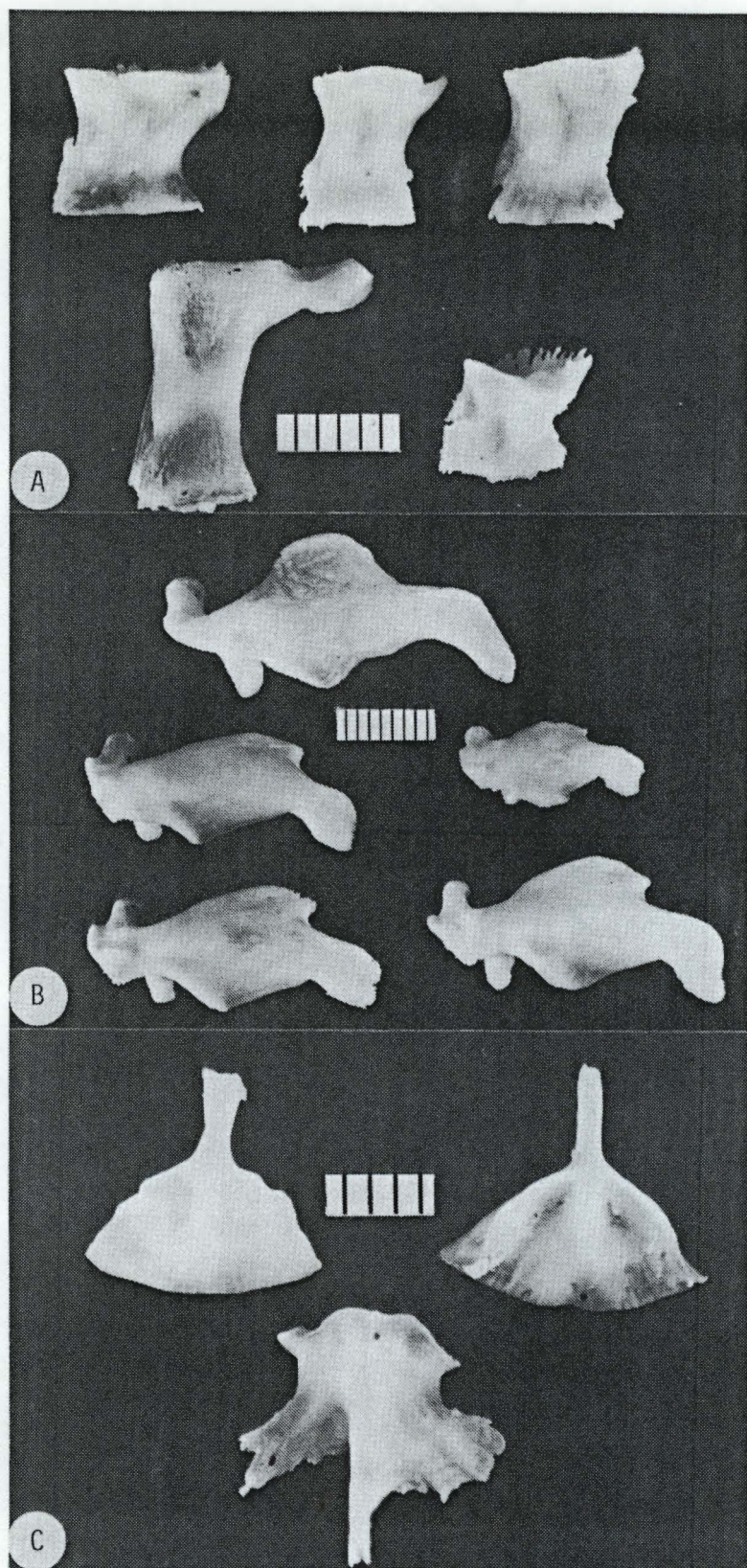


Fig. C-8.

Fig. C-9. Representative fish elements from Cheek Bend Cave and comparative skeletal material: pectoral spines of Noturus (Ictaluridae). (Scale marks in each illustration represent millimeters.)

A. (Top, left) Noturus elegans (UTZC 2568); (bottom, left) N. cf. elegans from cave (mid-Holocene); (top, right) N. eleutherus, comparative specimen; (bottom, right) N. cf. eleutherus from cave (late Holocene).

B. Noturus exilis, upper three fragments from cave (mid-Holocene); (bottom, left) UTZC 6087; (bottom, right) UTZC 6003.

C. (Top to bottom) Noturus flavater, UTRCF 48.132, two fragments from cave (mid-Holocene); N. flavipinnis, comparative specimen; N. stigmosus, comparative specimen.

D. Noturus cf. flavus (top and bottom) fragments from cave (mid-Holocene); (center) Noturus flavus, UTZC 164.

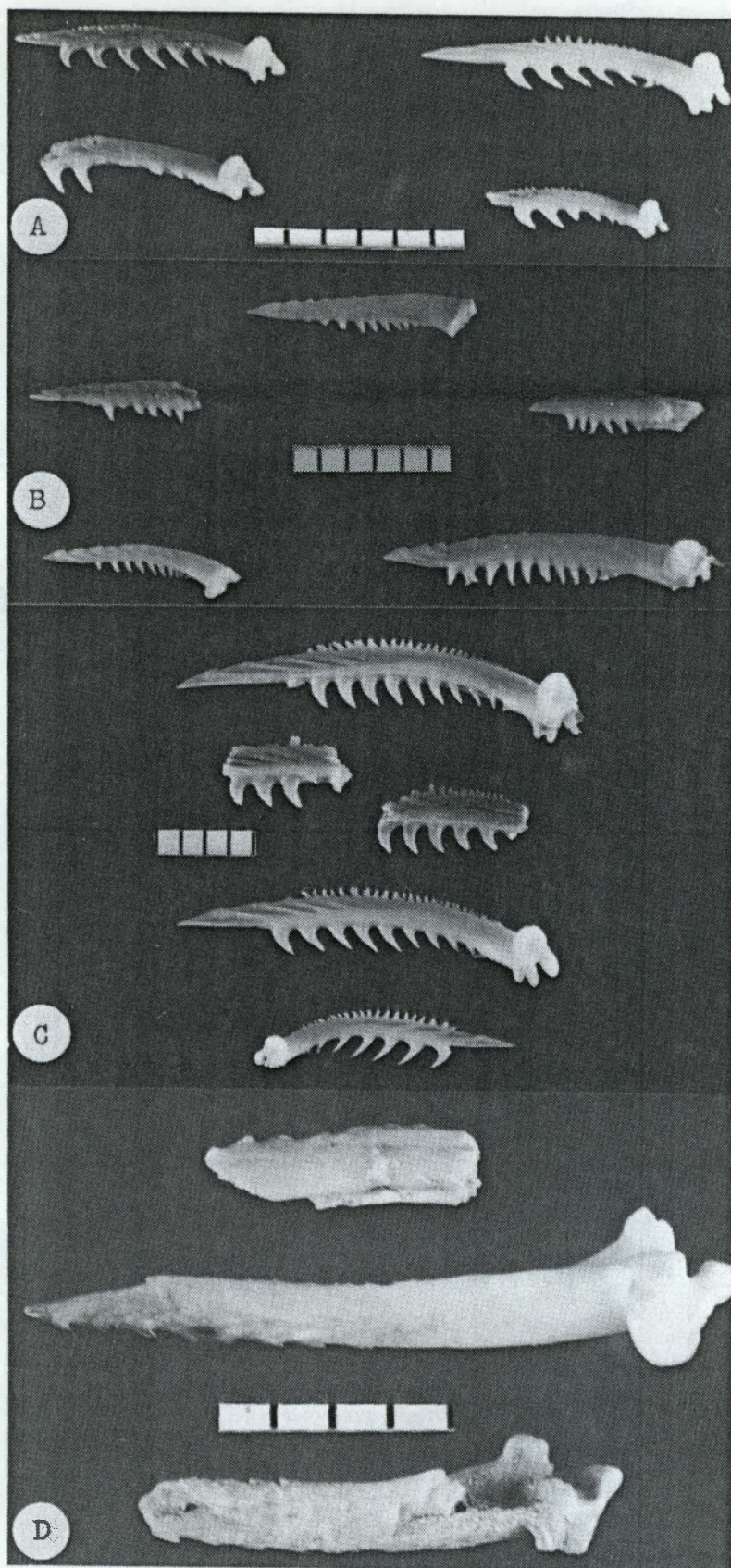


Fig. C-9.

Fig. C-10. Representative fish elements from Cheek Bend Cave and comparative skeletal material: Noturus cf. flavus. (Scale marks in each illustration represent millimeters.)

A. Pectoral spines (proximal end, posterior view): (left to right) Ictalurus punctatus, UTZC 1053; Noturus flavus, UTZC 164; Ictalurus melas, UTZC 166.

B. Pectoral spines (proximal end, posterior view): (left and center) Noturus cf. flavus from cave (mid-Holocene); (right) Noturus flavus, UTZC 164. Note obtuse angle on right (dorsal) side of two cave fragments.

C. Premaxillaries: (top) Noturus cf. flavus from cave (mid-Holocene); (bottom) Noturus flavus, UTZC 164. Specimens shown in ventral view except in top center and lower right, which show dorsal surface.

D. Right dentaries (ventral view): (left) Noturus cf. flavus from cave (early Holocene); (center) Noturus flavus, UTZC 164; (right) Noturus cf. flavus from cave (Pleistocene).

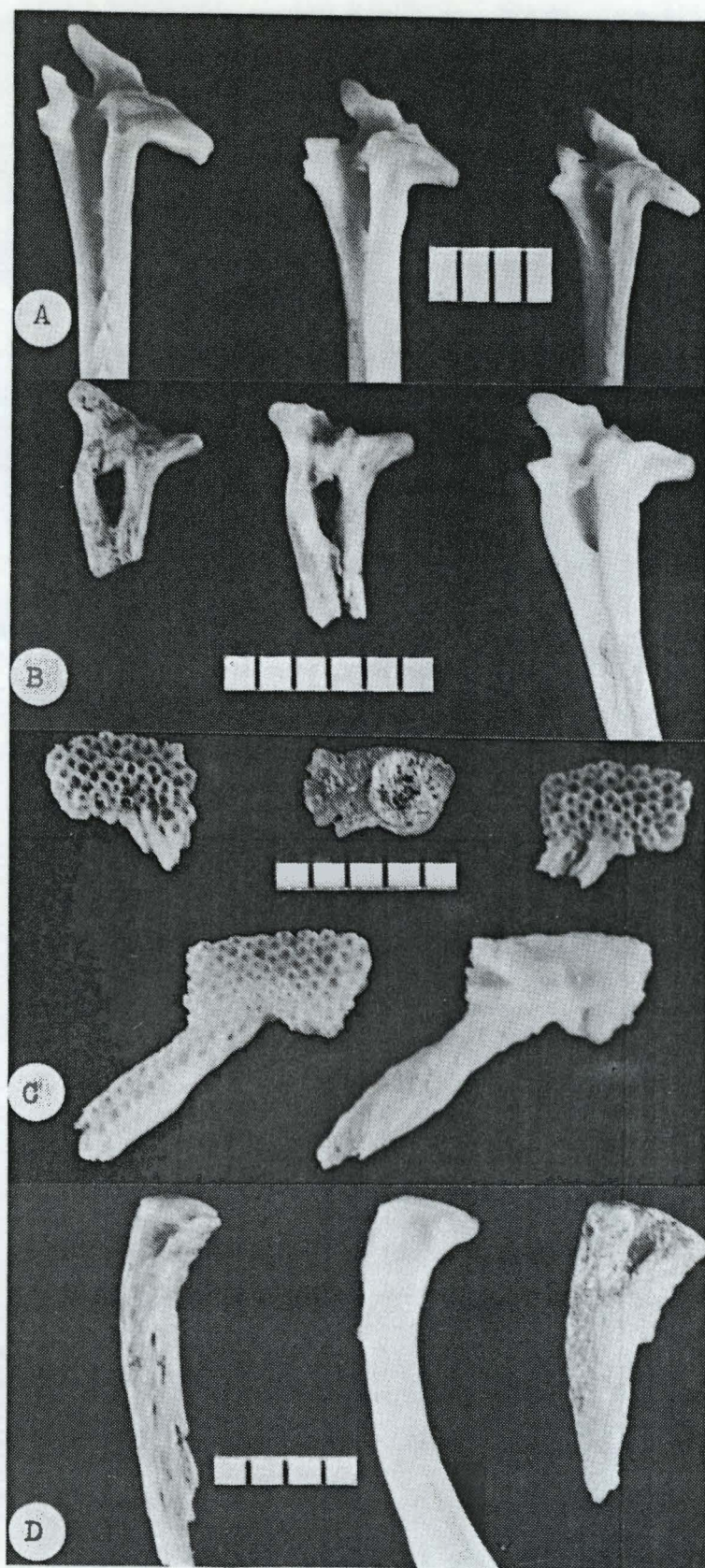


Fig. C-10.

Fig. C-11. Representative fish elements from Cheek Bend Cave: Ictaluridae and Cyprinodontidae. (Scale marks in each illustration represent millimeters.)

A. Noturus cf. flavus, from cave: (left) supraethmoid (mid-Holocene); (center) quadrate (Pleistocene); (right) ceratohyal (Pleistocene).

B. Noturus cf. flavus, from cave: (top) quadrate (mid-Holocene); (center) urohyals (mid-Holocene); (bottom) maxillary (Pleistocene).

C. Pylodictis olivaris, left premaxillary (late Holocene).

D. Fundulus catenatus, from cave (Holocene): (left, at top) suprapharyngeal; (left, center and bottom) infrapharyngeal fragments; (center row) quadrate fragments; (right) premaxillary fragments.

E. Fundulus catenatus, from cave (Holocene): (left, top to bottom) basioccipital, articular-angular fragment, modified vertebra; (center) ceratohyals; (right) dentaries.

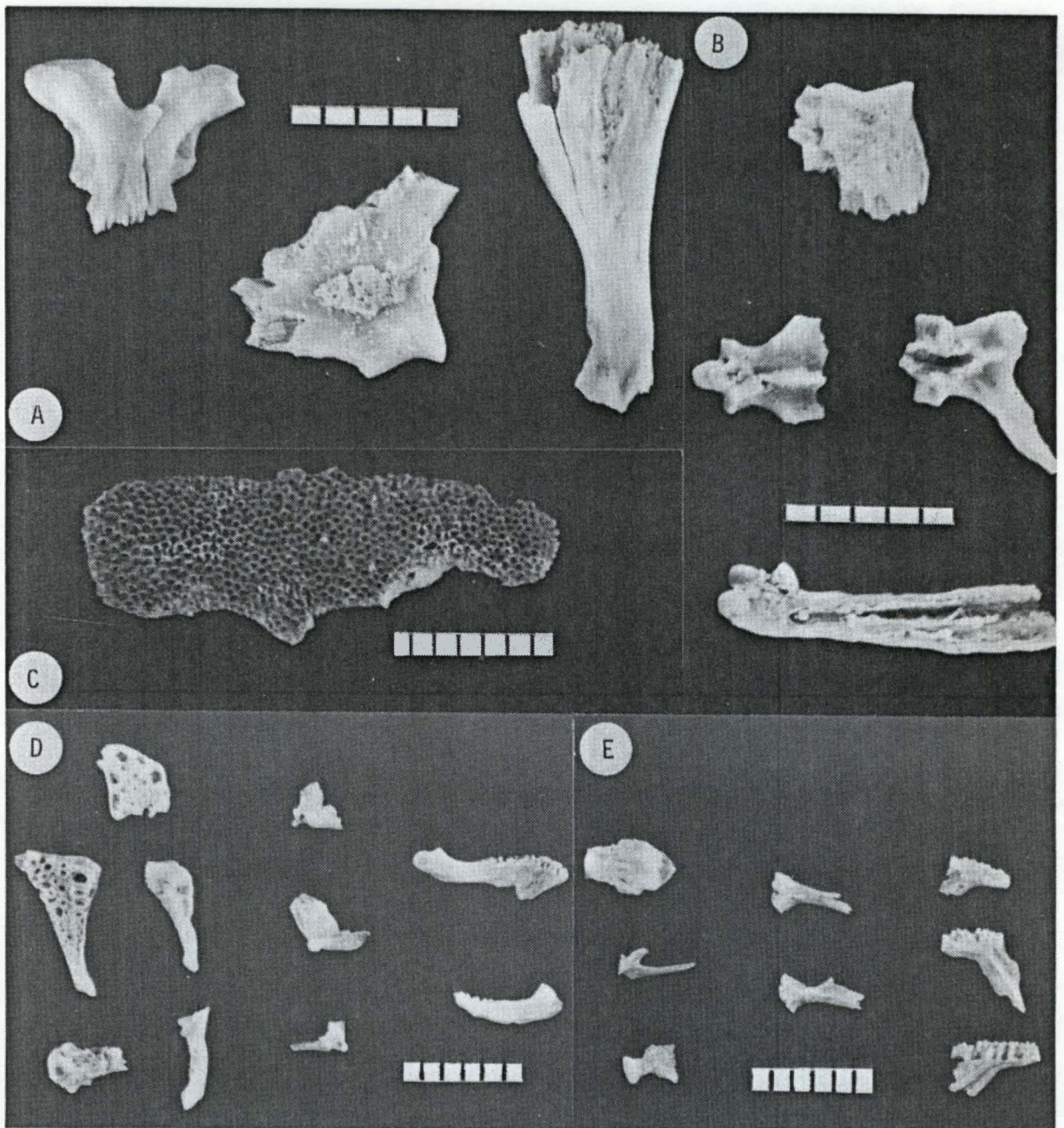


Fig. C-11.

Fig. C-12. Representative fish elements from Cheek Bend Cave and comparative skeletal material: Centrarchidae. (Scale marks in each illustration represent millimeters.)

A. Ambloplites rupestris, from cave (late Holocene): (top, center) maxillary fragment; (top, right) premaxillary fragment (anterior end); (bottom, left) palatine; (bottom, right) ceratohyal.

B. Micropterus dolomieu, right dentaries: (top, left) fragment from cave (late Holocene); (top, right) fragment from cave (mid-Holocene); (bottom) UTZC 5340.

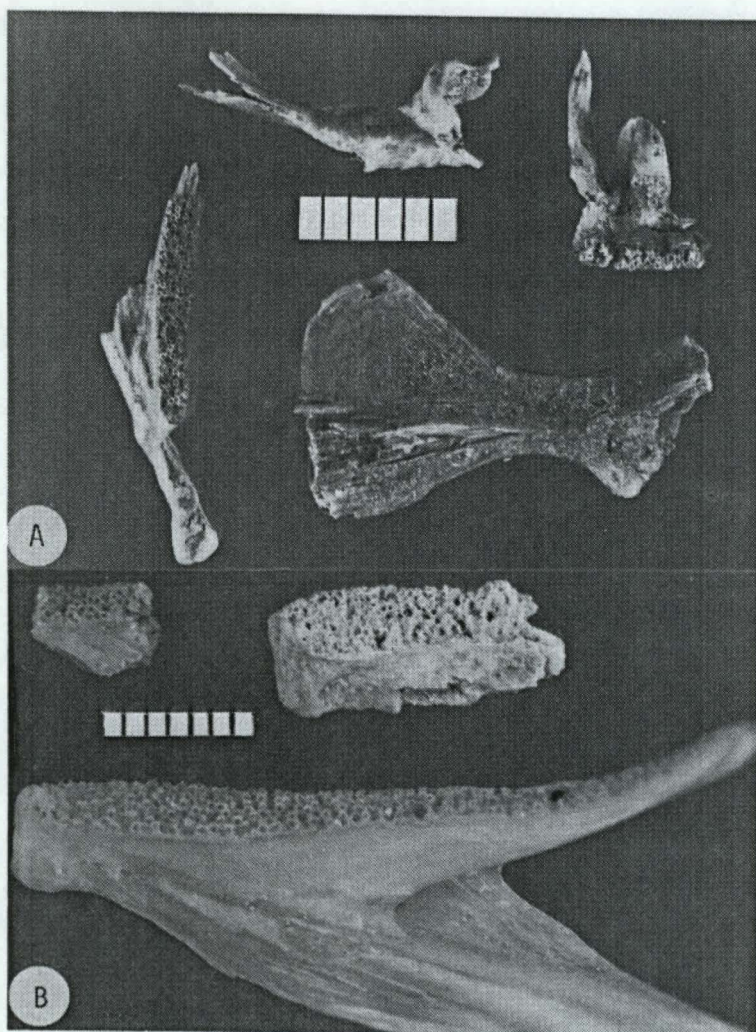


Fig. C-12.

Fig. C-13. Representative fish elements from Cheek Bend Cave and comparative skeletal material: Percidae (darters). (Scale marks in each illustration represent millimeters.)

A. Etheostoma blennioides, from cave (Pleistocene): (left) quadrate fragments; (center, top) right dentary fragment; (center, bottom) cleithrum fragment; (right, top) articular-angular; (right, bottom) nasal (pre-frontal) fragment.

B. Etheostoma blennioides, from cave (Pleistocene): (left and center) maxillaries (from four individuals); (right, top) articular-angular; (right, bottom) premaxillary fragment (anterior end).

C. Percina caprodes, left articular-angulars: (top, left) UTZC 2549; (top, right) UTZC 2546; (bottom) cave specimen (Pleistocene).

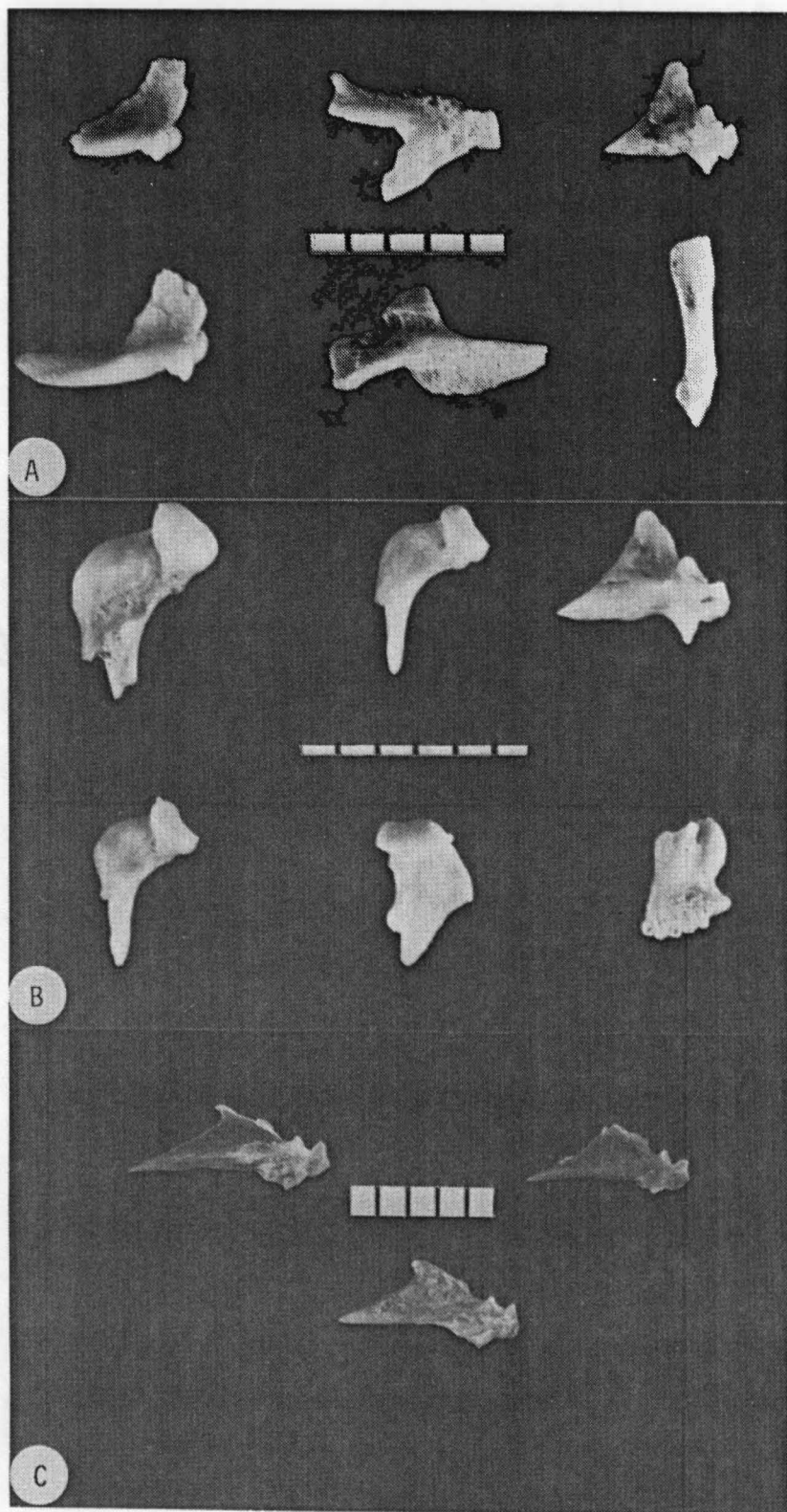


Fig. C-13.

Fig. C-14. Diagrammatic representation (lateral view) of the form of the articular-angular socket in (A) Percina caprodes, and (B) all other darters examined.

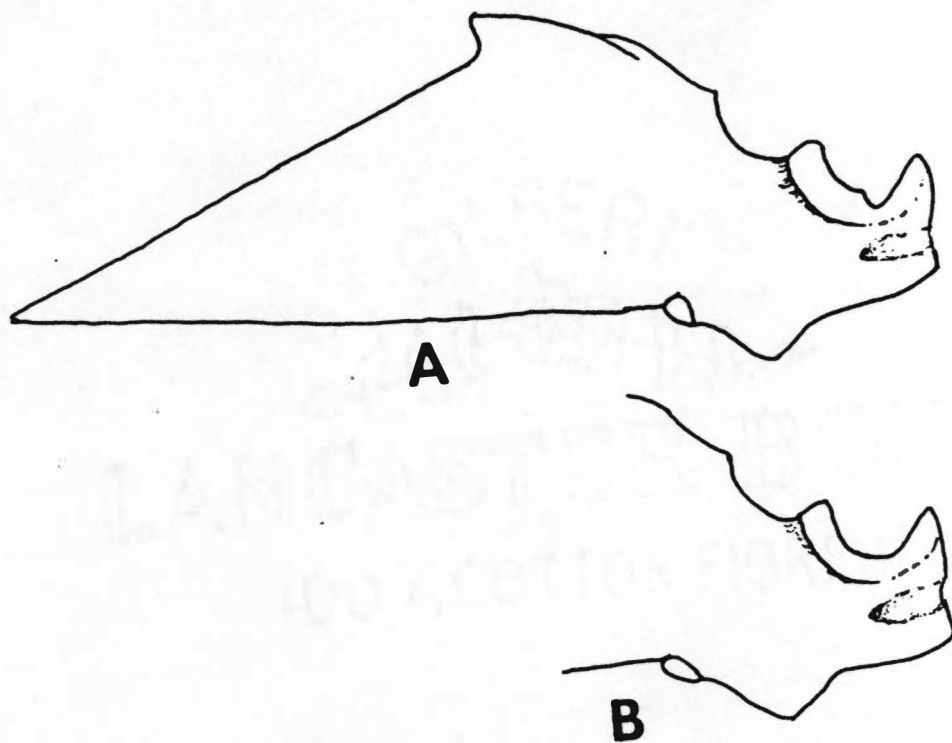


Fig. C-14.

Fig. C-15. Representative fish elements from Cheek Bend Cave: Percidae. (Scale marks in each illustration represent millimeters.)

A. Perca flavescens, from cave (Pleistocene): (left, top) articular-angular fragment; (left, bottom) palatine fragment; (center) vomer fragment (ventral view); (right) preoperculum fragments.

B. Perca flavescens, from cave (Pleistocene): dentary fragments (lateral view) from at least five individuals.

C. (Top) Stizostedion vitreum, from cave (Pleistocene), epihyal; (bottom, left) Stizostedion canadense, from cave (Pleistocene), pre-maxillary fragment (anterior end); (bottom, right) Stizostedion sp., dentate fragment.

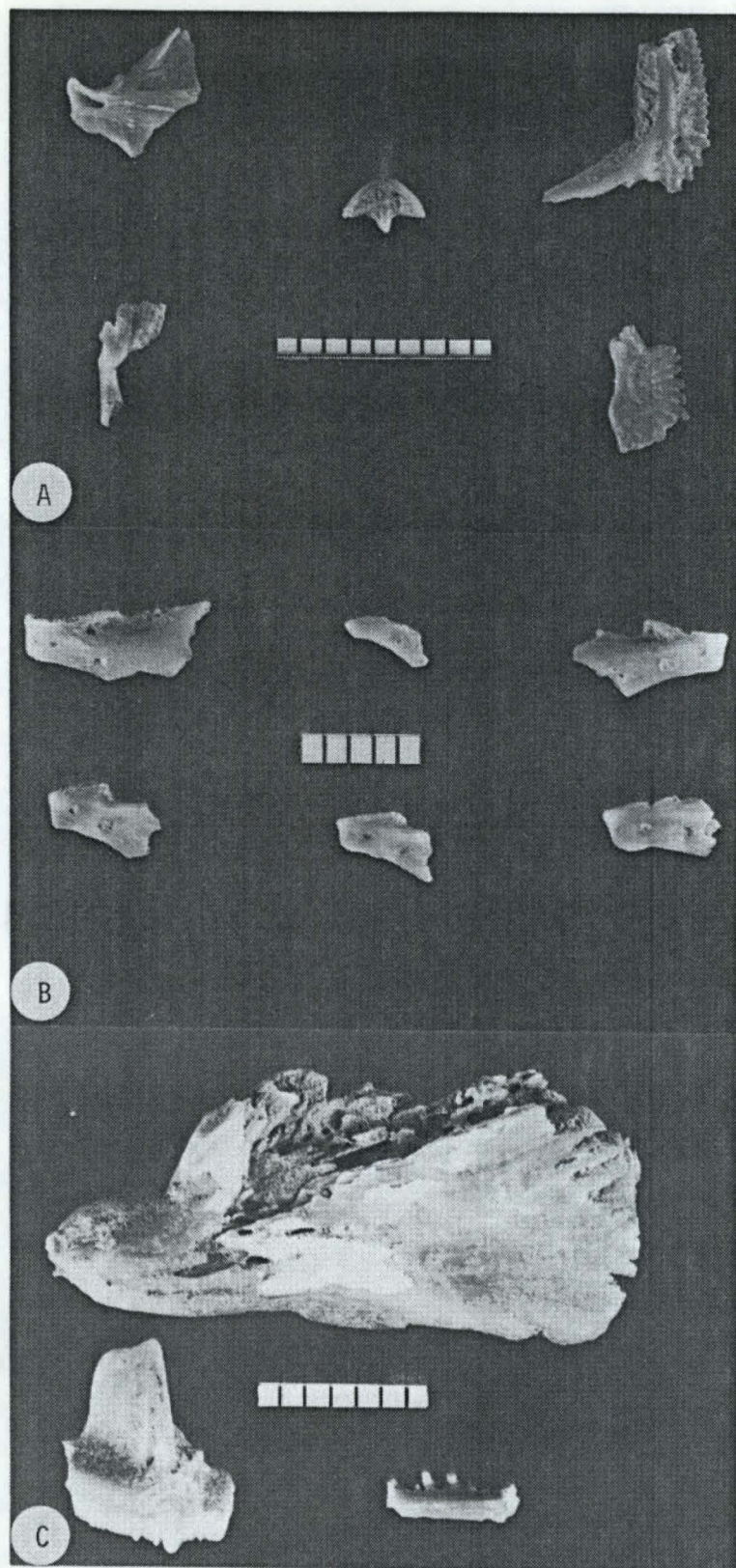


Fig. C-15.

Fig. C-16. Representative fish elements from Cheek Bend Cave: Sciaenidae, Cottidae and miscellaneous. (Scale marks in each illustration represent millimeters.)

A. Aplodinotus grunniens, from cave (late Holocene), saccular otoliths. Both sides are shown, using separate specimens.

B. Cottus carolinae, from cave (Pleistocene): (top row, left to right) left dentary fragment, palatine fragment, right articular-angular fragment; (bottom row, left to right) right premaxillary fragment (mediolateral view), left premaxillary fragment (anterior end), suboperculum fragment.

C. Miscellaneous fragments (vertebrae, spines, rays, scales, pterygiophores, nondescript cranial fragments) representative of most of the volume of fish bone from the cave.

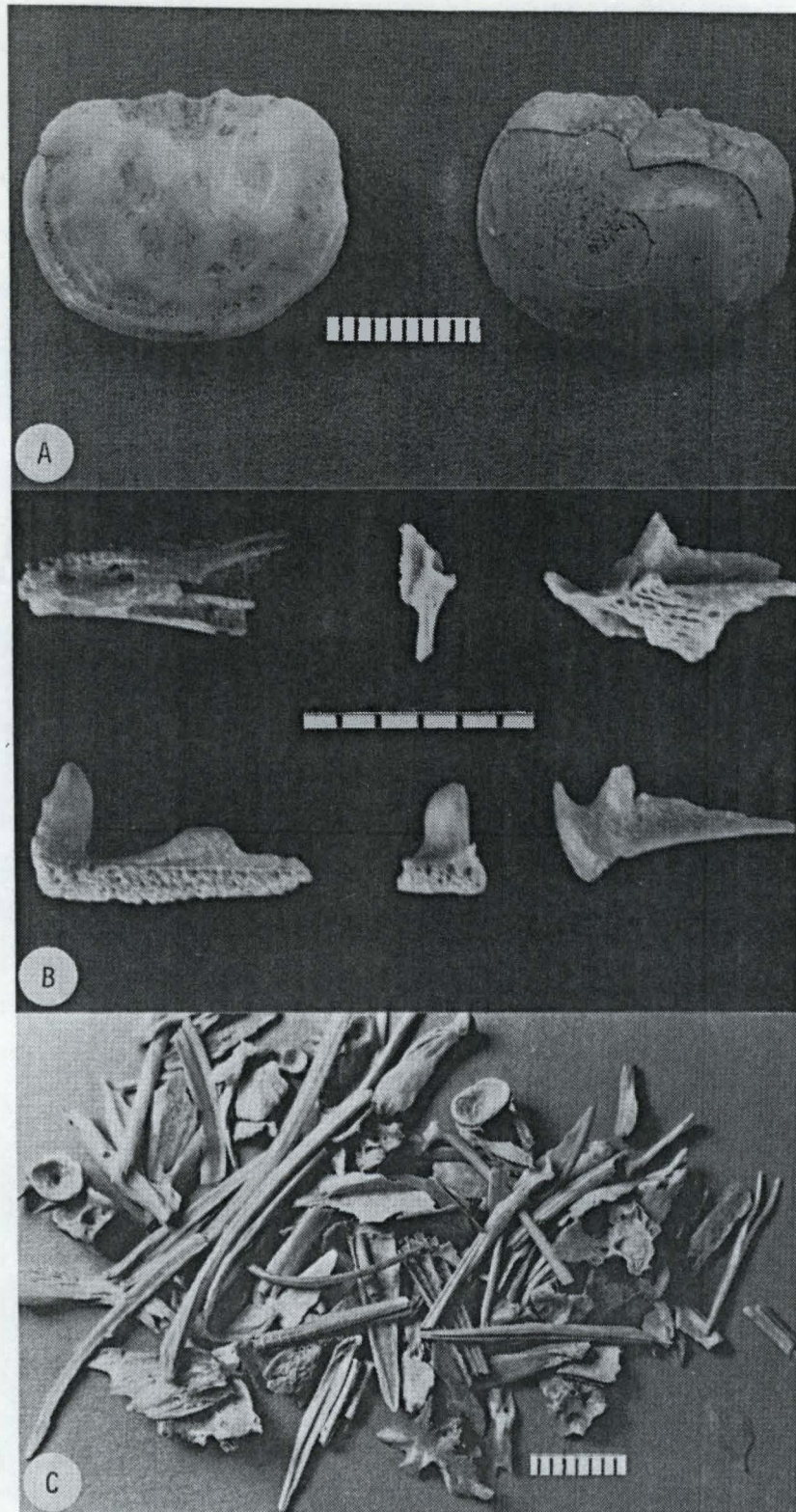


Fig. C-16.

APPENDIX D

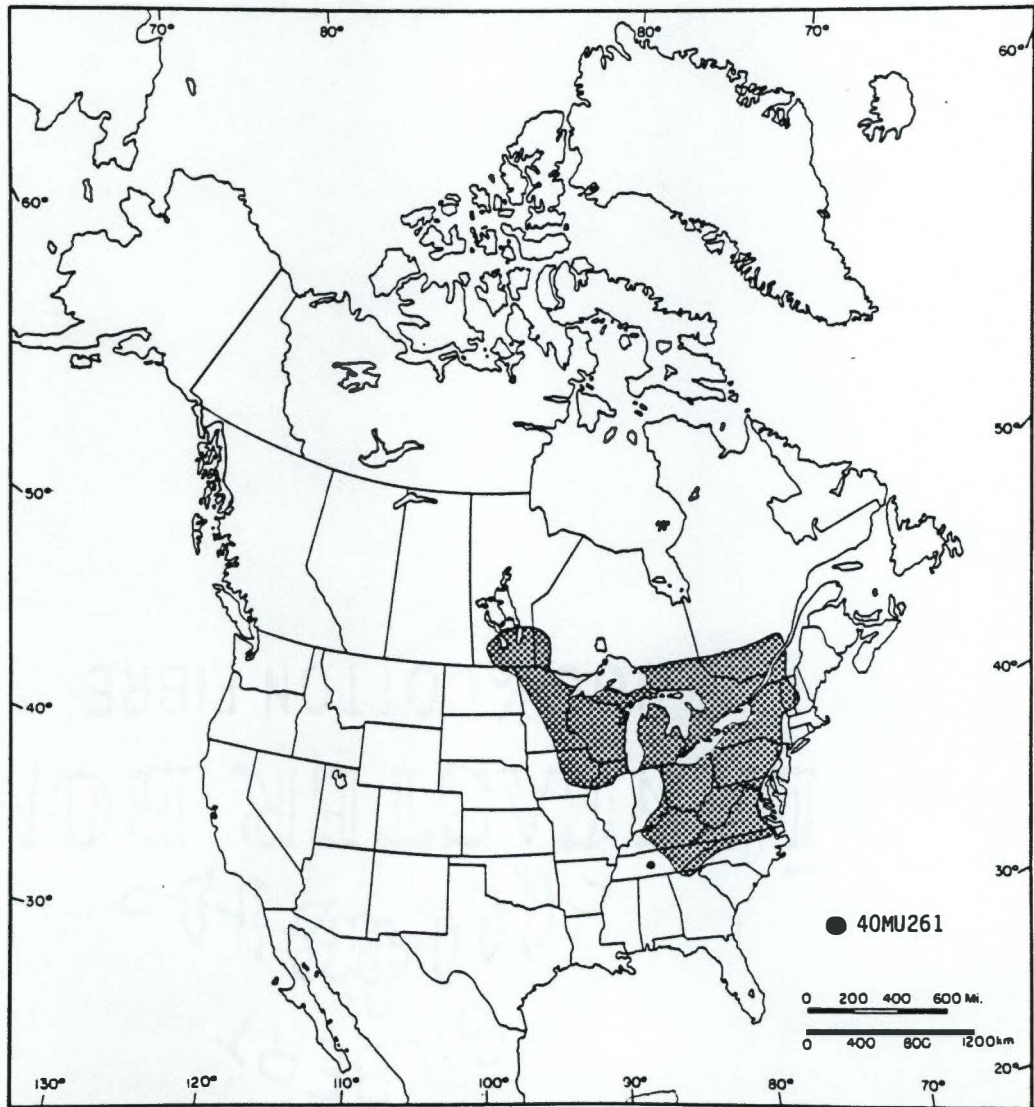


Fig. D-1. Distribution of the muskellunge, *Esox masquinongy* Mitchell (after Crossman 1980).

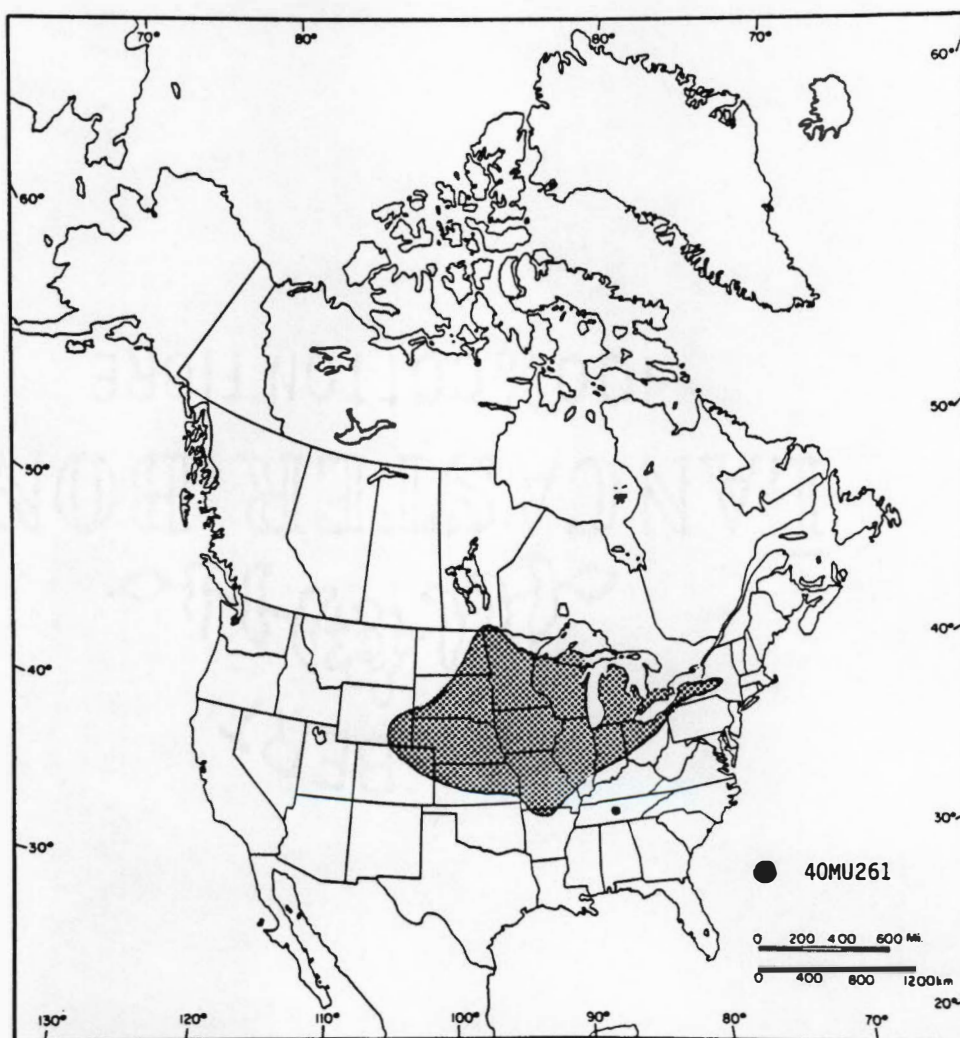


Fig. D-2. Distribution of the hornyhead chub, *Nocomis biguttatus* (Kirtland) (after Jenkins and Lachner 1980).

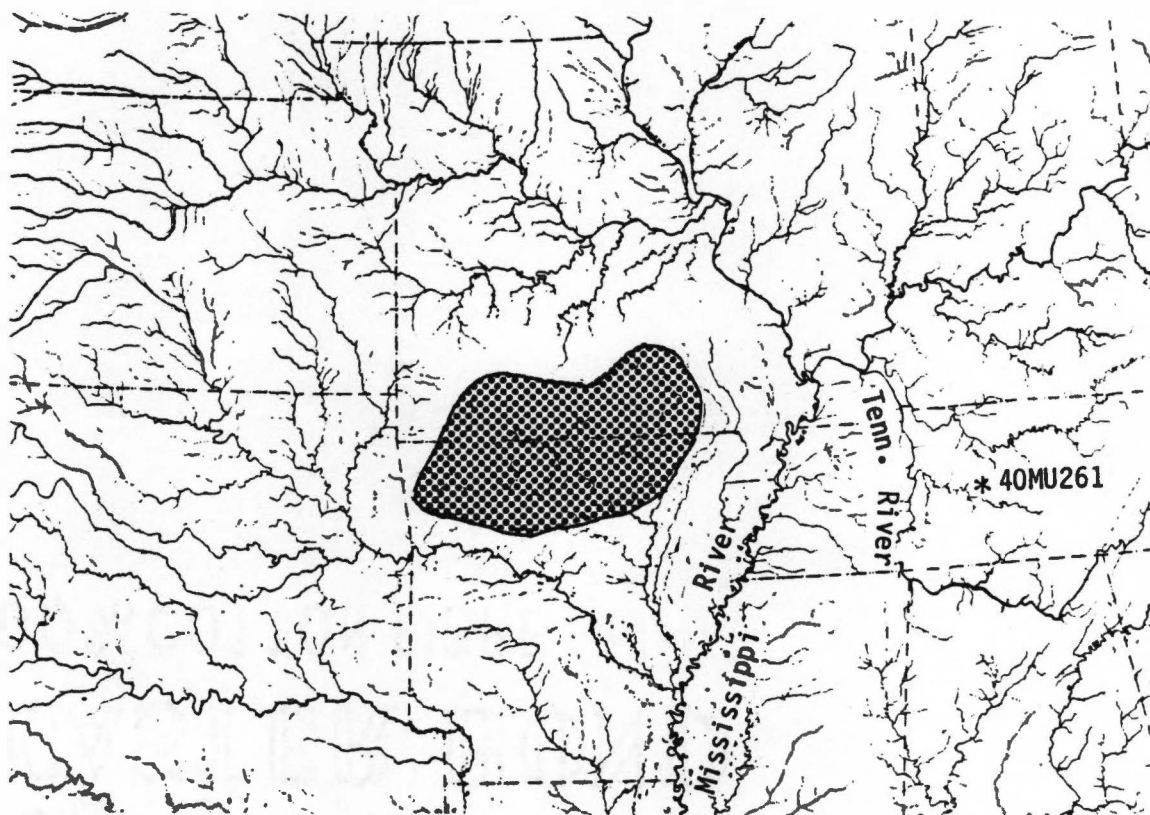


Fig. D-3. Distribution of the checkered madtom, Noturus flavater Taylor (after Rohde 1980).

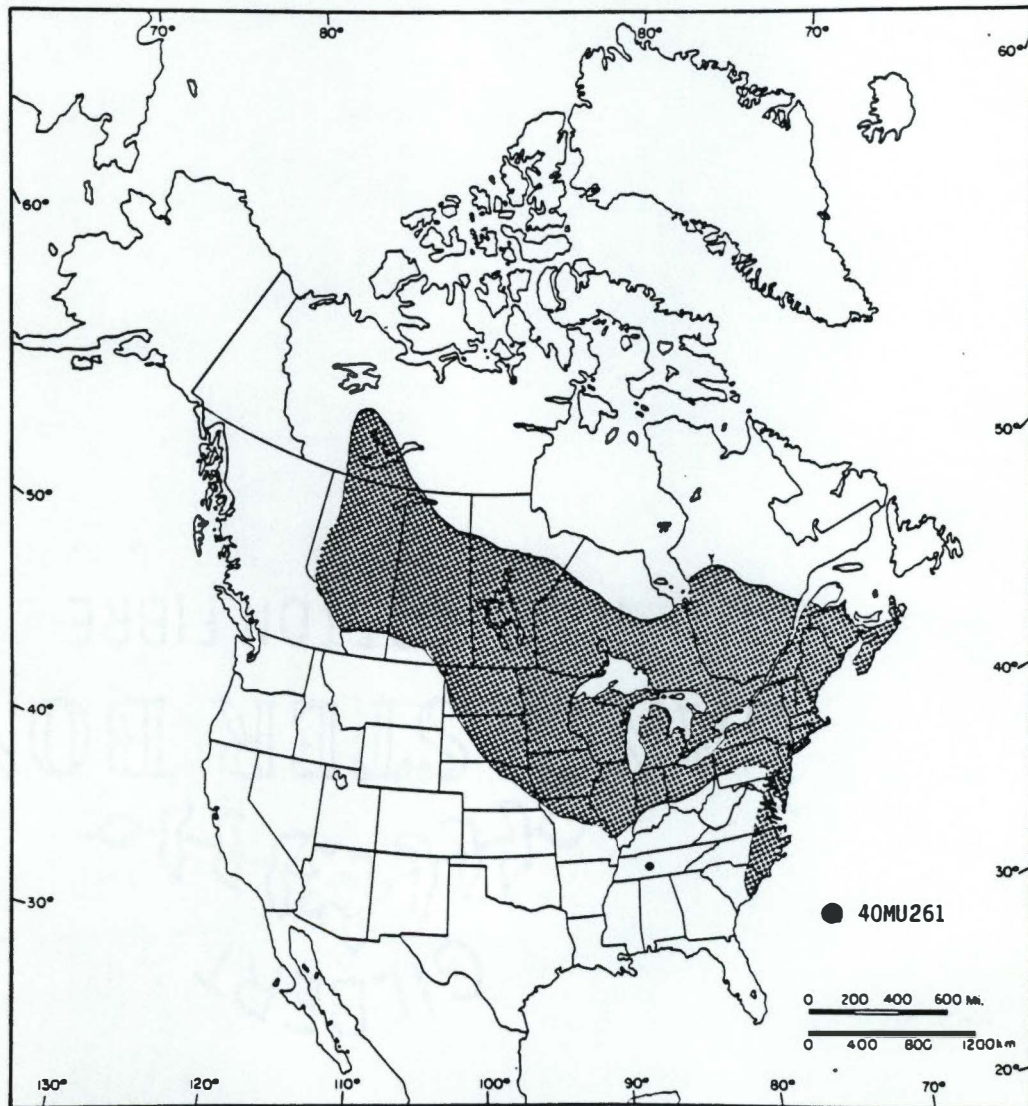


Fig. D-4. Distribution of the yellow perch, *Perca flavescens* (Mitchill) (after Lee 1980).

VITA

William Clark Dickinson was born in Murray, Kentucky, June 5, 1946. He resided in Ripley, Tennessee, for most of the following time until age 18, when he graduated from Ripley High School in 1964 and later that year entered The University of Tennessee at Martin. In 1968, he graduated from that institution with the B.S. degree in Education (Biology). The next four years were spent teaching science and biology in the Lauderdale and Obion County, Tennessee school systems and pursuing, on a part-time basis, a Master's degree in Zoology at The University of Tennessee, Knoxville. After completion of this degree in 1973, he later entered the Graduate Program in Ecology at The University of Tennessee, Knoxville to begin course work toward the Ph.D. degree. From 1975 to 1982, during which time he worked in the TVA Fisheries Division at Norris, Tennessee, and later at various research assistant jobs at The University of Tennessee, Knoxville, his graduate study interests shifted somewhat from taxonomy and ecology of freshwater fishes and aquatic insects to osteology of fishes. In 1982, he began studies of fossil fishes while working on the Columbia Archaeological Project at The University of Tennessee, Knoxville. This study culminated in a dissertation completed in partial fulfillment of the requirements for the Ph.D. degree in Ecology, conferred in the Fall of 1986. He is married to the former Cathy Lynn Jones of Memphis, Tennessee, and has three children, Laurel, Curt and Sarah. He is a member of the Southeastern Fishes Council and The American Society of Ichthyologists and Herpetologists.