THE MOSASAUR

THE JOURNAL OF THE DELAWARE VALLEY PALEONTOLOGICAL SOCIETY

VOLUME VII

MAY 2004

First Record of a Velociraptorine Theropod (Tetanurae, Dromaeosauridae) from the Eastern Gulf Coastal United States

Caitlin R. Kiernan[1] and David R. Schwimmer[2]

[1] #304 Liberty House, 2301 1st Avenue North, Birmingham, Alabama 35203-4320, and
[2] Department of Chemistry and Geology, Columbus State University,
4225 University Avenue, Columbus, Georgia 31907-5465.

ABSTRACT - A single tooth recovered from the marine Mooreville Chalk Formation (Early Campanian) of western Alabama indicates the presence of dromaeosaurid theropods on the Appalachian subcontinent during the Late Cretaceous. The tooth compares closely with teeth referred to the small velociraptorine *Saurornitholestes.*

Introduction

Dromaeosaurid theropods were first described in the early 1920's (Matthew and Brown, 1922; Osborn, 1924) from fossil remains recovered in Canada and Asia, and are now known to be an important component of Late Cretaceous North American dinosaur assemblages from the western side of the Interior Seaway. Dromaeosaurids have figured prominently in the continuing and often-heated debate over the ancestry of birds, beginning with the works of J. H. Ostrom on the velociraptorine *Deinonychus antirrhopus* (Ostrom, 1969) and proceeding to the spectacular recent discoveries of feathered dromaeosaurids from a Lower Cretaceous (Early Barremian) konservat-Lagerstätte deposit in Liaoning, China (e.g. Xu et al. 2001; Norell et al., 2002). Many workers currently view dromaeosaurids as the closest sister-group to birds (see Padian and Chiappe, 1997). Indeed, so many synapomorphies (derived similarities) are shared by birds and dromaeosaurs, it has even been speculated that the latter represent an early lineage of secondarily-flightless, predatory ground birds (Paul, 1984, 2001), though this idea has not gained widespread support. Two subtaxa of the Dromaeosauridae are presently recognized: the Velociraptorinae (including *Velociraptor),* and the Dromaeosauridae (represented by *Dromaeosaurus,* and perhaps others, including *Utahraptor).*

The origins of the Dromaeosauridae probably extend back at least as far as the Late Jurassic (Currie, 1997), but the oldest fossils are in the Lower Cretaceous. Dromaeosaurids are known from several Early Cretaceous (Neocomian) faunas of western North America, including the giant *Utahraptor ostrommaysi* (Kirkland et. al., 1993) from the Cedar Mountain Formation (Barremian) of Utah, and *Deinonychus antirrhopus* (Ostrom, 1969) from the Cloverly Formation (Albian) of Montana and Wyoming. Toward the close of the Cretaceous in North America, three dromaeosaurid species, *Dromaeosaurus albertensis* (Matthew and Brown, 1922), *Saurornitholestes langstoni* (Sues, 1978), and *Bambiraptor feinbergi* (Burnham, et al. 2000), were present in Cordilleran faunas from Judithian to Lancian times.

However, until recently, there has been little evidence to support the presence of dromaeosaurids in the Late Cretaceous dinosaur faunas of eastern North America. Lipka (1998) reported a single tooth, possibly velociraptorine, from the Arundel Clay facies of the Potomac Formation (Early Cretaceous, Aptian) of Maryland. Subsequently, Lipka (personal commun., 2000) has recovered a number of additional teeth from the Arundel which may be referable to the Velociraptorinae. Teeth identified as dromaeosaurid have also been recovered from the Marshalltown Formation (Late Campanian) near Ellisdale, New Jersey (B. Grandstaff, personal commun., 2000). In this paper, we report the discovery of a single dromaeosaurid tooth from the Mooreville Chalk Formation (Selma Group; latest Santonian—Early Campanian) of western Alabama, which provides the first evidence for the presence of dromaeosaurids in southeastern North America during the Late Cretaceous.

Abbreviations and Institutions — AGr, Alabama, Greene County; RMM, Red Mountain Museum, Birmingham, Alabama; RTMP, Royal Tyrrell Museum of Palaeontology, Drumheller, Alberta; ALMNH, Alabama Museum of Natural History, Tuscaloosa.

Systematic Paleontology

THEROPODA Marsh 1881
TETANURAE Gauthier, 1986
COELUROSAURIA Huene, 1914
MANIRAPTORIFORMES Holtz, 1996
DROMAEOSAURIDAE Matthew and Brown, 1922
VELOCIRAPTORINAE Barsbold, 1983
cf. SAURORNITHOLESTES Sues, 1978

Material examined — ALMNH 2001.1 (Fig. 1.1-1.3), a single tooth. The specimen was collected by the senior author as surface float during the excavation of a carapace and plastron of a toxochelyid turtle (*Toxochelys moorevillensis*).

Locality and Horizon — ALMNH 2001.1 was collected from a large series of erosional gullies in northwestern Greene County, Alabama, near Old West Greene, Section 2, T. 22 N., R. 1 W., Red Mountain Museum locality AGr-11 (exact locality data is on file at the Alabama Museum of Natural History and available to qualified researchers). Locality AGr-11 has been collected by the senior author and others since at least 1980 (extensive work was carried out there by RMM in 1981). The locality is especially rich in microvertebrates, including subadult mosasaurs, odontornithian birds (*Ichthyornis*? sp.), and a diverse assemblage of elasmobranchs and teleosts. A number of vertebrate species otherwise rare throughout the Mooreville Chalk are fairly common here, including the sclerorhychid sawfish *Ischyrhiza mira* and the small anacoracid shark *Pseudocorax laevis*. An exquisitely-preserved and nearly-complete skeleton of the rare protostegid turtle *Calcarichelys gemma* (RMM 3164 and 3216) has also been recovered from the site (Hooks, 1998).

AGr-11 exposes several meters of the lower unnamed member of the Mooreville Chalk Formation, including (in ascending order): 1) a lower layer of shelly, slightly sandy, whitish, marly chalk containing numerous burrows, serpulimorph worm tubes (*Hamulus onyx, Hamulus squamosus, Serpulus* sp.), disarticulated echinoid spines and plates, bryozoans, the balanomorph barnacle *Acroscapellum* sp., and large numbers of bivalves (*Inoceramus* sp., *Agerostrea falcata, Ostrea* sp., etc.) in reef-like concentrations; 2) a thinner bed of dark gray marly chalk, largely devoid of bivalves (this bed may have originated under dysoxic conditions and contains many of the site's microvertebrates); and 3) an upper layer of light gray marly chalk, weathering to yellow.

ALMNH 2001.1 was recovered from the uppermost beds, just beneath the soil zone. The portion of the Mooreville Chalk exposed at AGr-11 lies within the *Exogyra ponderosa* biozone of Stephenson (1914) and was placed within the *Clidastes* Acme-zone by Kiernan (2002). A sediment sample from AGr-11 was analyzed at the Geological Survey of Alabama and revealed a particularly high concentration of calcareous nannoplankton (40-60 billion per cc). The sample is dominated by *Aspidolithus parcus parcus*, and lacks *Bukryaster hayi* and *Quadrum gartneri,* indicating a mid-Early Campanian age for the site (Nannofossil Zone 18a of Sissingh, 1977).

Description and Discussion

ALMNH 2001.1 is well-preserved, though some minor crushing is evident on the lingual surface. The tooth is strongly recurved distally and laterally compressed. Though the lingual surface is slightly flattened, the tooth is not D-shaped in basal cross-section. Mesial denticles are present (Figs. 1.1, 1.2) but minute, and the denticulate portion of the mesial carina extends less than halfway from the tip of the crown. In contrast, the entire preserved length of the distal carina is denticulate, and the denticles are large and elongate (Figs. 1.1, 1.3). Some of the denticles along the distal carina are hooked apically. Distally, there are 23 denticles (approximately 7 per mm), and 19 to 22 denticles (approximately 9 per mm) are on the mesial carina. The tip of ALMNH 2001.1 is missing, and the root is not preserved. The preserved portion of the tooth has a length of 3.6 mm mesio-distally, and a apical-basal height of 4.9 mm. Currie et al. (1990) discussed the difficulties encountered when measuring small theropod teeth and suggested adoption of the fore-aft basal length (FABL) as a standard, as it exhibits a relatively constant relationship to the total tooth length. ALMNH 2001.1 has a FABL of 2.8 mm. All measurements were made with digital calipers.

Ordinarily, isolated dinosaur teeth are of limited use in identifying dinosaurian taxa to the genus or species level. However, previous authors (Currie et. al. 1990; Fiorillo and Currie, 1994; Baszio, 1997) have established the enhanced taxonomic utility of some isolated theropod teeth. Currie (et. al., 1990, 1995) considered the significant disparity in size between mesial and distal denticles in the teeth of many dromaeosaurids to be diagnostic for the Velociraptorinae. In this respect, and in general, ALMNH 2001.1 compares favorably with RTMP 82.19.180, which has been referred to *Sauronitholestes langstoni* (Currie et. al. 1990: fig. 8.2 S). Although this genus is a common component of dinosaur assemblages from the Late Campanian and Maastrichtian of the western U.S. and Canada, prior to this study the oldest and easternmost report of possible *Saurornitholestes* remains was from the Late Campanian Aguja Formation of Brewster County, Texas (Rowe et. al., 1992). However, small theropod teeth from the Marshalltown Formation (Late Campanian) of New Jersey also compare favorably with *Saurornitholestes* (B. Grandstaff, personal commun., 2000).

ALMNH 2001.1 indicates that a small velociraptorine dromaeosaurid, possibly congeneric with *Saurornitholestes*, inhabited the Appalachian subcontinent during the Early Campanian. The possible occurrence of this genus on both sides of the Western Interior Seaway may provide evidence that western and eastern dinosaur faunas were not completely isolated during the Late Cretaceous. Alternatively, dromaeosaurid populations may have descended in parallel on either side of the Seaway from pre-Seaway (i.e. Middle Cretaceous) common ancestors. New studies and phylogenetic analyses (Carr et al., in press; Schwimmer and Kiernan, 2001) indicate that tyrannosauroid theropods of the eastern USA rep-

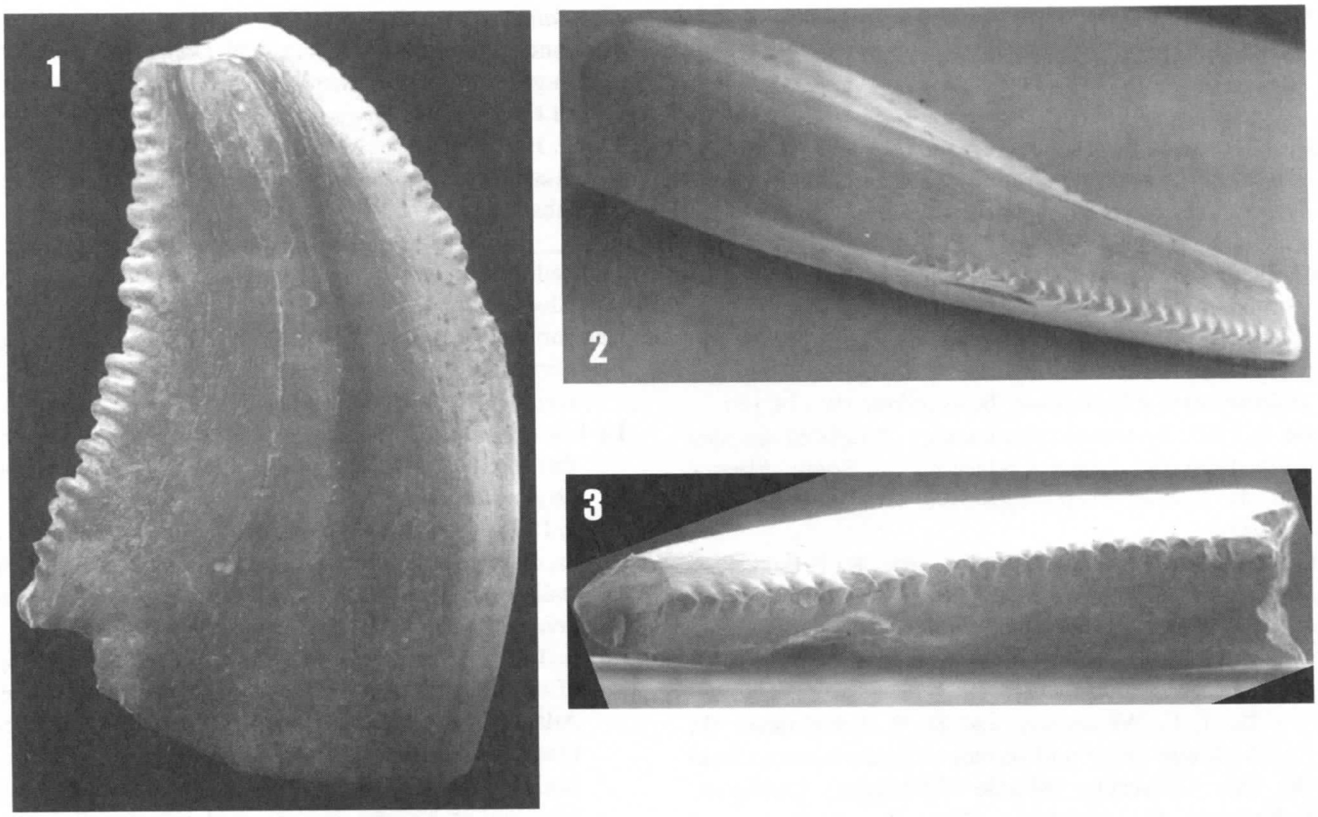

Figure 1. cf. *Saurornitholestes* sp., ALMNH 2001.1. 1, Labial view, X22; 2, mesial carina with denticles, X16; 3, distal carina with denticles, X27. Mooreville Chalk Formation, lower unnamed member, Early Campanian, RMM locality AGr-14, near Old West Greene, Alabama.

resent the latter situation (that of independent descent in place from basal common ancestors), rather than derivation from a western population. It is plausible that the dromaeosaurids of the eastern USA had a similar origin. In this latter case, their ancestry could have been either from Asia or Europe, where sparse remains of dromaeosaurs have been discovered (e.g. LeLeouff and Buffetaut, 1998; Allain and Taquet, 2000). Also, in this latter case, it is very unlikely that the Alabama velociraptorines would be congeneric with *Saurornitholestes.*

Remains of terrestrial animals are rare in the open marine facies of the Mooreville Chalk and, excluding volant (flying) birds and ornithocheirid pterosaurs, have previously been confined to fragmentary remains of crocodylians (*Deinosuchus rugosus, Leidyosuchus* sp. [Schwimmer, 2002]) and large to medium-sized saurischian and ornithischian dinosaurs (Ornithomimidae *insertae sedis* [Baird, 1986], the iguanodontian *Lophorhothon atopus* [Langston, 1960; Lamb, 1998] and nodosaurid ankylosaurs [Langston, 1960; Lamb, 1996]). Mooreville deposition occurred in deep water in an outer-shelf environment (Puckett, 1996) and the discovery of a small dromaeosaurid theropod tooth is unexpected. Schwimmer (1997) has most recently reviewed taphonomic and biogeographic models that may account for the distribution of dinosaur remains in the Atlantic and Gulf Coastal Plains. Dinosaurian remains in the Mooreville Chalk (as well of those of its eastern clastic equivalent, the Blufftown Formation) most likely result from the fluvial transport of "bloat-and-float" carcasses originating in adjacent deltaic, estuarine, and marine coastal environments. ALMNH 2001.1 preserves delicate features (mesial and distal denticles) and doesn't appear to have suffered wear in a high-energy surf zone setting. Therefore, it is likely that it dropped from a passing carcass (either a dromaeosaur itself, or the prey of a dromaeosaur), perhaps dislodged by scavenging sharks (Schwimmer et al. 1997), after reaching the sea by way of a river-mouth estuary.

Acknowledgements

The authors wish to thank Charles C. Smith, Geological Survey of Alabama, who examined the microflora of AGr-11; Barbara Grandstaff and Philip J. Currie, who examined ALMNH 2001.1 and shared information about unpublished New Jersey theropod teeth; Brian J. Witzke, who read an early draft of this manuscript and offered many helpful suggestions; Thomas R. Lipka, for sharing unpublished information on the Arundel Clay fauna of Maryland; Richard A. Kirk, who drafted the cover illustration; Christine Bean and the Fernbank Museum of Natural History, for facilitating SEM imaging; and two anonymous reviewers for their thorough analysis and helpful suggestions.

References

Allain, R. and P. Taquet. 2000. A new genus of Dromaeosauridae (Dinosauria, Theropoda) from the Upper Cretaceous of France. *Journal of Vertebrate Paleontology 20*(2): 404-407.

Baird, D. 1986. Upper Cretaceous reptiles from the Severn Formation of Maryland. *The Mosasaur 3*: 63-85.

Barsbold, R. 1983. Carnivorous dinosaurs from the Cretaceous of Mongolia. *Soviet Mongolian Paleontological Expedition, Transactions 19*: 118-120.

Baszio, S. 1997. Systematic paleontology of isolated dinosaur teeth from the Latest Cretaceous of South Alberta, Canada. Courier *Forschungsinstitut Senckenberg, Band* 196: 33-77.

Burnham, D. A., K. L. Derstler, P. J. Currie, R. T. Bakker, Z. Zhou, and J. Ostrom. 2000. Remarkable new birdlike dinosaur (Theropoda: Maniraptoria) from the Upper Cretaceous of Montana. *University of Kansas Paleontological Contributions 13*: 1-12.

Carr, T. D., T. E. Williamson, and D. R. Schwimmer. (In Press). A new genus and species of tyrannosauroid from the Late Cretaceous (Middle Campanian) Demopolis Formation of Alabama. *Journal of Vertebrate Paleontology*.

Currie, P. J. 1995. New information of the anatomy of relationships of *Dromaeosaurus albertensis* (Dinosauria; Theropoda). *Journal of Vertebrate Paleontology 15*: 576-591.

__________. 1997. Dromaeosauridae, p. 194-195. *In* P. J. Currie and K. Padian (eds.), *Encyclopedia of Dinosaurs*. Academic Press, San Diego.

__________. J. K. Rigby and R. E. Sloan. 1990. Theropod teeth from the Judith River Formation of southern Alberta, Canada, p. 107-125. *In* K. Carpenter and P.J. Currie (eds.), *Dinosaur Systematics: Approaches and Perspectives*. Cambridge University Press, Cambridge.

Fiorillo, A. R. and P. J. Currie. 1994. Theropod teeth from the Judith River Formation (Upper Cretaceous) of south-central Montana. *Journal of Vertebrate Paleontology* 14: 74-80.

Hooks, G. E. 1998. Systematic revision of the Protostegidae, with a redescription of *Calcarichelys gemma* Zangerl, 1953. *Journal of Vertebrate Paleontology 18*(1): 85-98.

Kauffman, E. G. and W. G. E. Caldwell. 1993. The Western Interior Seaway in Space and Time, in Caldwell, W. G. E. and Kauffman, E. G., (eds.), Evolution of the Western Interior Basin, pp. 1-30. *Geological Association of Canada, Special Paper 39.*

Kiernan, C. R. 2002. Stratigraphic distribution and habitat segregation of mosasaurs in the Upper Cretaceous of Western and Central Alabama, with an historical overview of mosasaur discoveries in Alabama. *Journal of Vertebrate Paleontology 22*(1): 91-103.

Kirkland, J. I., Robert Gaston, and Donald Burge. 1993. A large dromaeosaur (Theropoda) from the Lower Cretaceous of Eastern Utah. *Hunteria 2* (10): 1-16.

Lamb, J. L. 1996. Ankylosauria from the Upper Cretaceous of Alabama. *Journal of Vertebrate Paleontology* 16 (3, Abstracts): 47A.

__________. 1998. *Lophorhothon*, an iguanodontian, not a hadrosaur. *Journal of Vertebrate Paleontology* 18 (3, Abstracts): 59A.

Langston, W. 1960. The vertebrate fauna of the Selma Formation of Alabama, part VI: the dinosaurs. *Fieldiana: Geology Memoirs* 3(5): 315-359.

Le Loeuff, J. and E. Buffetaut. 1998. A new dromaeosaurid theropod from the Upper Cretaceous of southern France. *Oryctos* 1: 105-112.

Leidy, J. 1856. Notices of remains of extinct reptiles and fishes, discovered by Dr. F. V. Hayden in the Bad Lands of the Judith River, Nebraska Territory. *Academy of Natural Sciences of Philadelphia, Proceedings* 8: 72-73.

Lipka, T. R. 1998. The affinities of the enigmatic theropods of the Arundel Clay facies (Aptian), Potomac Formation, Atlantic Coastal Plain of Maryland, pp. 229-234. In S. G. Lucas, J. I. Kirkland, and J. W. Estep (eds.), Lower and Middle Cretaceous Terrestrial Ecosystems. *New Mexico Museum of Natural History and Science, Bulletin* 14. Albuquerque, New Mexico.

Matthew, W. D. and B. Brown. 1922. The family Deinodontidae, with notice of a new genus from the Cretaceous of Alberta. *Bulletin of the American Museum of Natural History* 46: 367-385.

Norrell, M., JI, Q., Gao, K., Yuan, C., Zhao, Y., and Wang, L. 2002. 'Modern' feathers on a non-avian dinosaur. *Nature* 416: 36-37.

Osborn, H. F. 1924. Three new Theropoda, *Protoceratops* Zone, central Mongolia. *American Museum of Natural History Novitates* 144:12.

Padian, K., and Chiappe, L. M. 1997. The early evolution of birds. *Biological Reviews of the Cambridge Philosophical Society* 73: 1-42.

Paul, G. S. 1984. The Archosaurs: phylogenetic study, pp. 175–180. *In* Reif, W.-E. & Westphal, F. (eds.),*Third Symposium on Mesozoic Terrestrial Ecosystems*, Tübingen 1984, Short Papers. Attempto Verlag, Tubingen.

__________. 2001. Increasing evidence for an arboreal origin of dinosaurian-avian flight, and for losses of flight in post-Ÿrvogel dinosaurs. *Journal of Vertebrate Paleontology* 21 (3, Abstracts): 88A.

Puckett, T. M. 1996. Ecologic atlas of Upper Cretaceous ostracodes of Alabama. *Geological Survey of Alabama, Monograph* 14, 176 pp.

Rowe, R., R. L. Cifelli, T. M. Lehman, and A. Weil. 1992. The Campanian Terlingua Local Fauna, with a summary of vertebrates from the Aguja Formation, Trans-Pecos Texas. *Journal of Vertebrate Paleontology 12*: 472-493.

Schwimmer, D. R. 1997. Late Cretaceous dinosaurs in eastern USA: a taphonomic and biogeographic model of occurrences, pp. 203-211. *In* D. L. Wolberg, E. Stump, and G. D. Rosenberg (eds.), *Dinofest International*. The Academy of Natural Sciences, Philadelphia.

__________. 2002. *King of the Crocodylians: The Paleobiology of Deinosuchus*. Indiana University Press, Bloomington, 221 pp.

__________ and C. R. KIERNAN. 2001. Eastern Late Cretaceous theropods in North America and the crossing of the Interior Seaway. *Journal of Vertebrate Paleontology* 21(3, Abstracts): 99A.

________, J. D. STEWART AND G. D. WILLIAMS. 1997. Scavenging by sharks of the genus *Squalicorax* in the Late Cretaceous of North America. *Palaios* 12(1): 71-83.

Sissingh, W. 1977. Biostratigraphy of Cretaceous nannoplankton of marine sediments. *Geologie en Mijnbouw* 56(1): 37-65.

Stephenson, L. W. 1914. Cretaceous deposits of the eastern Gulf region; and species of *Exogyra* from the eastern Gulf region and the Carolinas. *U.S. Geological Survey Professional Paper* 81: 1-77.

Sues, H. D. 1978. A new small theropod dinosaur from the Judith River Formation (Campanian) of Alberta, Canada. *Zoological Journal of the Linnaean Society* 62: 381-400.

XU, X., Z. Zhou, and R. O. Prum. 2001. Branched integumental structures in *Sinornithosaurus* and the origin of flight. *Nature* 410: 200-204.