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Case study

Mandibular osteopathy in a Hagerman horse, *Equus simplicidens* (Equidae, Mammalia), from Hagerman Fossil Beds National Monument (Idaho, USA)

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ABSTRACT

Multimodality imaging, including computed tomography (CT) and digital radiography, was utilized to examine a fossilized hemimandible of a probable female Hagerman horse (*Equus simplicidens*) with a large, ventrally located, osseous deformation. Utilizing comparative pathology to the modern day horse, it was determined that the most likely etiology of the pathologic bony swelling along the ventral hemimandible was abnormal tooth development that led to chronic osteomyelitis and subsequent osseous proliferation, sclerosis and deformation.

1. Introduction

Approximately 3.5 million years ago, during the Pliocene epoch, the earliest known representative of the genus *Equus* roamed the plains of North America and Mexico. This horse, *Equus simplicidens* (also known as the Hagerman Horse), is the earliest species of *Equus* (Gidley, 1930). The Hagerman horse evolved into a diversity of species in North America, some of which later dispersed into the Old World by about 2.5 million years ago. They became extinct in North America approximately 10,000 years ago, along with many other members of the ice age megafauna such as camels, mammoths, mastodons and sloths as well as large predators including sabertooth cats, short-faced bears and the North American lion (McDonald, 2002).

The common name, Hagerman Horse, comes from the large deposit of fossilized remains of the species recovered by the Smithsonian from a quarry near Hagerman, Idaho, USA in the early 20th century (Gidley, 1930; Gazin, 1935, 1936). This has resulted in a remarkable collection of fossils representing one of the single largest samples of an extinct species of horse (McFadden, 1994). It has allowed for an unprecedented opportunity for documentation of the population. The wide variation in ages for both genders of the animals found here has led to various hypotheses as to the cause of death of a large herd of more than 200 animals. Early interpretations are that they were killed during a flash flood (McDonald, 1996). Subsequent research suggests that the die-off was the result of a major drought (McDonald, 1998).

Although originally described as a distinct taxa, *Plesippus shoshonensis,* by Gidley (1930), morphologically the Hagerman horse shares many characteristics with modern day horses, donkeys and zebras. It has often been closely compared to the extant Grevy's zebra (*Equus grevyi*) in Africa and placed in the same subgenus, *Dolichohippus*, (Skinner, 1972). However, more recently, Forsten and Eisenmann (1995) disagreed with utilizing Gidley's genus as a subgenus of *Equus,* instead referring the Hagerman Horse to *E.* (*Plesippus*) *simplicidens*, recognizing some of the primitive features of the species.

Though very little is known about the diseases in this prehistoric species, it can be assumed that these equids would have suffered from similar morbidities as the modern day horse. To the best of the authors' knowledge this is the first case report of a pathologic change associated with the fossilized remains of a Hagerman horse.

2. Materials and methods

A disarticulated, fossilized, pathologic left hemimandible of *E. simplicidens* (USNM 13848) with the second premolar to the third molar, and all of the right and left incisors, was collected by the Smithsonian in 1934 at the Hagerman Horse Quarry, section 16, T7S, R13E, Hagerman Quadrangle, Twin Falls County,

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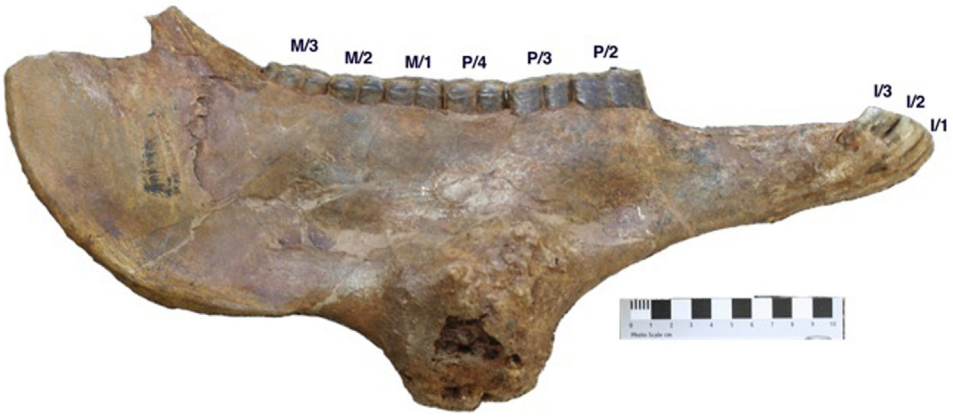

Fig. 1. Left hemimandible from Hagerman horse, *E. simplicidens*, (USNM 13848) with the expansile osseous lesion along the ventral aspect.

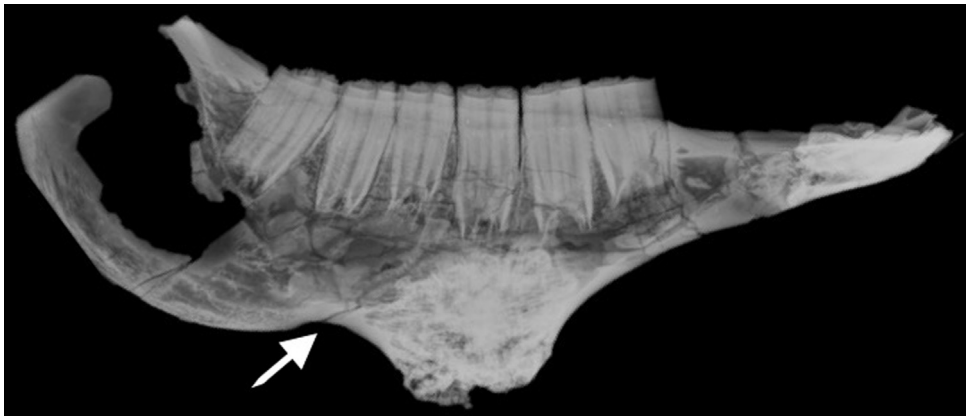

Fig. 2. Lateral radiograph of left hemimandible from Hagerman horse *E. simplicidens* (USNM 13848) with a ventrally placed expansile, osseous mass of the mandibular body. Fractures are visualized as multiple irregular, lucent lines (example indicated by arrow).

Idaho, and curated at in the Department of Paleobiology, United States National Museum of Natural History. The hemimandible was originally found with an associated skull that exhibited no grossly pathologic changes and is estimated to be 3.0–3.2 MA in age (McDonald et al., 1996). The Hagerman Horse Quarry is now part of Hagerman Fossil Beds National Monument established November 18, 1998. The lack of weathering of the bones collected from this location indicates that the bodies were not exposed to the elements for a prolonged period and likely were buried within a year after death. Few skeletons are found articulated and most specimens are often recovered as isolated bones or smaller articulated subunits of the skeleton, indicating a sufficient interval of time between death and burial to permit decay and disarticulation of the carcasses; however, there has not been any significant loss of small bones from the assemblage as carpals, tarsals, sesamoids and even terminal caudal vertebrae have been recovered. To date 148 mandibles of *E. simplicidens* are known to have been recovered from the site (McDonald, 1996). Within this sample the left hemimandible (USNM 13848) is the only specimen with a grossly visible pathologic change. (Fig. 1).

Lateral and ventral–dorsal radiographs of the complete left hemimandible, mandibular symphysis and incisors of the provided partial right hemimandible were obtained using digital radiographic technique with a Seimens Multix Fusion digital radiography machine. A computed tomographic (CT) examination was performed using the Philips Gemini TF Big Bore 16-slice scanner. A non-contrast volumetric (helical) dataset was obtained through the hemimandible. Images were reconstructed at 1.0 mm and 2.0 mm contiguous intervals with a 512 matrix, using the detail and smooth algorithms respectively. Images were evaluated by a specialty-trained veterinary radiologist, veterinary dentist, and veterinary pathologist.

3. Results

The hemimandible was most probably from a mature adult female based on the lack of canine teeth (Windley et al., 2009b) and moderate wear.

Aging of horses based upon dental morphology is a well-established science in veterinary medicine and assumptions have been made that the Hagerman's horse would follow a similar timeline for tooth eruption, deciduous tooth exfoliation and apical root closure as modern day horses. It is known that in the modern day horse the mandibular premolars erupt roughly between 3 and 4.5 years of age with root closure taking an additional 1–2 years. Based upon comparisons to the known ages of the zebra and horse, the Hagerman horse in this case report is estimated to have died at approximately 5–6 years of age (Windley et al., 2009a).

The fossilized bone was stained brown on the exterior, likely from the tannins in the water and mud the bone was preserved in. The coronoid process of the vertical ramus was missing due to fracture and was not available for imaging. A radiodense material, plaster of Paris, had been used to reassemble the osseous fragments. Grossly, the plaster of Paris was stained a similar brown color as the remainder of bone. Along the ventral aspect of the mandible, adjacent to the roots of the premolars, there was a large, irregularly