Virginia Museum of
NATURAL HISTORY
PUBLICATIONS

JEFFERSONIANA

Contributions from the
Virginia Museum of Natural History

Number 29 4 March 2013

The first terrestrial mammal from the Late Miocene Eastover Formation of Virginia

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ISSN 1061-1878 (print)
ISSN 2163-8020 (online)

Virginia Museum of Natural History
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Printed in the United States of America
ISSN 1061-1878 (print)
ISSN 2163-8020 (online)

Jeffersoniana, Number 29 pp. 1–6
Virginia Museum of Natural History

The first terrestrial mammal from the Late Miocene Eastover Formation of Virginia

Brian Lee Beatty[1] and Alton C. Dooley, Jr.[2]

ABSTRACT

A partial deciduous premolar from a gomphothere is reported from the Late Miocene Eastover Formation in New Kent County, Virginia. This represents the first definitive occurrence of a terrestrial mammal from the Eastover Formation.

Gomphotheres are now known from nearly every marine formation from the Middle Miocene to the Early Pliocene along the middle Atlantic Coastal Plain. Gomphotheres are typically associated with more open habitats, but floral data suggests that the region transitioned from warmer, more forested conditions in the Middle Miocene to heterogeneous conditions in the Late Miocene. The persistence of gomphotheres throughout this interval suggests that substantial open habitats were present along the Coastal Plain from the Middle Miocene to at least the Early Pliocene.

INTRODUCTION

Tertiary terrestrial mammal faunas are extremely sparse in northeastern North America, with only a few key faunas available from the Miocene and Pliocene that can illuminate anything about the region's fauna and environment before and after the dramatic environmental changes associated with the development of the East Antarctic Ice Sheet in the Middle Miocene, between 18-6.5 Ma (Flower and Kennett 1994). This limitation restricts paleoecological studies that require large sample sizes to comparisons of Florida faunas to those of the Great Plains and western faunas (Beatty and Mihlbachler 2011), even though this makes it hard to isolate the effects of latitude from proximity to coastal influences on climate.

Fossil sites bearing terrestrial mammals along the Atlantic margin are particularly good for making marine and non-marine correlations when localities can be linked temporally by diatom, foraminifera, or mollusk-based dating schemes. Much has been done to establish such relationships for Early and Middle Miocene sediments of the Atlantic coast, particularly that of Virginia, Maryland, the Carolinas, and Florida (Tedford and Hunter 1984). Late Miocene and Pliocene faunas are similarly rare, but have had less benefit from well-established regional collecting like the predominantly Middle Miocene and Early Pliocene exposures found at the Calvert Cliffs or Lee Creek Mine. Terrestrial mammals mentioned by Geisler et al. (2012) as coming from the Late Miocene Eastover Formation from Gravatts Millpond in Virginia were in fact recovered from the upper part of the Middle Miocene Calvert Formation according to Whitmore (1984).

The Eastover Formation is an unconsolidated marine sand to clay located on the Middle Atlantic Coastal Plain. The unit has been identified at least as far north as the Virginia side of the Potomac River (Ward 2005) and perhaps into southern Maryland (Ward and Blackwelder 1980), and to the south along the Trent and Neuse Rivers in North Carolina (Ward 2008a; Ward and Blackwelder 1980). It is thin to the south, and in some areas is absent (for

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example, at Lee Creek Mine) (Ward 2008a). Two members have been identified in the Eastover, the older Claremont Manor Member and the overlying Cobham Bay Member (Ward and Blackwelder 1980).

Ward and Blackwelder (1980) reported the Eastover age as Late Miocene, based on a glauconite dates of 8.7±0.4 Ma and 6.46±0.15 Ma from the Cobham Bay Member, and a glauconite date of 12.0±0.5 Ma from the underlying St. Marys Formation. Ward (1992) placed the Cobham Bay Member in Molluscan Interval Zone M-7, and correlates this with Planktonic Foraminiferal Zone N17 (Blow 1969), which ranges from approximately 5.4-7.1 Ma (Berggren et al. 1985). The Claremont Manor Member is placed by Ward (1992) in Molluscan Interval Zone M-8, which he correlates with Planktonic Foraminiferal Zone N16 (Blow 1969), which ranges from approximately 7.1-10.2 Ma (Berggren et al. 1985).

The Late Miocene is a key period in the transition from the faunas associated with the warm climate of the early Neogene and the cooling environment of the Plio-Pleistocene. This is a time during which grasslands that originated earlier in the Miocene (Strömberg 2005) were spreading across North America and causing faunas of the Great Plains to shift from being dominated by browsers to grazers (Janis et al. 2004; Mihlbachler et al. 2011). Fossil-bearing Late Miocene strata in the Mid-Atlantic or Northeast of North America are rare, making any information available about terrestrial vertebrate faunas during this period precious. Here we report the first specimen of a terrestrial mammal from the Late Miocene of Virginia.

Abbreviations: FLMNH, Florida Museum of Natural History, Gainesville, Florida; VMNH, Virginia Museum of Natural History, Martinsville, Virginia.

SYSTEMATIC PALEONTOLOGY

Order PROBOSCIDEA Illiger 1811
Family GOMPHOTHERIIDAE Hay 1922
Genus INDETERMINATE

Referrred specimen: VMNH 120092, a partial lower deciduous premolar. Collected by Rose Schooff and Christie Aldridge-Nunn from the Schooff Property, New Kent County, Virginia.

Stratigraphic horizon and age: Eastover Formation, Cobham Bay Member. Late Miocene. The specimen was collected *in situ* in a shell bed that included the bivalve *Isognomen* sp., and immediately below a bed that included the bivalve *Chesapecten jeffersonius*. *Isognomen* sp. goes locally extinct at the top of the Eastover Formation, while *C. jeffersonius* is restricted to the Sunken Meadow Member of the Yorktown Formation (Ward 1992).

VMNH 120092 (Fig. 1) is a partial upper left deciduous premolar (most likely DP4) of a gomphothere. Gomphothere dentitions can be discerned from mammutids by having tetralophodont M3s (Lambert and Shoshani 1998). Unfortunately, this tooth is a partial upper premolar, and is diagnosed from mammutids primarily because it has trefoils present only on the pretrite half of cheek teeth (single trefoiling), unlike mammutids that have trefoils on both posttrite and pretrite halves of upper molars (Lambert and Shoshani 1998).

Gomphotheres have been known from the Plum Point Member of the Calvert Formation (14-16 Ma) for over a hundred years (Case 1904; Gazin and Collins 1950). The Cobham Bay Member of the Eastover Formation is a Late Miocene marine unit, approximately 6.5-9 million years old, and this new specimen comes from New Kent County, Virginia, from the top of the unit, making it the youngest occurrence of gomphotheres on the east coast north of the Carolinas. Occurrences of gomphotheres that are as young or younger are rare in the southeastern United States, including the Late Miocene to Early Pliocene (4.5-7 Ma) occurrence at the Gray Fossil Site in Tennessee (Wallace and Wang 2004;

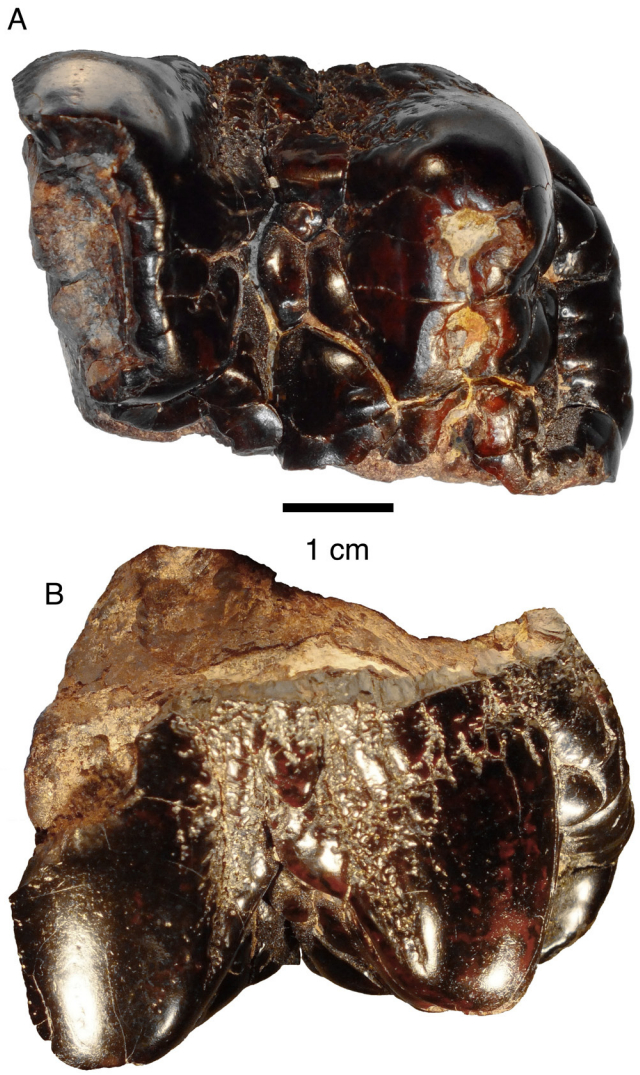

Figure 1. VMNH 120092, gomphothere upper left deciduous premolar 4. A, occlusal view. B, lingual view.

DeSantis and Wallace 2008), and the Lee Creek Mine (4.9 to 5.4 Ma, Late Hemphillian, Early Pliocene) (Eshelman and Whitmore 2008).

Gomphotheres from Lee Creek Mine were diagnosed basically by size and undefined comparison to other specimens of *Rhynchotherium*, *Serridentinus*, and *Gomphotherium* from the FLMNH (Eshelman and Whitmore 2008). Though all of these specimens appear to be gomphotheres because of the trefoils on the pretrite regions of their molars, these genera are best diagnosed by differences in their tusks, which are not preserved for most specimens identified from Lee Creek, and not for the isolated tooth described here. At best, tusked specimens may be identified to genus and isolated molars to family, leaving us still with the conundrum of how to deal with gomphotheres in North America.

DISCUSSION

Given that gomphotheres are known from both the Middle Miocene Calvert Formation in Virginia, and the Pliocene Yorktown Formation in North Carolina, it is perhaps not surprising that they were also present in Virginia in the Late Miocene. Nevertheless, the presence of this specimen directly confirms the presence of gomphotheres on or near the Atlantic coast in the Late Miocene.

The earliest records of *Gomphotherium* indicate that it entered North America from Asia in the Barstovian (Middle Miocene), and quickly spread and became abundant in Late Barstovian and Early Hemphillian (Late Miocene) (Lambert 1996; Lambert and Shoshani 1998), particularly in the Great Plains and western North America. This is the time when grasslands were spreading in these areas (Janis et al. 2004), and perhaps the record of gomphotheres in these regions reflects this. By the Late Hemphillian, *Gomphotherium* is scarce, presumably because of climate change and associated ecological changes that forced faunal changes across the Western Hemisphere at this time (Webb 1983), with the exception of some Blancan representatives in Florida (Lambert and Shoshani 1998). It is interesting to note that dental morphology has suggested that *Gomphotherium* is restricted to grazing habitats (Lambert and Shoshani 1998), and even occurrences of gomphoteriids in the forested environment of the Miocene of Tennessee (Wallace and Wang 2004) have isotopic data indicating that its presence there was migratory or temporary in some way, as it was clearly a grazer when its teeth were developing (DeSantis and Wallace 2008).

Miocene floral assemblages from the region are uncommon, though information from the lower Miocene portions of the Calvert Formation indicate that early in the Miocene the region was dominated by cypress estuary swamps (Berry 1909; Berry

1937). The late Miocene was a time of cooling after the Mid-Miocene Climatic Optimum (Zachos et al. 2001), and one might expect that the region would be transitioning to more open habitats, which would be consistent with the presence of gomphotheres in the Late Miocene to Early Pliocene. Floral records from late Miocene deposits in the region provide inconsistent data on Coastal Plain habitats and temperatures. The Brandywine Flora in Maryland represents an equivalent deposit to the Late Miocene St. Marys and Eastover Formations, and was dominated by a warm temperate forest (McCartan et al. 1990). Palynology from nearby Late Miocene sites in Delaware and Maryland, however, have gymnosperms that are more indicative of a cooler environment (Owens and Denny 1979). This conflicting floral data suggests that, like today, Coastal Plain environments were not homogenous and may have still been transitioning from a warm wet environment into a drier, more temperate region. Even so, the continuous presence of gomphotheres from the Middle Miocene to the Early Pliocene suggests the presence of substantial open habitat throughout this period.

ACKNOWLEDGEMENTS

Thanks to Rose Schooff and Christie Aldridge-Nunn for donating VMNH 120092 to the Virginia Museum of Natural History. We would also like to thank Stephen Godfrey and an anonymous reviewer for comments that greatly improved this manuscript.

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