Faunal Analysis of a Fossil Microsite from the Late Cretaceous Hell Creek Formation, North Dakota

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Introduction

The fauna of the Hell Creek Formation may be the world's best-sampled Cretaceous vertebrate assemblage, but studies typically focus on mammalian or dinosaurian material – a fraction of the fossils found there. Fossil microsites were first studied in the mid-1960s, and interest in them grew throughout the 1970s with studies concentrating on the evolutionary history of Cretaceous mammals from North America (Sankey, 2008). More recently, microsites have been acknowledged for their usefulness in taphonomic studies, recording assemblages at specific stratigraphic intervals, reconstructing paleoecology and paleoenvironments, and analyzing trends in abundance, especially within the context of an extinction.

This project aimed to document a vertebrae microfossil accumulation in the Hell Creek Formation near Marmarth, North Dakota, to gain a better understanding of the local fauna and paleoenvironment, provide context to nearby dinosaur excavations, and build a collection for use in future microsite research.

Microsite Description and Collection

During July of 2016, a fossil microsite was discovered by surface prospecting along the side of a butte near a dinosaur fossil excavation (Figure 1). The site is about 30 m long and roughly 3 m at its widest.

The site is made up of light-brown to light-grey mudstones containing some silt and little sand. The mudstone exhibits classic popcorn weathering, a surface texture resulting from clays that swell and resemble popped popcorn. Casts of plants and small coal pieces are common.

The site was divided into five roughly equal sections to make collecting easier and more organized. It was searched by closely examining the ground surface and collecting all fossil material found (Figure 2). The site was sampled again in July of 2017 and 2018; repeated site sampling can aid in giving a better representation of the original diversity and abundance at a stratigraphic interval (Pearson, et al., 2002). Two bulk sediment samples with a volume of approximately five gallons each were collected from the main fossiliferous areas of the microsite in 2016. These were processed by separating fossil material by hand from the sediment.

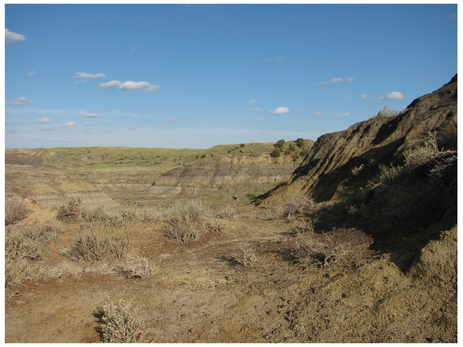

Figure 1. Two views of the fossil microsite near Marmarth, North Dakota.

Identified Taxa and Abundance

Over three seasons, 480 skeletal fragments were collected at the site (Figure 3). Fossils were sorted and identified to the most specific taxonomic level possible. In addition to unidentifiable dinosaur bone fragments, the site produced fossils of turtles, champsosaurids, crocodilians, fish, rays, dromaeosaurids, mammals, and mollusks (Figure 4). Individual fossils of each identified taxon were tallied to determine the relative abundance of different taxa at the site (Figure 5).

The mix of terrestrial and aquatic fauna at the site is not surprising, considering the Hell Creek Formation represents a low-lying coastal plain environment during the retreat of the Western Interior Seaway during the Late Cretaceous (Johnson, 2002).

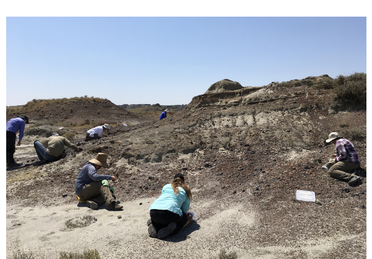

Figure 2. Typical collecting at a fossil microsite.

Figure 3. Some unsorted, unidentified bone fragments from the site.

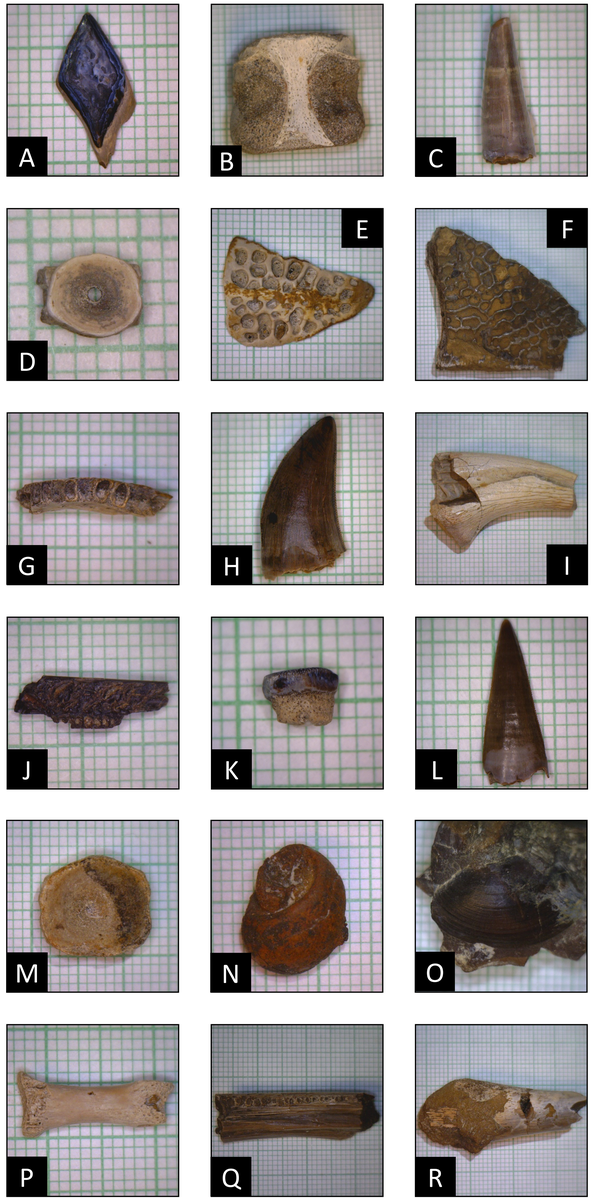

Figure 4. Representative fossils from the Marmarth, North Dakota microsite: A, Lepisosteidae (gar fish) scale; B, *Champsosaurus* sp. vertebra; C, Crocodilian tooth; D, Amiidae (bowfin fish) vertebrae; E, Crocodilian dermal bone; F, Trionychidae (turtle) carapace fragment; G, Amiidae (bowfin fish) partial dentary; H, Dromaeosaurid tooth crown; I, Theropod claw; J, Amiidae (bowfin fish) partial dentary; K, *Myledaphus bipartitus* (ray) tooth; L, Fish tooth; M, Amiidae (bowfin fish) vertebrae; N, Gastropod; O, Bivalve; P, Mammalia, possible femur or tibia; Q, Amiidae (bowfin fish) partial dentary; R, *Champsosaurus* sp. fibula. 1mm scale.

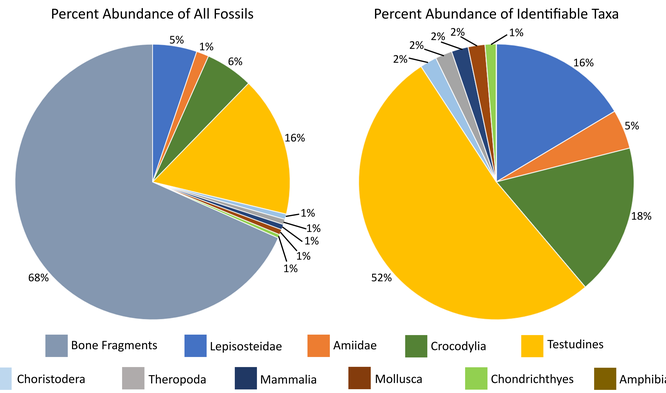

Figure 5. Percent abundance of all fossils at the microsite (left) and percent abundance of identifiable taxa (right). The majority of fossil fragments found at the microsite were larger pieces of bone that could not be identified due to their weathered condition. The major identifiable taxa were separately tallied and summed to determine their relative abundance.

Fossil Microsite Biases

Microsites often provide large sample sizes and diverse taxa, but various biases must be considered when attempting analysis or interpretation of microsites:

- Taphonomic biases cause considerable variation in the preservation and the condition of fossils. Nearly all fossil specimens found at the site were fragmentary, and this led to difficultly in making species-level identifications and determining the abundance of taxa. Many fossils displayed some degree of abrasion, which also leads to difficulty when identifying species (Moran, 2011).
- Preservation potential is another important bias that affects apparent species diversity. The number of bones for a given taxon, and therefore the number of preservable elements, can vary greatly. For example, taxa with numerous scales (like fish) have the potential to preserve many more skeletal elements per individual than those without scales, and taxa with higher tooth replacement rates will produce more potentially preservable elements (Wilson, 2008). Considering each element as representing a single individual can lead to a wildly inaccurate accounting of abundance.
- Smaller and more fragile fossils can be more easily destroyed at any point in time during preservation or during excavation, causing a size bias (Sankey, 2008). Small fossils may also be more affected by weathering and abrasion. This can cause fossils to lose identifiable features, break up, or be destroyed. Larger bones that are typically more resilient and not as easily weathered or abraded are often found more readily and identified more easily.
- Sedimentary processes may favor certain fragments over others. Size, shape, and density of bone varies between different taxa, and are all important factors that influence which fragments are preserved in a certain location (Wilson, 2008). For example, smaller and less dense fragments may be entrained in a flow more easily and transported to a specific locality, affecting the fossil abundance at that location.

Analyzing relative abundance and diversity can be very useful when investigating relationships between modern fauna and their environments. But due to the various biases affecting fossils, care must be taken not to draw unwarranted conclusions. Relative abundance and diversity data presented here is used only to infer probable paleoenvironmental conditions and is not meant to reflect the complete fauna or offer proof of certain environmental conditions.

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