

LATE CRETACEOUS DINOSAURS FROM THE BLUFFTOWN FORMATION IN WESTERN GEORGIA AND EASTERN ALABAMA

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ABSTRACT—Fragmentary bones and teeth of three Late Cretaceous dinosaur taxa occur along both sides of the Georgia–Alabama border, in the extreme southeastern Coastal Plain Province. The localities lie in the middle and upper Blufftown Formation, in nearshore marine deposits. *Exogyra* ssp. and calcareous nannofossils give a late Santonian through mid-Campanian age range. Taxa determined are: Hadrosauridae, genus and species indeterminate; Ornithomimidae, genus and species indeterminate; and *Albertosaurus?* sp.

INTRODUCTION

DINOSAUR BONES are distributed widely, but sparsely, in Upper Cretaceous marine strata of the Coastal Plain Province of the eastern United States. The majority of these fossils are isolated limb bones, vertebrae, and teeth of hadrosaurs (Ornithischia, Ornithopoda), largely unassignable below family; nevertheless, several partial hadrosaur skeletons are known, including the eponymous hadrosaur *Hadrosaurus foulkii* Leidy, 1858, from the Matawan Formation in New Jersey, and *Lophorothon atopus* Langston, 1960, from the Mooreville Formation in western Alabama. Carnivorous dinosaur remains (Saurischia, Theropoda), from both large and small taxa (i.e., “Carnosauria” and “Coelurosauria” in general usage), are also common in the Coastal Plain (indeed, Russell, 1988, stated that

theropods are the most widely distributed dinosaurs in marine strata). These again are largely isolated bones and teeth, although a substantial skeleton comprises the type specimen of *Dryptosaurus aquilunguis* (Cope, 1866), an anomalous, possibly endemic, large taxon. Another partial theropod skeleton, not yet formally described (see King et al., 1988; Baird, 1989), has been found in upper Campanian age strata in central Alabama.

Horner (1979) provided an annotated checklist of Upper Cretaceous dinosaur taxa and occurrences from marine strata in North America known to that date. The collective eastern Coastal Plain assemblage of Horner (1979) included eight clearly different dinosaur taxa, and several additional forms not determinable below family. Baird and Horner (1979) reduced the generic count by absorption of *Parrosaurus* into *Hypsibema*

(which they assigned to Sauropoda, family indet.) and by absorption of *Coelosaurus* (Theropoda, Ornithomimidae) into *Ornithomimus*. A further reduction of apparent taxonomic diversity in Cretaceous eastern Coastal Plain strata occurred with recognition that the caudal vertebrae comprising *Parrosaurus missouriensis* (Gilmore, 1945) belonged to an indeterminate large hadrosaur (Parris et al., 1988) rather than to a sauropod. Substantial numbers of new dinosaur localities and specimens (but as yet, no new taxa) have become known in the Late Cretaceous eastern outcrop since Horner (1979); these are listed in Appendix A and are included, in part, by Russell (1988) in a checklist of occurrences of all vertebrates in North American Cretaceous marine rocks.

The purpose of this paper is to describe the Late Cretaceous dinosaur fauna from the marine strata in the Coastal Plain in westernmost Georgia and easternmost Alabama. The fossils come from the Blufftown Formation, of late Santonian through mid-Campanian age. The occurrence of dinosaur bones in the study area has been noted previously (Cope, 1878; Stephenson, 1911; Schwimmer, 1981, 1986a; Schwimmer et al., 1988; Russell, 1988; Schwimmer and Best, 1989) but this is the first systematic report of the entire regional assemblage.

GEOLOGIC SETTING

Geography and stratigraphy.—The study area is located largely in the valley of the Chattahoochee River, at the western Georgia–eastern Alabama border, and occupies a pivotal geomorphic position between the Atlantic and eastern Gulf Coastal Plain Provinces (Figure 1). During the Late Cretaceous, these two sedimentary provinces were not clearly demarcated by peninsular Florida, but they did sustain significantly different marine environments and dominant styles of sedimentation—respectively, pericontinental marine/coarse siliclastic on the Atlantic coast, versus epicontinental marine/clay and carbonate on the Gulf coast. Cretaceous sediments in the study area have been variously incorporated as part of the eastern Gulf section (e.g., in Stephenson, 1911, 1914; Reinhardt and Donovan, 1986; Skotnicki and King, 1986), as an intermediate link between the Gulf and Atlantic Coastal Plains (Sohl and Smith, 1981), and as the southern limit of the Atlantic Coastal Plain (Owens and Gohn, 1985). Evidence from regional studies of Late Cretaceous fish (Case and Schwimmer, 1988) and other vertebrates from the study area (Schwimmer, 1986a) suggests the presence of coastal and marine vertebrate assemblages somewhat more typical of the Atlantic Coastal Plain than of the Gulf Coastal Plain (see also “Additional Observations”).

Fossils described here were collected from four localities, as shown in Figure 1 (to which all locality references are made). Detailed stratigraphy of the Blufftown Formation at locality 1 in western Georgia is presented in Schwimmer (1986b) and Case and Schwimmer (1988). Sedimentary analysis of the Blufftown Formation in eastern Alabama is presented in King and Skotnicki (1986), Skotnicki and King (1986), and King (1990). Fossils described in this study occur in the upper-middle to uppermost portions of the relatively thick (125 m) formation, and most likely accumulated in back-barrier or estuarine settings during relatively high sea-level stands. At Hannahatchee Creek in western Georgia (locality 1), dinosaur bones were collected from the uppermost few meters of the Blufftown Formation in sediments representing a brief transgressional interval with a condensed marine sedimentary section.

Age of the fossils.—The Blufftown Formation was deposited largely during the early and mid-Campanian, but a substantial portion of the lower part of the formation may have been deposited during the late Santonian. The oyster *Exogyra ponderosa*

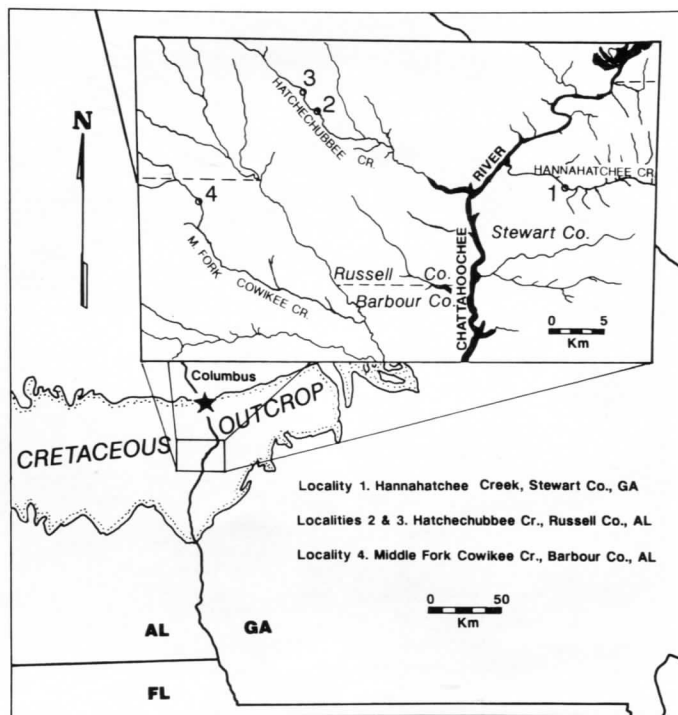


FIGURE 1—Dinosaur localities in the Blufftown Formation, in western Georgia and eastern Alabama. Localities numbered as discussed in text.

Roemer is associated with dinosaur bones at all four localities; the range zone of *E. ponderosa* extends through the upper Santonian to the mid-Campanian (Stephenson, 1914; Stephenson et al., 1942; Lerman, 1965; Sohl and Smith, 1981). At Hannahatchee Creek in Stewart County, Georgia, the strata contain abundant *Exogyra ponderosa* var. *erraticostata* Stephenson, which does not have a well-delimited stratigraphic range but is commonly observed only near the upper range of the species (Lerman, 1965; DRS field observations). Its occurrence therefore suggests a mid-Campanian age at locality 1.

Calcareous nannofossils were analyzed from matrix enclosing dinosaur bones at localities 1 and 2. At locality 2, a well-preserved assemblage of nannofossils included *Lucianorhabdus cayeuxii* Deflandre and *Marthasterites furcatus* (Deflandre), whose overlapping ranges delimit Sissingh's (1977) Zones 16 to 18 (latest Santonian–early Campanian). At locality 1, the matrix contained few diagnostic nannofossils; however, rare *Calculites obscurus* (Deflandre) and *Reinhardtites anthophorus* (Deflandre) occur and their ranges overlap within Sissingh's Zones 17 to 22 (early to mid-late Campanian).

In summary, the probable dates for the Blufftown dinosaur fossils are: mid-Campanian at locality 1; late Santonian to early Campanian at locality 2; and late Santonian to mid-Campanian at localities 3 and 4, which are dated only by stratigraphic association and the presence of *Exogyra ponderosa*.

SYSTEMATIC PALEONTOLOGY

Terminology and collections.—Orientations and anatomical nomenclature follow suggestions in Weishampel et al., (1990). Materials listed are housed and cataloged in the Cretaceous research collections at Columbus College (CCK) and Auburn University Museum of Paleontology (AUMP).



FIGURE 2—1–3, 7–9, *Albertosaurus?* sp. 1–3, CCK-87-5-1, left metatarsal IV lacking the distal condyle, cranial, medial, and caudal views, locality 1, $\times 0.35$; 7, CCK-90-1-2, phalangeal fragment, locality 4, $\times 1.5$; 8, 9, CCK-83-81-7, CCK-85-1-2, cross sections of theropod bone shafts, showing thick cortical bone and smooth medullary cavity linings, locality 1, $\times 1.2$. 4–6, Ornithomimidae, gen. and sp. indet. 4, 5, CCK-85-1-1, fragment of the proximal one-third of a right tibial shaft, lateral and caudal views, locality 1, $\times 0.55$; 6, cross-sectional view, distal aspect of CCK-85-1-1, $\times 0.7$.

Order SAURISCHIA Seeley, 1888
 Suborder THEROPODA Marsh, 1881
 Family TYRANNOSAURIDAE Osborn, 1906
 Genus ALBERTOSAURUS Osborn, 1905
 ALBERTOSAURUS? sp.
 Figure 2.1–2.3, 2.7–2.9

Material.—CCK-87-5-1 (loc. 1), left metatarsal IV lacking the distal condyle. CCK-90-1-2 (loc. 4), fragmentary pedal? phalanx. CCK-83-81-7, CCK-85-1-2 (loc. 1), CCK-90-5-1 and -2 [not figured] (loc. 4), four indeterminate, large, theropod metapodial shaft fragments.

Discussion.—Fragmentary Cretaceous theropod bones from the eastern Coastal Plain Cretaceous outcrop are rarely identifiable at even the generic level (Horner, 1979; Baird and Horner, 1979; Carpenter, 1982; Baird, 1989). However, the left fourth metatarsal from locality 1 (Figure 2.1–2.3) is sufficiently preserved to allow favorable comparison with specimens from the Campanian Judith River (Oldman) Formation in Alberta referred to *Albertosaurus* (e.g., Tyrrell Museum of Paleontology 67.15.16 and 73.30.1). The Blufftown specimen is undistorted and nearly complete, lacking only some margins of the proximal end and the distal condyle. Shaft diameters immediately below the proximal head are 42.0 mm medial-lateral by 51.0 mm cranio-caudal. Reconstructed length is approximately 440 mm; therefore, if the tentative generic identification is correct, the bone represents a young *Albertosaurus*, weighing approximately one-half tonne.

As noted in the introduction, a partial theropod skeleton was collected recently in central Alabama from the Demopolis Chalk in Montgomery County (King et al., 1988, describe the sedimentary environment of the site). This theropod is presently in preparation in the Red Mountain Museum, Birmingham, and, at late Campanian age, is slightly younger than the Blufftown material. However, comparison of the left fourth metatarsals from the Blufftown and Montgomery theropods shows they are indistinguishable in size and overall morphology (James Lamb, personal commun., and see Baird, 1989, p. 56).

The remaining theropod bones listed above are taxonomically nondescript. The single phalangeal fragment is split medially and retains less than one-half of the distal-lateral surfaces. Its assignment as a pedal phalanx is based on the relatively large lateral fossa. The four metapodial shaft fragments are assigned to Theropoda by virtue of extremely smooth surfaces lining the open medullary cavities and by their round to subround cross sections. They are further identifiable as "carnosaur" remains by the presence of relatively thick, dense cortical bone relative to the total cross-sectional area (see Figure 2.8, 2.9). Among these shaft fragments, the external cross-sectional diameters range from 36.0 to 55.0 mm, and all feature wall thicknesses equal to or greater than diameters of medullary cavities.

TABLE 1—Comparative measurements (in mm) of ANSP 9222, right tibia, cotyle of *Ornithomimus antiquus* (Leidy, 1865), and Blufftown tibial fragment CCK-85-1-1.

	ANSP 9222	CCK-85-1-1
External dimensions:		
Lateral	33.0	63.0
Cranio-caudal	28.5	62.0
Wall thicknesses:		
Medial	unavailable	16.2
Craniomedial	do.	19.0
Caudal	do.	8.2
Lateral	do.	9.0

Family ORNITHOMIMIDAE Marsh, 1890
 Gen. and sp. indet.
 Figure 2.4–2.6

Material.—CCK-85-1-1, fragment of the proximal one-third of a right tibial shaft (loc. 1).

Discussion.—The only eastern North American ornithomimid assigned genus and species is *Coelosaurus antiquus* Leidy, 1865, based on a complete right tibia and fragments of additional legbones from the late Maastrichtian of New Jersey (see Baird and Horner, 1979). *Coelosaurus* was considered by Russell (1972) a nomen dubium, although a valid ornithomimid, and Baird and Horner (1979) reassigned the species *antiquus* to *Ornithomimus*. Ornithomimid fossils from the Upper Cretaceous Coastal Plains in eastern United States have traditionally been classified as *O. antiquus* for lack of other known representatives of the family (e.g., Baird, 1986).

The single ornithomimid specimen from the Blufftown Formation, consisting of a fragment of the right tibial shaft, especially invites comparison with the syntype right tibia of *O. antiquus* (Academy of Natural Sciences, Philadelphia [ANSP] 9222). The fragment comes from the proximal shaft and includes part of the fibular crest on the lateral surface. Given the limited information available, the Blufftown fragment compares favorably with the corresponding region of ANSP 9222 except for its larger size and slightly greater cranio-caudal diameter. Dimensions of CCK-85-1-1 and ANSP 9222, taken at comparable sections at mid-point of the fibular crest, are presented in Table 1.

The slightly greater cranio-caudal proportion of the Blufftown specimen may reflect positive allometry. Although the Blufftown specimen is from a considerably larger animal than ANSP 9222, the thin shaft walls and correspondingly large medullary cavity show this individual was still a lightly built, cursorial theropod with limb proportions typical of Ornithomimidae. Nevertheless, given that the Blufftown specimen is considerably older as well

FIGURE 3—1–11, Hadrosauridae, gen. and sp. indet., associated left distal leg bones. 1, 2, CCK-87-20-4, tibia with attached, ablated astragalus, caudal and lateral views, $\times 0.17$; 3, 4, CCK-87-20-1, fibula, lateral and cranial views, $\times 0.17$; 5, CCK-87-20-5 through 87-20-8, digit IV phalanges 1, 2, 4, and ungual, dorsal view, $\times 0.4$; 6, 7, CCK-87-20-3, metatarsal II, medial and lateral views, $\times 0.25$; 8, 9, CCK-87-20-2, metatarsal III, lateral and caudal views, $\times 0.2$; 10, 11, CCK-87-20-9, distal tarsal element (after Weishampel and Horner, 1990, p. 553) ?distal and ?proximal views, $\times 0.75$; locality 2.

FIGURE 4—1–16, Hadrosauridae, gen. and sp. indet. 1, 2, CCK-79-3-1, posterior left dentary fragment, split rostro-caudally through the posterior alveoli, lingual and buccal views, locality 1, $\times 0.85$; 3, 4, CCK-85-2-1, distal third of a left metacarpal III, cranial and caudal views, locality 1, $\times 0.5$; 5–7, CCK-88-16-1, small, posterior caudal vertebra, neural region ablated, dorsal, caudal, and lateral views, locality 1, $\times 1.4$; 8–10, CCK-90-17-1, large posterior caudal vertebra, margins and neural region ablated, lateral, cranial, and dorsal views, locality 1, $\times 0.8$; 11, 12, AUMP3083, left metatarsal IV, cranial and medio-caudal views, locality 3, $\times 0.25$; 13, 14, AUMP3026 and CCK-90-6-1, ablated tooth crowns, positions indeterminate, localities 3 and 4, $\times 2.75$; 15, 16, CCK-90-4-1, dentary tooth crown and partial root, showing marginal denticulations, lingual and mesial views, locality 1, $\times 2.6$.



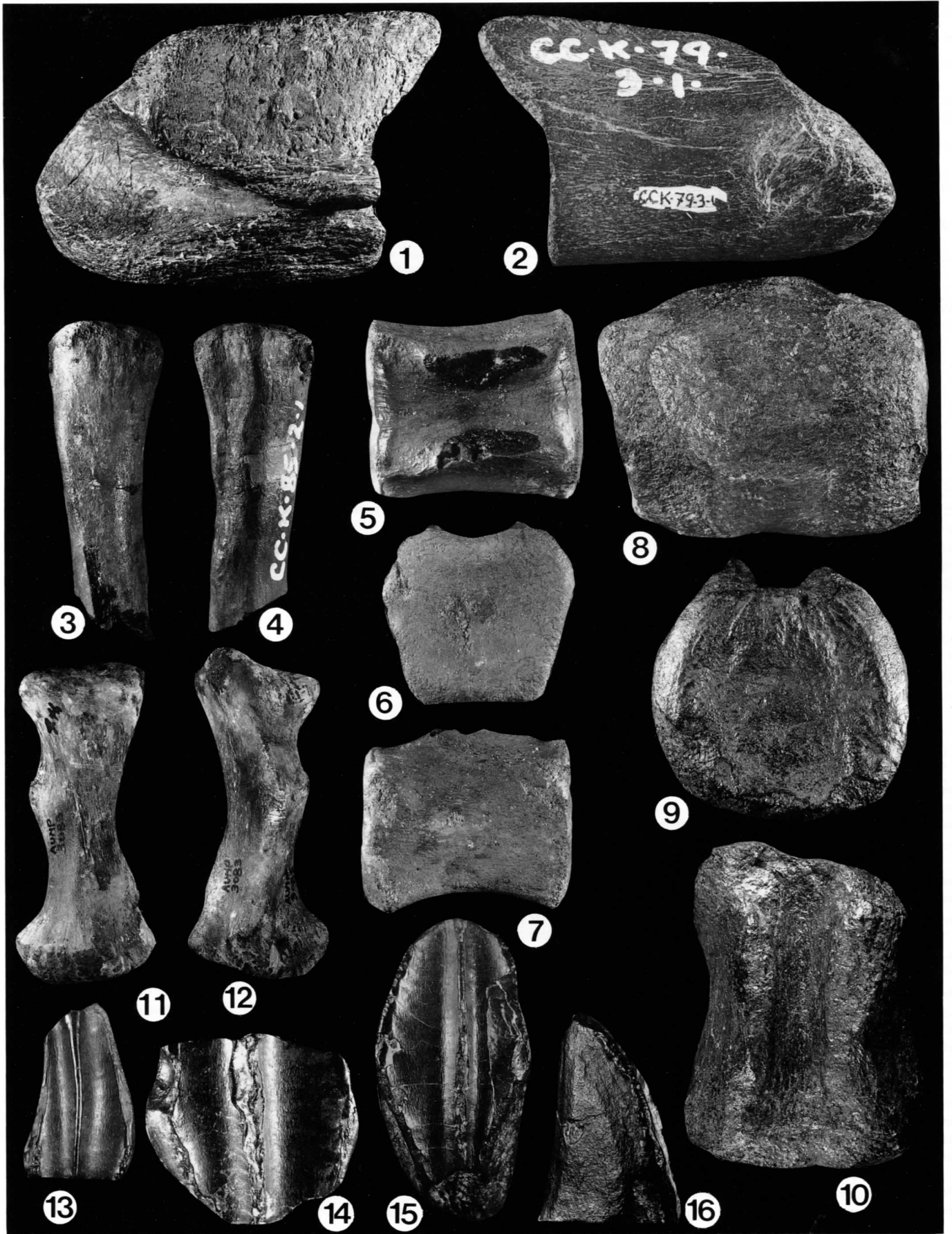


TABLE 2—Comparative measurements (in mm) of legbones from *Hadrosaurus foulkii* Leidy, 1858, and Blufftown specimen CCK-87-10-1-9. Data for *H. foulkii* from Leidy, 1865, and Lull and Wright, 1942.

	CCK-87-20-1-9	<i>H. foulkii</i>
Tibia:		
Length	835	933
Width, proximal head	307	286
Minimum shaft circumference	317	296
Fibula:		
Width, distal end	112	133
Metatarsal III:		
Length	321	320

as larger than ANSP 9222, there is no reason to assign it to *O. antiquus* based on such scanty material.

Order ORNITHISCHIA Seeley, 1888
 Suborder ORNITHOPODA Marsh, 1881
 Family HADROSAURIDAE Cope, 1869
 Subfamily HADROSAURINAE Lambe, 1918
 Gen. and sp. indet.
 Figures 3.1-3.11, 4.1-4.16

Material.—CCK-87-20-1 through CCK-87-20-9 (loc. 2), nine associated left legbones, including tibia with attached, partially ablated astragalus, fibula, metatarsals II and III, a distal tarsal, and four phalanges of digit IV, including the ungual. AUMP3083 (loc. 3), left metatarsal IV. CCK-88-16-1 (loc. 1), small posterior caudal vertebra with ablated neural arch. CCK-90-17-1 (loc. 1), large posterior caudal vertebra with ablated neural arch. CCK-85-2-1 (loc. 1), distal third of a left metacarpal III. CCK-79-3-1 (loc. 1), ablated buccal-caudal region of a small left dentary. CCK-90-4-1 (loc. 1), dentary tooth crown and partial root. AUMP3026 (loc. 3), ablated small tooth crown, position indeterminate. CCK-90-6-1 (loc. 4), ablated large tooth crown, position indeterminate.

Discussion.—None of these hadrosaur remains from the Blufftown Formation can be assigned definitively to either subfamily Hadrosaurinae or Lambeosaurinae (Weishampel and Horner, 1990); nevertheless, most identifiable duckbilled dinosaurs from the Atlantic and Gulf Coastal Plains are hadrosaurines, and the tentative classification here is largely based on that probability (although the single dentary tooth discussed below adds some support to the assignment).

The associated legbones from locality 2, CCK-87-20-1-9, are undistorted and largely complete; missing are a portion of the medial surface of the internal distal tibial condyle and the adjacent medial half of the astragalus, and the lateral surface of the distal fibular head. These ablated surfaces were apparently weathered on the outcrop prior to discovery. The distal tarsal element CCK-87-20-9 (Figure 4.10, 4.11) is a bone that was first described by Lull and Wright (1942, p. 92), but is rarely figured or recognized (see Weishampel and Horner, 1990, p. 553). The bones are typically hadrosaurine in overall morphology; however, the tibia is notably wide at the knee and ankle and massive through the shaft in proportion to length. Conversely, in comparison with *Hadrosaurus foulkii*, the metatarsals are relatively long (see below). Articular surfaces of these bones show considerable rugosity, suggesting some resorption or ossification of cartilage; thus, despite the relative shortness of the tibia and fibula, there is the impression of a large, old individual. Table 2 compares available dimensions of CCK-87-20-1-9 with the type of *Hadrosaurus foulkii* Leidy, 1858, from the Campanian of New Jersey.

Unfortunately, no other adult hadrosaur from the eastern United States is known with comparable bones. The complete hadrosaur tibiae described by Langston (1960) for the type of *Lophorhothon atopus* from the Campanian in western Alabama, and by Kaye and Russell (1973) for an unnamed hadrosaur from the Santonian in Mississippi, are from sub-adults and therefore are not useful for this comparison. The type specimen of *Ornithotarsus immanis* Cope from the Monmouth Formation (Campanian) in New Jersey includes a distal tibial fragment measuring 315 mm width across the condyles (Lull and Wright, 1942). However, in the absence of a length measurement, the *O. immanis* tibia shows only that a heavy-boned hadrosaur was present in the Campanian of the Atlantic Coastal Plain.

The isolated left fourth metatarsal, AUMP3083, although found within the same stream valley and within 2 km of CCK-87-20-1-9, is not from the same individual. The overall size of AUMP3083 is approximately 14 percent smaller than the corresponding bone would be in CCK-87-20-1-9, and AUMP3083 has relatively more phosphatic and less calcitic permineralization than the bones of CCK-87-20-1-9.

The distal caudal vertebra CCK-88-16-1, with a total length of 28 mm, is from a young hadrosaur, but the exact position in the tail sequence (and, hence, the restored size of the individual) is indeterminable. Dentary fragment CCK-79-3-1 represents either another young hadrosaur or is from the same individual as the caudal vertebra CCK-88-16-1. They were both found at the same general site in locality 1, but there is no firm stratigraphic evidence of association. The dentary fragment is from the caudal region, is split rostro-caudally through the tooth row, and the lingual surface shows faint impressions of the last six tooth alveoli. The fragment was substantially ablated before deposition and there is no remnant of the coronoid process; however, the Meckelian canal is evident. Distal caudal vertebra CCK-90-17-1, at 79 mm length, is much larger than CCK-88-16-1 and is from an adult hadrosaur.

Among the three teeth, only CCK-90-4-1 is preserved sufficiently to be reliably assigned to upper or lower jaw; the lower jaw position is shown by indentation of the enamel at the base of the crown (which accommodates the apex of the replacement tooth crown only in the dentary). Among characteristics traditionally used in taxonomic assignment of hadrosaur teeth (e.g., Sternberg, 1936; Langston, 1960), all of the Blufftown teeth show marginal denticulations on the crowns, and the crown/fang angle (Figure 4.16) in CCK-90-4-1 is 140° (like *Lophorhothon* and unlike *Hadrosaurus*; Langston, 1960). However, Coombs (1988) has argued that hadrosaur teeth are not reliable tools to discriminate between hadrosaurines and lambeosaurines, and the teeth and other bones in this study are clearly not preserved sufficiently well to test that argument.

ADDITIONAL OBSERVATIONS

Occupying a central position between the Atlantic and Gulf Coastal Plains, each with substantial records of Late Cretaceous dinosaur fossils, the study area invites examination for evidence of biogeographic provinciality in dinosaur occurrences across the East Coast. In fact, and considering the limited range and quality of fossils from the study area, no such evidence of provinciality appears. In western Georgia and eastern Alabama we find taxa that would be unremarkable in either New Jersey or Mississippi. Equally characteristic of marine Late Cretaceous dinosaur occurrences (Horner, 1979), we find a regional fauna dominated in abundance by hadrosaurs. The greatest novelty of the Blufftown assemblage, as known, is the relatively large number of "carnosaurian" theropod bones present, representing at least four individuals.

Among the local dinosaur fossils, there is also a notable bias

toward preservation of distal limb and tail bones (plus hadrosaur teeth and at least one lower jaw bone). Insight into the cause of this phenomenon comes from pioneering taphonomic studies by Weigelt (1927, p. 82). Weigelt cited even earlier studies on large mammal carcasses subject to wave and river current action, which disarticulated as follows: "... individual vertebra became detached, those of the tail first, then the extremities and skull. Finally, under favorable conditions, the thorax is buried in the bank." The same text continues with observations that beached carcasses are typically destroyed by surf, and that lower jaws tend to fall off early in decomposition. By this model we may envision bloat-and-float dinosaur carcasses on the Late Cretaceous coastal seas, with limbs, tails, and heads dangling below the axis of the torso. Distal limb and tail bones, and occasionally jaws, dropped into bottom sediments to become the majority of fossils. It is assumed that proximal limb elements and skulls tended to remain with the trunks, which were blown or washed ashore and rarely preserved. Sharks undoubtedly assisted in dismemberment of dinosaur carcasses, and we have observed unusual abundances of teeth from *Squalicorax kaupi* (Agassiz) in the matrix enclosing CCK-87-20-1-9, suggesting that this was a major selachian scavenger.

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APPENDIX

A checklist of publications and other reports on Late Cretaceous dinosaur localities and collections from marine strata of the eastern United States, subsequent to Horner (1979).

- New Jersey: ?Potomac/?Raritan/or/?Magothy Formations (Baird, 1989).
 Marshalltown Formation (Grandstaff et al., 1987; Denton and Gallagher, 1989).
 Maryland: Severn Formation (Baird, 1986).
 North Carolina: Black Creek Formation (Baird and Horner, 1979).
 Georgia: Blufftown Formation (Schwimmer, 1981, 1986a; Schwimmer et al., 1988; Schwimmer and Best, 1989).
 Alabama: Demopolis Formation (King et al., 1988); Blufftown Formation (Schwimmer et al., 1988).
 Mississippi: ?Eutaw or ?McShan Formations and Selma Group (Carpenter, 1982).
 Missouri: unnamed Campanian paleokarst (Parris et al., 1988).
 Tennessee: undetermined Campanian stratum on Coon Creek (Bryan et al., 1989).