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QUATERNARY RESEARCH **4**, 85–93 (1974)

Pleistocene Vertebrates with Boreal Affinities in the Georgia Piedmont

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Pleistocene alluvium along Little Kettle Creek in east-central Georgia contains a unique record of vertebrate life in the Appalachian Piedmont during a colder phase of the late Quaternary. The small fauna includes fishes and the following mammals: *Synaptomys cooperi*, the southern bog lemming; *Clethrionomys* sp., a redback vole; *Mammut americanum*, the American mastodon; a mammoth, *Mammuthus* sp.; *Odocoileus* cf. *virginianus*, a deer; and *Bison* sp. Both *Synaptomys* and *Clethrionomys* are primarily boreal genera of rodents which today reach their southern limits at higher elevations in the Great Smoky Mountains about 175 km north of the fossil locality. The American mastodon is also commonly associated with Pleistocene spruce bogs in eastern North America. Catfish (*Ictalurus* (?) sp.) vertebrae from the deposit show well-defined annual rings in contrast with the weakly marked annuli produced by fish living in the same area today. The total aspect of the fauna is one of considerably lower temperatures than those prevailing in the Georgia Piedmont now. The joint occurrence of bison and proboscideans indicates an age no older and no younger than late Pleistocene (Rancholabrean) for the assemblage. Because no pollen was found in the sediments and there was insufficient organic matter present for ^{14}C dating, no more precise age can yet be assigned to the fauna.

INTRODUCTION

The fossils to be described in this paper were found in dissected floodplain deposits in the Appalachian Piedmont Province of east-central Georgia. In April 1971, Mr. Tony Tucker found a portion of a mastodon tooth in the bed of Little Kettle Creek approximately 10 km southwest of Washington, Wilkes County, Georgia. The find was kindly brought to my attention by Mr. Alexander Wright, U.S. Soil Conservation Service. As no Pleistocene fossils of known stratigraphic provenance had been described from the Piedmont of Georgia or adjacent states, it was obvious that a thorough search of the area should be made for additional material. Through the courtesy of Mr. Hubert Tucker, landowner, and Mr. Wright, the writer, and students from the University of Georgia visited the locality several times and succeeded in making small but informative collections of fossil vertebrates, mostly by screen washing.

The vertebrate assemblage, herein named the Little Kettle Creek Local Fauna, is of particular paleoclimatic and biogeographic interest because (1) it provides the first, albeit meager, glimpse of the Pleistocene vertebrate biota of the southern Appalachian Piedmont; (2) vertebrate evidence is added to the pollen record (Whitehead and Barghoorn, 1962; Watts, 1970) of "cool" climate in the southern Appalachians, not just at higher elevations but in adjacent lowlands as well; and (3) the discovery illustrates that, at least locally, significant deposition occurred along Piedmont

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streams during the Pleistocene and suggests that further prospecting may reveal alluvial vertebrate fossil concentrations comparable to those in paleontologically better known areas.

Bones of large Pleistocene mammals have been known since colonial times to occur in the Savannah and Brunswick areas along the Georgia coast; the useful annotated bibliography by Cramer *et al.* (1967) should be consulted for references to the contributions of Harlan, Lyell, Leidy, and other pioneer workers. Renewed collecting in the Brunswick area (Voorhies, 1971, and unpublished) is underway in an attempt to stratigraphically document the occurrence of Pleistocene vertebrates relative to the sequence of coastal terraces in Georgia. Important collections have recently been made from fissure deposits at Ladds in the Appalachian Valley and Ridge Province of northwest Georgia (Lipps and Ray, 1967; Ray, 1967). The Ladds fauna appears to be a mixture ". . . of materials deposited at different times, and the apparent ecological incompatibility displayed among the fossil mammals reinforces this supposition" (Lipps and Ray, 1967, p. 115). Continued excavations at Ladds by Lipps (personal communication) hopefully will yield undisturbed, stratigraphically controlled collections.

The Little Kettle Creek assemblage is, as presently known, a unit fauna without admixture of chronologically or ecologically heterogeneous elements. The vertebrates collected so far have been found together elsewhere in natural association and probably shared a common habitat as will be discussed below. The collection appears to represent a sample of a full-glacial vertebrate biota—the first to be obtained from the Appalachian Piedmont of Georgia or the Carolinas, an area of more than 100,000 km².

GEOLOGIC SETTING

Wilkes County, Georgia (Fig. 1) lies wholly within the Piedmont geomorphic and geologic province; the bedrock consists of igneous and metamorphic crystalline rocks of Precambrian and Paleozoic age. A mantle of deeply weathered residuum (saprolite) blankets most of the area. No detailed geologic map of the county is available but on the state geologic map of Georgia (Stose *et al.*, 1939) the area around Little Kettle Creek is shown as "Granite Gneiss, probably Precambrian." In the immediate vicinity of the fossil locality the bedrock is hornblende gneiss in which the dip of the foliation is nearly vertical and the strike is NE–SW. The gneiss is overlain by semiconsolidated alluvial sands with occasional silty and clayey interbeds. When fresh the alluvium is dark grey, upon weathering it turns brick red. The total thickness of the alluvium varies from 2 to 3 m along the 2 km reach of the stream in which it is exposed. The top of the deposit is nearly horizontal, being dissected only by the stream itself and a few major tributaries, but its lower contact is highly irregular because of differential erosion of the underlying bedrock. Quartz dikes up to 1 m thick project at least 1 m above the general level of the disconformity and act as current baffles behind which sediment has collected. All the fossils discussed here except for the mastodon teeth were collected *in situ* in a lense of sandy silt ponded behind one of these dikes. The mastodon teeth were found about 100 m downstream from the screening locality. Presumably they also originated from the lense containing the other bones but this cannot be proved. Further prospecting failed to reveal any other fossiliferous sites in the vicinity.

Most of the fossils, especially the teeth, are unabraded and fresh in appearance but the mammoth tooth and several of the ungulate limb bones are somewhat waterrolled. All are permineralized and stained brown or black. The general similarity of preservation of the fossils and their occurrence together in the same small lense of sediment suggests that they may represent contemporaneous organisms which lived

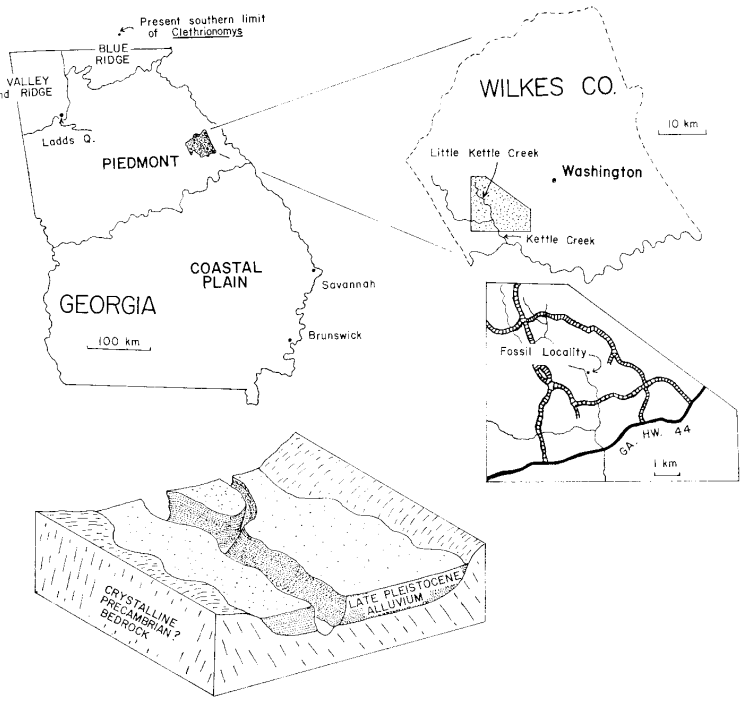

FIG. 1. Maps showing location of Late Pleistocene vertebrate locality on Little Kettle Creek, Wilkes County, Georgia. Block diagram shows stratigraphic relationships.

not far from the site of deposition. There is no obvious difference in fossilization between those forms that are still living in the area (deer, catfish) and those that are locally (bison, microtines) or totally (mastodons, mammoths) extinct.

SYSTEMATIC PALEONTOLOGY

All specimens are housed in the collections of the Geology Department, University of Georgia (catalog numbers UGV-).

CLASS OSTEICHTHYES
ORDER SILURIFORMES
FAMILY ICTALURIDAE

Ictalurus (?) *sp.* (*Fig. 2*)

A small catfish is represented in the fauna by isolated pectoral spines and verte-

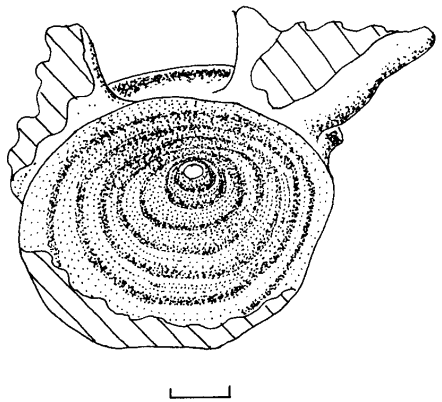

FIG. 2. Catfish (*Ictalurus?*) vertebra from Little Kettle Creek Local Fauna (UGV-11). Very distinct annuli suggest strongly seasonal climate. Bar = 1 mm.

brae which compare favorably with those of *Ictalurus punctatus*, the channel catfish, but are too fragmentary for positive identification. The vertebrae display well-defined annuli, the paleoecological significance of which will be discussed below in the section on Paleoclimatology.

CLASS MAMMALIA
ORDER RODENTIA
FAMILY CRICETIDAE
SUBFAMILY MICROTINAE

Synaptomys cooperi *Baird* (*Fig. 3*)

Two well-preserved cheek teeth of the southern bog lemming are present, a lower right first molar (UGV-2) and an upper left third molar (UGV-3). The teeth are rootless and are invested with cement. M_1 has three closed triangles between the terminal loops on the lingual side; dentine tracts are present on the three buccal salients but they have not yet interrupted the enamel at the occlusal surface of this ontogenetically young tooth. The combination of features listed characterizes *Synaptomys*. The well-developed, cement-filled buccal reentrant angles indicate that the specimen represents *S. cooperi* rather than *S. borealis* in which the reentrants are weak or absent. The M_3 may similarly be distinguished as *S. cooperi* rather than *S. borealis* by its comparatively deep lingual reentrant. The teeth are also smaller than those of typical *S. borealis*, the occlusal length of M_1 being 2.35 mm and that of the M_3 being 1.90. Small size also distinguishes the Georgia specimens from *S. australis* Simpson of the Florida Pleistocene.

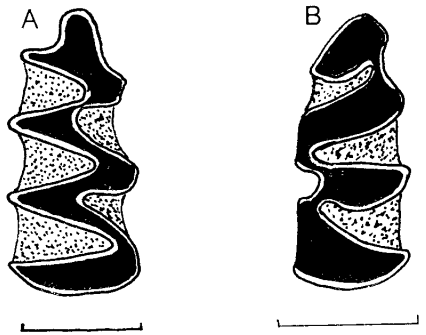

FIG. 3. Cheek teeth of *Synaptomys cooperi*, Little Kettle Creek Local Fauna. A. lower right first molar (UGV-2), occlusal view. B. upper left third molar (UGV-3), occlusal view. Bars—1 mm. White—enamel. Black—dentine. Stipple—cementum.

Guilday *et al.* (1964, 1969) have shown that Pleistocene as well as recent *S. cooperi* populations exhibit a negative Bergmann's response, i.e., the average size of the animals is larger in the southern than in the northern parts of the species' range. Such a trend becomes even more obvious if *S. australis* is merely a large, extinct, southern subspecies of *S. cooperi* as suggested by Patton (1963) and Ray (1967). The mean length of the first lower molar in large samples ($N = 20$) of Late Pleistocene *S. cooperi* studied by Guilday *et al.* (1964, 1969) ranges from 2.4 mm in the north (New Paris Sinkhole no. 4, Pennsylvania) to 2.7 mm in the south (Robinson Cave, Tennessee). Intermediate populations were of intermediate sizes. The Little Kettle Creek specimen is smaller than any of the 26 first molars from Robinson Cave, suggesting that its affinities lie with more northern populations. Such a conclusion must remain tentative until more specimens are found but at least the material collected so far is not at all suggestive of typical southern *Synaptomys* in size.

Clethrionomys *sp.* (*Fig. 4*)

A right M_2 in the collection (UGV-4) represents a microtine with rooted teeth. In size and occlusal pattern it accords well with *C. gapperi* the red-backed vole although until more material is found specific identification will not be possible. *Clethrionomys* is a common component of Pleistocene cave faunas in the Appalachians north of Georgia but has not been reported, either alive or as a fossil, from the Piedmont before. *Clethrionomys* is characteristically a boreal rodent genus but *C. gapperi* has long been known to penetrate into the southeastern United States along the higher ridges of the Appalachians (Hall and Kelson, 1959:713). E. P. Odum, who studied one of the southernmost known populations, on the Highlands Plateau, North Carolina, stated (1949:191): "We have no record of this species [*C. gapperi*] below 3600 ft [1100 m], nor is it known to occur south of the Highlands Plateau." Although the modern range of the species has recently been shown to extend into northernmost Georgia at higher elevations in the Blue Ridge Province (Wharton and White, 1967) it surely does not extend into the Piedmont lowlands (elevation 100–200 m) in which Wilkes County is located.

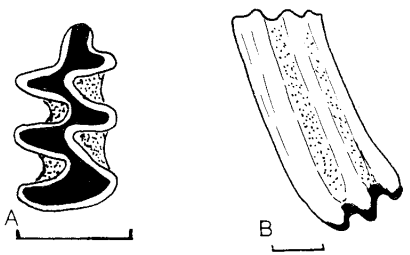

FIG. 4. *Clethrionomys* sp., right lower molar (UGV-4), Little Kettle Creek Local Fauna. A. occlusal view. B. lingual view. Bars—1 mm. White—enamel. Black—dentine. Stipple—cementum.

ORDER PROBOSCIDEA
FAMILY MAMMUTIDAE

Mammut americanum

The anterior half of a mastodon lower left molar (UGV-1) and the posterior portion of an upper molar (in the possession of Mr. Tony Tucker, Washington, Georgia) were collected in the stream bed downstream from the fossiliferous outcrop. Both teeth are little worn and may represent the same individual.

FAMILY ELEPHANTIDAE

Mammuthus *sp.*

A partial upper right molar of a mammoth (UGV-5) was collected from the same lense of sediment which produced the small vertebrates. Specific identification of isolated mammoth teeth is notoriously difficult. Because of breakage neither the maximum length nor the maximum width of the specimen are determinable. That the specimen is a molar rather than a premolar is shown by its possession of a minimum of 13 dental lamellae, no more than 12 being present in premolars. It is particularly unfortunate that the position within the molar sequence is unknown because the most commonly applied criteria for specific identification of mammoths (Aguirre, 1969; Whitmore *et al.*, 1967; Davis *et al.*, 1972) are based on the second and third molars only. The thickness of the enamel in the Little Kettle Creek specimen (measured by the technique of Aguirre, 1969) is 1.6, and the number of enamel plates per 100 mm of occlusal surface is 10. In both of these features the Georgia specimen falls within the range of *M. primigenius*, the woolly mammoth, as determined by Aguirre (1969) and Whitmore *et al.* (1967) for ultimate and penultimate molars. Since these authors give no data for the first molar, however, and since the specimen at hand may, in fact, be a first molar, no definite conclusions regarding the identity of the Little Kettle Creek mammoth can be made without additional material.

ORDER ARTIODACTYLA
FAMILY CERVIDAE

Odocoileus *cf.* virginianus

An upper left third or fourth premolar (UGV-6) and a damaged fused left metatarsals III and IV (UGV-7) compare closely with homologous elements in modern white-tailed deer but positive identification to species should not be based on such scanty material.

FAMILY BOVIDAE

Bison *sp.*

A right lower first molar (UGV-10), an intermediate phalanx (UGV-8), and the proximal end of fused right metacarpals III and IV (UGV-9) represent a large bovid. The heavy coating of cementum and strongly developed labial stylid on the molar indicate *Bison* rather than an ovibovine. Specific assignment is unwarranted on the basis of such incomplete material, but the specimens are important geochronologically because they indicate an age not earlier than Rancholabrean (Late Pleistocene) (Hibbard *et al.*, 1965).

PALEOCLIMATOLOGY

As noted by Guilday (1971) studies on the Quaternary climatic history of the southern Appalachians have only recently advanced beyond the stage of hypothetical deduction. Reports on fossil mammals in Tennessee caves (Guilday *et al.*, 1969) and pollen in Pleistocene sediments in southeastern North Carolina (Whitehead, 1964) leave no doubt that boreal faunal and floral elements penetrated far into the southeastern states during Wisconsin glacial maxima. The area between the cave-riddled backbone of the Appalachians and the pollen-rich organic deposits of organic muck along the Atlantic coast has thus far received little study. The only study of Pleistocene vegetation in the southern Piedmont known to me is that of Whitehead and Barghoorn (1962) who discovered pollen indicative of boreal vegetation (spruce, fir, hemlock) in western North and South Carolina. Watts (1970) has recently completed a study of Pleistocene pollen in two ponds in the Appalachian Valley and Ridge Province in northwestern Georgia. Referring to the pollen assemblage bracketed by ^{14}C dates of approximately 13,500 and 20,000 yr, Watts concluded (1970:32) that "a displacement southward of some 700 miles would be required to bring the same species back to Georgia."

A search for pollen in the Little Kettle Creek alluvium by Mrs. A. Martin has so far been unsuccessful so the Late Pleistocene climate in the area must be inferred from the fossil vertebrates. The latter have generally proved less sensitive as environmental indicators than have fossil plants, but, especially in the Late Pleistocene, they can provide significant information (Romer, 1961). Two vertebrate indices of past climate will be used here: one, the modern distribution of mammals found in the fossil assemblage, is well known and needs no further comment; the other, comparative development of annual growth rings in fish vertebrae, has seldom been used as a paleoclimatic indicator and requires further explanation.

Fishes

Catfish vertebral centra in the Little Kettle Creek Local Fauna (Fig. 2) show well-defined alternating light and dark bands. In regions with marked seasonal changes in temperature, such poikilothermic organisms as fishes show inequalities in growth rate through the year which are reflected in various bones of the skeleton and in the scales. Periods of slow growth (usually in the winter) are marked by narrow zones of bone which are shiny in reflected light and dark in direct light; times of fast growth are marked by wide zones of light-colored bone. Such bands have been shown to represent annual growth increments in many species of fish and have proved invaluable in fisheries management work. Tesch (1968) usefully summarizes the procedures for age and growth determination using marks on opercula, otoliths, scales, vertebrae, spines, and other hard parts. More interesting to the paleoecologist is the fact that growth marks are closely related to climate. Biologists have often experienced difficulty in applying conventional ageing techniques to fishes from southern waters. Huish (1953) for example, cited several unsuccessful attempts to age Florida bass and sunfish with the scale method and reported a number of black crappie which had reached nearly a foot in length without forming an annulus on their scales and others which developed only very faint year marks. Prather (1966) also questioned the reliability of the scale method based on his study of centrarchids in Alabama, a singificant number of which showed no distinct annuli on their scales.

Much experimental work has been done on the relationship between temperatue and growth in fishes. A complex relationship exists but in general warm uniform temperatures promote steady growth while seasonal chilling retards it (see Chap. 4 in Weatherley, 1972). Freshwater fishes in temperate and polar regions do little or no feeding in the winter, bringing their growth virtually to a standstill, whereas southern fishes mostly feed year round. Marshall (1966: 110) generalizes as follows: "the scales of most tropical fishes have no annual rings."

Potentially, the investigation of seasonal growth marks in fossil vertebrates may yield data on ancient climates although little has yet been done along these lines (Voorhies, 1969, discusses the significance of annuli in fish bones and scales from a Pliocene bone bed in Nebraska). Rigorous application of fish vertebrae as "paleothermometers' will not be possible until a reference collection of fish skeletons from a wide selection of climates and habitats is available. Such a collection is presently being assembled at Southern Methodist University by Professor Bob Slaughter (personal communication). Preliminary comparisons of vertebrae of *Ictalurus punctatus* from Georgia and Florida with vertebrae from the same species taken in Nebraska and South Dakota indicate that significant differences do exist in the development of annuli. Those in the southern fish examined ($N = 20$) are less distinct than those from northern waters ($N = 15$). In this respect the fossil vertebrae from Little Kettle Creek are much more similar to those from the midwestern catfish than from the modern Georgia specimens. The small size of the fossil sample ($N = 8$, some of which may be from the same individual) hampers the drawing of definitive conclusions but the evidence suggests that the climatic regime under which the fossil catfish grew was considerably more rigorous than that of modern Wilkes County, Georgia.

Mammals

To demonstrate, in detail, sequential climatic change using fossil mammals as Guilday *et al.* (1964) have done with a Pennsylvania cave assemblage, requires very large population samples. However, even small samples containing temperature-sensitive mammalian taxa can be useful in paleoclimatic reconstructions, although necessarily at a lower order of precision.

Clethrionomys and *Synaptomys* are primarily boreal rodents which range into the southern Appalachians only along the "peninsula" of Hudsonian vegetation which occupies the crests of the higher mountains. The occurrence of *Clethrionomys* in the Little Kettle Creek Local Fauna, the southern-most record of the genus in eastern North America, strongly suggests that cooler conditions prevailed in the Georgia Piedmont at the time of deposition. A depression of altitudinal ecological zones amounting to approximately 1000 m would probably be required to bring suitable *Clethrionomys* habitat back to the Georgia Piedmont. *Synaptomys cooperi* is also limited, in the southern Appalachians, to patches of boreal vegetation at higher elevations but its paleoclimatic significance is less clear for reasons mentioned previously—namely that *S. australis*, a closely related or conspecific form, is found in Florida where the magnitude of Pleistocene climatic changes is as yet poorly understood. In size, the Georgia *Synaptomys* is more closely allied to northern populations of *S. cooperi* than to *S. australis*, but the sample is much too small to inspire confidence in its climatic meaning.

American mastodon remains are very widespread geographically but it is not yet

clear whether these fossils represent contemporaneous populations spread over a broad spectrum of climatic and vegetation zones or whether the animals were more strictly confined to a particular vegetation zone which transgressed and regressed across the continent through time. The latter hypothesis has been advanced by Dreimanis (1967, 1968) who cites an impressive number of associations between *Mammut americanum* and spruce forest vegetation preserved as stomach and mouth contents, plant megafossils associated with mastodon bones, and pollen. Martin and Guilday (1967) on the other hand, question the implied restriction of mastodons to coniferous forest habitats, citing occurrences in Florida as evidence to the contrary.

There is simply not enough known about the vegetational history of Florida to decide whether elements of the boreal forest ever penetrated so far south and, if so, whether *Mammut* was invariably associated with them. Study of a full-glacial pollen assemblage in Florida is much to be desired. Recent studies by Watts (1969, 1971), although confined by accidents of preservation to post- and preglacial maxima, show that dramatic changes have repeatedly occurred in the vegetation of southern Georgia and northern Florida within a few thousands of years. The venerable concept of Florida as a uniformly tropical refuge through the ice ages is no longer tenable. The paleoclimatic significance of mastodons remains an open question but at least the positive evidence available shows that their presence at Little Kettle Creek is entirely consistent with a cool, moist habitat.

Mammoths are also virtually ubiquitous in the Pleistocene of North America but their taxonomy, and consequently their ecology, is much more complex. Those with thin enamel and narrow dental lamellae are primarily if not exclusively confined to faunas of boreal aspect, however. As far south as Saltville, Virginia, Ray *et al.* (1967) list *M. primigenius* in association with muskox and spruce pollen. Whitmore *et al.* (1967) also found that mammoth teeth dredged from the continental shelf (and hence coeval with glacially lowered sealevel) had high lamellar frequency. The Little Kettle Creek mammoth tooth, although not definitely assignable to a species, is consistent with this pattern.

The presence of deer and bison in the fauna reveals little of paleoclimatic interest since both animals have extremely wide geographic ranges which today (*Odocoileus*) or within historic time (*Bison*) have embraced the Georgia Piedmont as well as much more northerly areas.

CONCLUSIONS

The Appalachians and coastal plain of the southeastern United States have been described as a "zone of tension" between boreal, temperate, and subtropical environments (Watts, 1971). Spruce–fir and northern hardwood forests in the high Appalachians grade progressively southward into temperate hardwood forests, southern mixed forests, and eventually into stands of subtropical vegetation in southern Florida. The lack of transverse mountain barriers make the region a very suitable one for studying Pleistocene shifts in boundaries between climatically controlled biotic provinces. As the first sample of the vertebrate biota from the southern Piedmont the Little Kettle Creek Local Fauna, inadequate as it is, reveals that a cool, moist climate suitable for boreally adapted mammals once extended rather far south of the mountains, nearly to the coastal plain. The discovery is encouraging in that it revives hope of discovering a sequence of alluvial Pleistocene vertebrate assemblages in an area previously considered barren of fossils.

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