PTEROSAUR TRACKS FROM THE LOWER CRETACEOUS PATUXENT FORMATION OF VIRGINIA

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ABSTRACT – Blocks of Patuxent Sandstone, used as cornerstones in Gunston Hall in Fairfax County, Virginia, contain occasional footprints of Lower Cretaceous vertebrate animals. Among these are footprints of a large pterosaur, which is the first reported occurrence of this group of animals in the Lower Cretaceous footprint record of Virginia. A well-preserved wing-finger print and a pes print are recognizable. Both pertain to a pterosaur that had a wingspan of about 25 feet (7.9 m).

INTRODUCTION AND GEOLOGIC SETTING

A number of kinds of vertebrates and vertebrate footprints have been reported from the Lower Cretaceous Patuxent Formation of Virginia including a fish, a frog, a turtle, and ten kinds of dinosaurs (Weems and Bachman, 1997, 2015; Weems, 2021). Recently, footprints of another kind of vertebrate have been discovered at Gunston Hall (Figure 1), which was the home of the Revolutionary War figure George Mason. The main body of this building, built between the years 1754 and 1759, was largely constructed with bricks made at this locality, but its cornerstones were made from blocks of “Aquia freestone” which were derived from the Lower Cretaceous Patuxent Formation (Broadwater, 2020). This formation was quarried in those days from a locality called “Government Island,” near where Aquia Creek flows into the Potomac River (Figure 2). Material from this locality began to be quarried for building stone around 1694, and the site was actively excavated for dimension stones until the time of the American Civil War (Wikipedia, 2021). At Gunston Hall, a number of footprints are present on the sandstone surfaces of some of these blocks, two of which can be identified as having been made by large pterosaurs (Figure 3).

Pterosaur footprints have been reported from a number of Jurassic and Cretaceous localities around the world, and a considerable number of ichnotaxa have been described from them. A fairly recent summary of the taxonomy of these prints (Lockley et al., 2008) discusses the problems inherent with trying to distinguish these various pterosaur tracks in a systematic taxonomic manner. These authors concluded that four pterosaur ichnogenera can be recognized worldwide, and most of the described species can be included in the ichnogenus *Pteraichnus*. The rear footprint of the pterosaur described here, with a shortened digit I, is readily comparable only to the pes prints of *Pteraichnus*. Therefore, these tracks are ascribed to that ichnogenus. The specific identity of these tracks, however, is not certain and the correlation of the wing and rear foot tracks with each other is indefinite, even though very probable. Therefore, no effort is made here to try to assign these tracks to an ichnospecies. The pterosaur tracks described here are considerably larger than manus tracks that have been previously measured from the Lower Cretaceous of Maryland (Lockley et al., 2008).

Figure 1 -- Picture of the north side of Gunston Hall, showing the location of the cornerstone sandstone blocks that contain a pterosaur wing impression (1) and foot impression (2). Image adapted from "Gunston Hall" by Stephen Brooke Studios (ca. 2012).

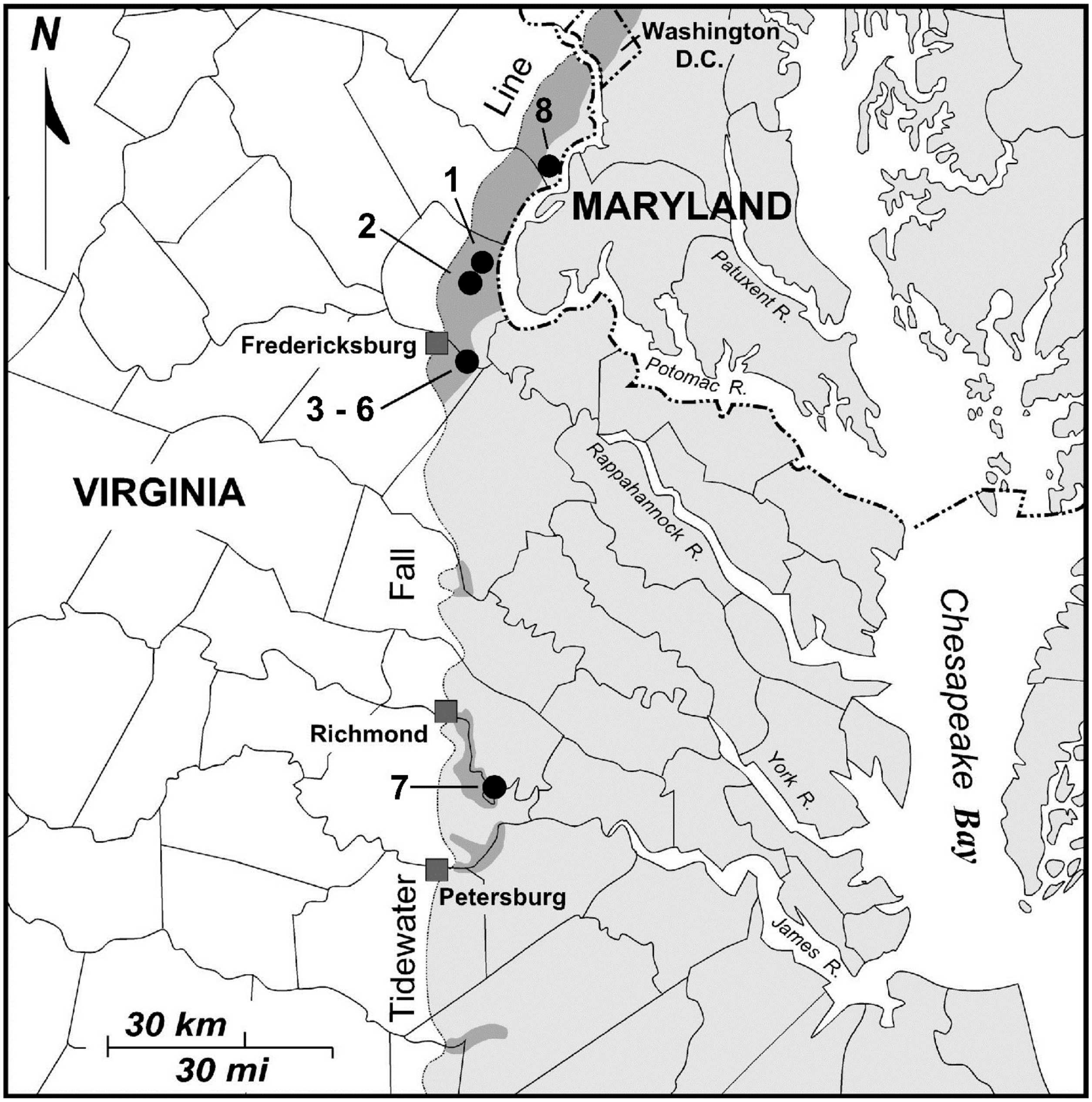

Figure 2 -- Location of Gunston Hall (8) in northern Virginia. The source of the Cretaceous rocks in the walls of Gunston Hall was to the south at Government Island (1). Other numbers refer to other localities in Virginia that have produced Lower Cretaceous vertebrate fossils from the Patuxent Formation (see Weems, 2021 for specific localities). Light gray shaded area represents the Coastal Plain region of Virginia and Maryland, while the dark gray shaded areas represent the outcrop regions of the Lower Cretaceous Patuxent Formation along the western border of the Coastal Plain region.

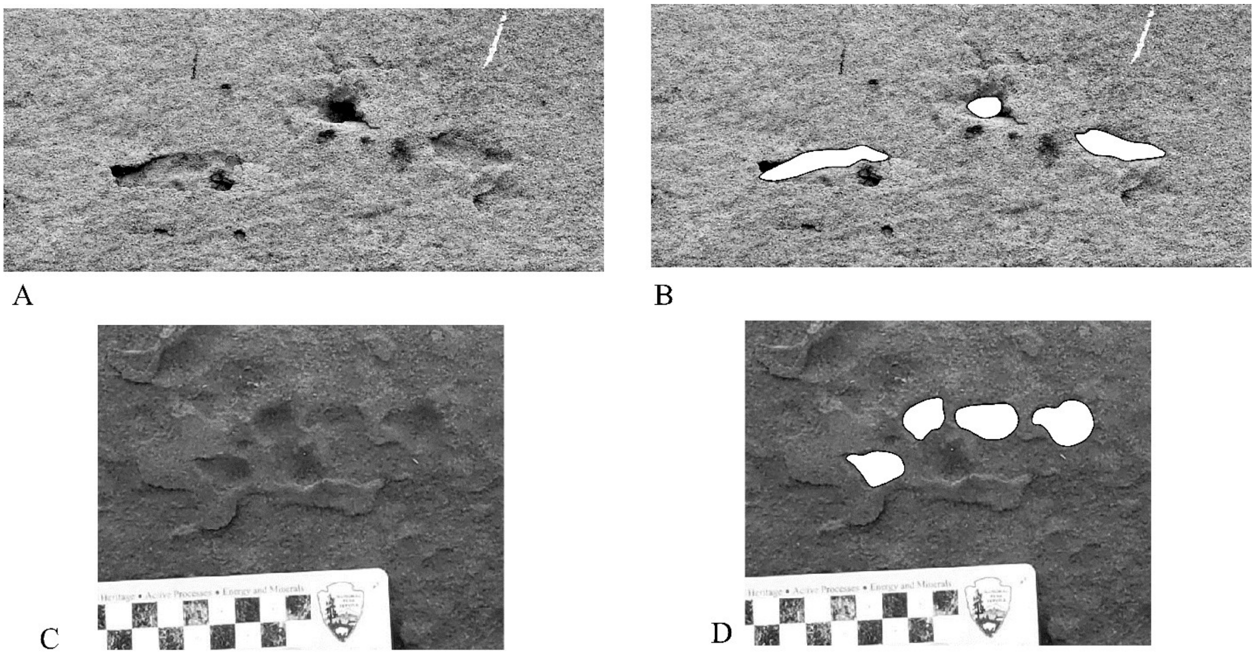

Figure 3 – Images of a left pterosaur manus impression (A, B) and a right pes impression (C, D) at Gunston Hall, Virginia. B and D show the locations and outlines of the track marks shown unshaded in A and C. Scale is shown in C and D and is marked in centimeters.

SYSTEMATIC DESCRIPTION

Order Pterosauria Kaup, 1834

Suborder Pterodactyloidea Plieninger, 1901

Ichnofamily Pteraichnidae Lockley et al., 2000

Ichnogenus *Pteraichnus* Stokes, 1957

Pteraichnus sp.

Figured Specimens —Manus impression (Figures 3A, B) and pes impression (Figures 3C, D).

Locality – There are two well preserved pterosaur tracks that can be seen on two of the Patuxent Formation sandstone blocks that line the outer borders of Gunston Hall (Figure 1). Because these tracks are on separate blocks of sandstone, they cannot be certainly assigned to the same trackmaker even though both tracks are quite large and do seem to represent tracks of animals of very nearly the same size. Given their likely origin from the same sandstone quarry, they are here considered to be at least tracks made by the same kind of pterosaur and quite possibly tracks of the same pterosaur.

Stratigraphic Unit and Age – These tracks came from the "Aquia Freestone" quarry south of the present location of Gunston Hall (Figure 2). Their stratigraphic unit of origin is the Early Cretaceous Patuxent Formation of Virginia.

DISCUSSION

The two tracks documented here are the first pterosaur tracks to be recognized from the Lower Cretaceous of Virginia. Lockley et al. (2008) noted that the footprints left by pterosaurs are very variable and not readily attributable to any specific ichnospecies, so the specimens described here for now are simply assigned to *Pteraichnus* without any species level of designation being attempted. Stanford (2013) expressed the opinion that at least three basic footprint shapes are present among Maryland's Patuxent pterosaur tracks, but he offered no description of the differences among these track types so there is no way to compare the specimens described here to the likely ichnospecies that Stanford mentioned. Lockley et al. (2008) documented five pterosaur wing imprints from the Patuxent Formation of Maryland that ranged in width from 5 to 10 cm. None of those tracks were nearly as large as the wing impression shown here (16 cm), though an unmeasured wing track mentioned by Stanford (2013) potentially could be of comparable size.

The width of the imprint of the wing toes region (Figure 3A, B) can be estimated to be 16 cm, based on comparison of the size of this imprint to the size of the sandstone block in which it is impressed. The width of the imprint of the four toes of the rear foot is 10 cm (Figure 3C, D). Based on the estimated relative sizes of the rear feet vs. the wingspan of the Late Cretaceous pterosaur *Pteranodon* (Figure 4), the wingspan of the Early Cretaceous pterosaur that made the rear footprint at Gunston Hall can be estimated to be about 79 times the width of the rear foot or about 7.9 meters (25 feet). This is about the same size as the largest pterosaur so far known from Early Cretaceous skeletal material, which is *Tropeognathus* from the Albian Stage of South America.

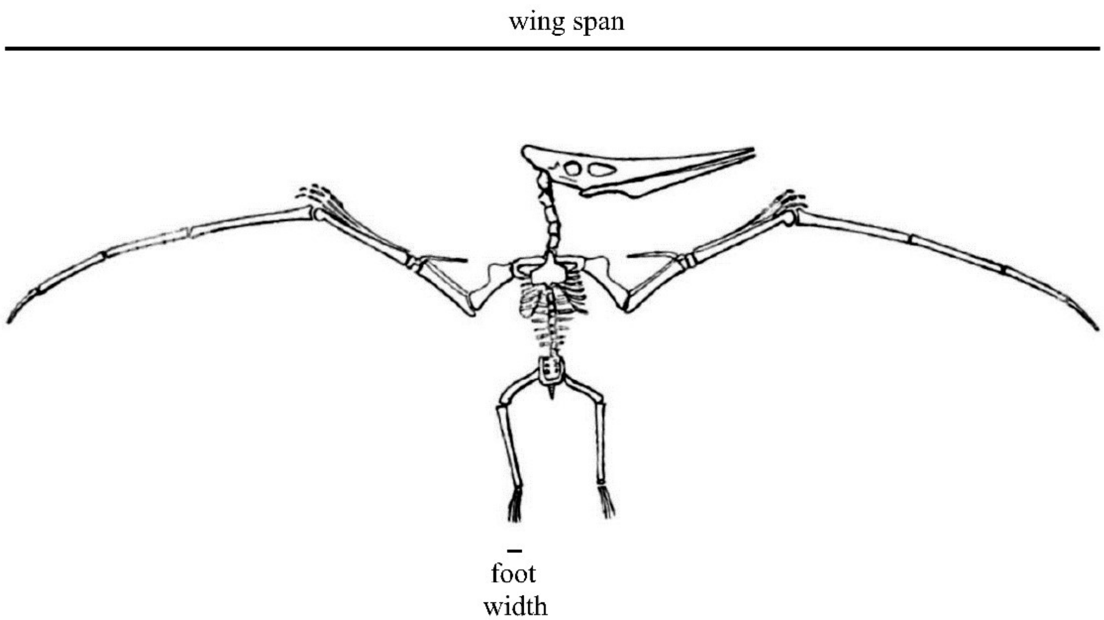

Figure 4 – *Pteranodon* skeleton showing the relative difference in proportions between the width of the rear foot and the total wingspan. Image is adapted from Wikimedia Commons (2017).

The nature of anterior pterosaurian tracks has been very controversial over the years, but it is now fairly well established that pterosaur anterior manus tracks represent digits I-III of the anterior limbs (Unwin, 1996). Digit IV, which supported the wing, generally was held above the level of the associated track. Digit V was lost during the early evolution of the pterosaurian lineage and therefore was not part of the anterior limb structure in these animals. The location of the manus digit prints can be strikingly variable, with the impression of the first digit sometimes facing outward at right angles to the rest of digit III and, at other times, lying essentially parallel to the position of the rest of digit III (Li et al., 2015). For this reason, variations in the track orientation of digit I tend to indicate differences in the walking or landing behavior of these animals and not differences in their taxonomy. During landing and takeoff, the manus digits might have been held in a forward position to allow the wings to spread, but while these animals were walking their wings were held close to the body so that the wing-toe imprints pointed out laterally at right angles to the rear footprints and to the body. Because the wing-toe print found at this site is preserved in an isolated position with no associated rear foot impression being present, it is impossible to say for certain if this print resulted from behavior associated with landing, walking, or take-off. However, it is here assumed that the widely outward spread position of digit I most likely indicates that it was made during landing or take-off, when the maintenance of lateral balance was especially important.

Most of the pterosaur tracks known from the Late Jurassic and Cretaceous of North America are associated with mudflats that formed near to the sea that then occupied the central region of North America (Lockley et al., 2008). The large tracks reported here from Virginia at first glance seem very large for animals whose remains were seemingly found in a continental setting, but regional studies show that during the mid-Early Cretaceous the proto-Atlantic Ocean had progressed inland to a point about mid-way across the Virginia Coastal Plain (Reinhardt et al., 1980). Therefore, at the time when the tracks described here were being formed, the edge of the Early Cretaceous Atlantic seaway was probably only about sixty-five kilometers (forty miles) to the southeast of where these tracks were made. Given the large size and wide wingspan of the pterosaurs that likely made these tracks, this distance is not very far inland from where these trackmakers probably hunted food. At the same time, this locality was probably somewhat protected from any major storms that might have spread inland from the coastal region of Virginia during Early Cretaceous time.

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