Preliminary Report:
Analysis of the Horse Skeleton Recovered from Jamestown Island, Virginia

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Introduction

In June of 2013, archaeologists with the Jamestown Rediscovery Archaeological Project came upon an articulated equine skeleton in an east-west ditch. Based on artifacts found near and underneath the interred equine, the equine burial post-dates 1760 (Dan Gamble, personal communication). The analysis of this equine provided a unique opportunity to study horses in eighteenth-century Virginia from a zooarchaeological standpoint, as horse remains are relatively rare in the archaeological record and are often limited to isolated teeth and foot elements. Zooarchaeological analysis was able to identify the species, sex, age, stature, and general health of the Jamestown equine as well as to illuminate information on the life history of the individual.

The Articulated Equine Skeleton

The articulated equine skeleton recovered at Jamestown in 2013 was in fairly good condition (Figure 1) given its somewhat shallow burial. The skeleton contained no evidence of perimortem trauma. Post-mortem trauma, however, was evident in numerous areas of the skeleton. Plow scars were present on a number of elements and some elements were sheared off, as by the blade of a plow or by a shovel during excavation. The action of plows also likely removed and crushed the entire right femur and lower left front leg. Additionally, the right side of the calvarium had collapsed. Figures 2 through 4 indicate which portions of the skeleton were available for study in the laboratory of the Colonial Williamsburg Foundation. Analysis of the equine skeleton was conducted in the CWF faunal laboratory by Jenna Carlson in the spring of

2014. Because of the extremely fragmentary nature of the ribs, they were not thoroughly examined.

Figure 1. The articulated equine recovered from Jamestown Island. (Photo by S. Atkins, 2013)

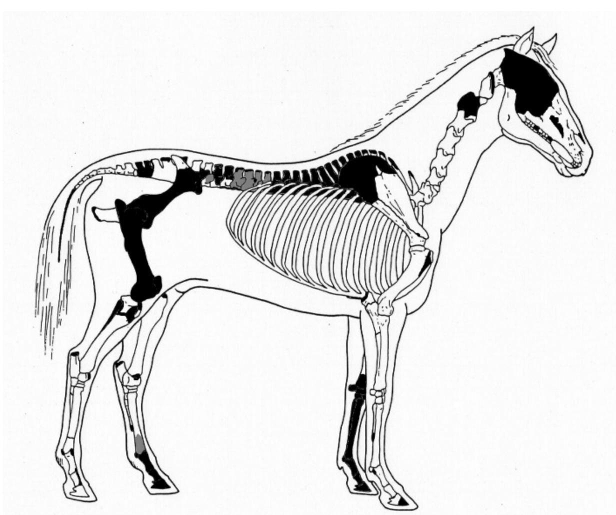

Figure 2. The right half of the Jamestown horse. Black indicates missing portions. Grey indicates where elements were only partially preserved.

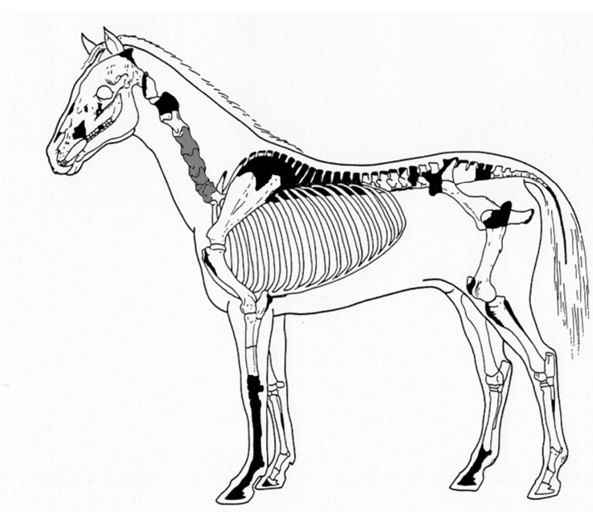

Figure 3. The left half of the Jamestown horse. Black indicates missing portions. Grey indicates where elements were only partially preserved.

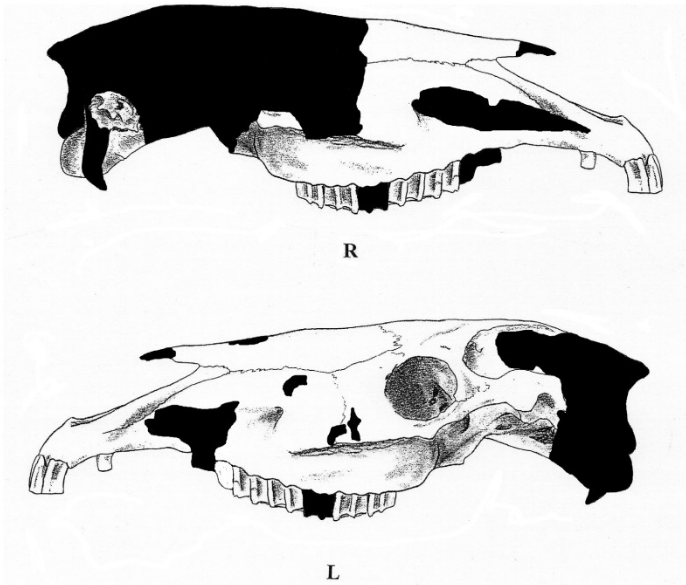

Figure 4. The right and left profiles of the skull of the Jamestown horse. Black areas indicate where areas were missing or otherwise unavailable for analysis.

Species Identification

The skeletal morphology clearly indicated that the individual was an equine. As the equine was deposited in the last half of the eighteenth century, there was a possibility that these skeletal remains could be those of a horse (*Equus caballus*), a donkey (*Equus asinus*), or a mule (*Equus asinus* x *Equus caballus*). However, the history of equines in North America and the skeletal morphology of the Jamestown equine indicated that the individual was, indeed, a horse (*Equus caballus*).

Although horses (Equidae) evolved in North America, they went extinct in the New World eight to ten thousand years ago and did not return until 1493 when Christopher Columbus brought Spanish horses to the West Indies on his second voyage to North America (Edwards1987:23; Howard 1965:8, 18). Donkeys and mules are even more recent introductions onto the North American landscape. Sixteenth-century Spanish colonizers brought donkeys and mules to South America (DeFrance 2010), but it was not until 1785 that donkeys made landfall in the newly formed United States of America and one year later that mules began dotting the landscape of the former British colonies. Mules, crossings between a mare and a jack ass, had been around for millennia and proven their worth as valuable work animals (Bartosiewicz and Gyonyossy 2006:290). George Washington wished to bring this hardy and hard-working animal to the agricultural fields of the newly-formed country. In 1784, Washington began investigating the purchase of a jack from Spain. Although the exportation of jacks from Spain was illegal at the time, King Charles III made an exception since Washington was interested in breeding with the jacks to produce working mules. King Charles III gifted two Spanish jacks to Washington in 1785, but only one survived the voyage. "Royal Gift," so named in honor of the Spanish king's generosity, arrived at Mount Vernon on December 5, 1785 and shortly thereafter began his lucrative career as a stud. In 1786, the Marquis de Lafayette gifted Washington another jack, "Knight of Malta," to aid in his mule-breeding and promoting enterprise, an enterprise which ultimately earned Washington the title of "Father of the American Mule" (Burnham 2002:103; Fusonie and Fusonie 1998:33-35).

The late-eighteenth-century introduction of the donkey and the mule into American agriculture coupled with the late-eighteenth-century introduction of a fully mature equine into the archaeological record at Jamestown suggests that the Jamestown equine is in fact a horse as opposed to a donkey or a mule. Osteological evidence further supports this conclusion. Different species of equine can be identified on the basis of dental morphology, anatomical differences in the cranial and postcranial skeleton, and skeletal proportions (Baxter 1998; Eisenmann 1986). Because isolated teeth and partial tooth rows are some of the most frequently recovered equine remains, zooarchaeologists have developed methods for distinguishing between horses and asses using the upper premolars and upper molars (Baxter 1998). However, the occlusal surfaces of the Jamestown horse's cheekteeth were largely obscured and were extremely worn, limiting the usefulness of Baxter's (1998) methodology (Figure 5).

Figure 5. The mandible remained articulated with the skull. This stabilized the fragile elements, but did obscure the occlusal surfaces of the majority of the teeth.

Fortunately, the skeleton of the Jamestown horse was intact enough to allow for the use of its non-dental anatomy in reinforcing the species identification. The cranium and mandible of the ass are proportionately different than those of the horse. Asses have muzzles which are enlarged in the middle, whereas horses have narrower muzzles (Baxter 1998:11). Osteometrically, this can be seen in comparing the greatest breadth of the snout with the least breadth in the region of the diastema, or the space between the canine teeth and the premolars (Figure 6) (Von den Driesch 2004:20-22, Measurement 45 and Measurement 47). In horses, the breadth of the snout is larger than the breadth of the diastema (Eisenmann 1986:73). This was the case in the Jamestown horse, where the snout was 64.70 mm across and the diastema was 56.70 mm across. Furthermore, the Jamestown horse was not identified as an ass because its mandible did not have an exceptionally high vertical ramus relative to the length of the horizontal ramus (Baxter 1998:11). The distal ulna of the Jamestown horse also did not extend to the distal radius, another asinine skeletal trait (Baxter 1998:13).

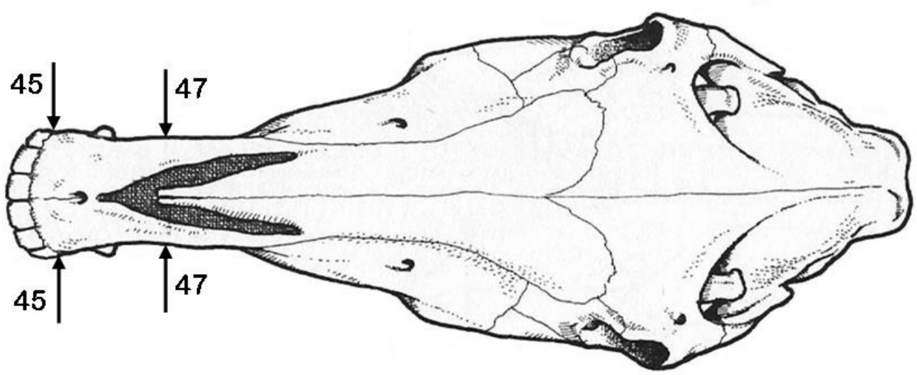

Figure 6. The greatest breadth of the snout (Measurement 45) compared with the least breadth in the region of the diastema (Measurement 47). (Adapted from Von den Driesch 2004:21-22)

Because mules are crosses between horses and asses, they share anatomical traits characteristic of both parent species. As such, distinguishing between the skeletal remains of horses and horse-ass hybrids can be challenging. The dam of horse-donkey crosses has the strongest influence on the size and shape of the offspring, while the sire influences certain qualitative traits like head shape, ear size, and hoof size (Bartosiewicz and Gyongyossy 2006:291). Thus, a mule would be horse-sized, but have a muzzle which is enlarged in the middle (Baxter 1998:11; Eisenmann 1986:73-74) and relatively narrow hooves (Baxter 1998:13). As stated earlier, measurements of the skull of the Jamestown horse indicate that it has a caballine rather than asinine muzzle shape. As for the shape of the hooves, only the right front third phalanx and the right rear third phalanx were discovered. The rear third phalanx was very eroded and recovered in three separate pieces. The front third phalanx was relatively broad and horse-like. The identification of the Jamestown horse as a horse as opposed to a mule, however, rests much more heavily on the skull proportions outlined above, as postcrania are rarely used to distinguish between horses and mules (Baxter 1998:13).

There was a very slim change that the Jamestown horse may have been a hinny, the cross between a stallion and a jennet (female donkey). Hinnies are similarly proportioned to horses but are donkey-sized (Baxter 1998:13). Hinnies never attained the popularity of mules because they are not as large as mules and are not as well-suited as working animals. This lack of popularity of hinnies in the eighteenth century (as well as today) coupled with the size of the Jamestown horse, which will be discussed below, precluded the Jamestown horse from being a hinny.

Age and Sex of the Individual

Once the Jamestown equine had been conclusively identified as a horse (*Equus caballus*), the remains could then be reliably assessed for indicators of the age and sex of the individual. It was determined that the Jamestown horse was a fully mature male, likely older than 20 years of age at the time of death. Aging of the horse remains was accomplished through tooth eruption and wear sequences and epiphyseal fusion. All of the permanent teeth of the Jamestown horse had erupted and were heavily worn, indicating an advanced age at the time of death (Evans 2000:33; Levine 1982:229). Additionally, both the left and the right upper first molars were absent, and wear on the lower left first molar suggests that the upper left first molar was lost pre-mortem. The first molar erupts between 7 and 14 months of age and is the first permanent tooth to erupt (Silver 1970:291, Table C). As such, it is also the first permanent tooth to be lost due to old age. The skull of the Jamestown horse shows no indication of the teeth being forcibly extracted from the maxillae and no indication of pathology leading to the loss of the teeth, so the teeth were likely lost due to old age. After about 14 to 16 years of age, tooth wear becomes progressively irregular and age estimation becomes more imprecise (Levine 1982:227). Yet, Galvayne's groove has been used by equestrians as a standard aging technique in elderly horses. Galvayne's groove appears as a longitudinal depression at the gum line on the surface of the upper corner incisor at 9 to 10 years of age. At 20, the groove extends the full length of the tooth. At 25 years, the groove is absent from the upper half of the tooth (Evans 2000:37-38). Using this logic, the Jamestown horse was just over 20 years of age, as Galvayne's groove had just begun disappearing from the upper portion of the lateral incisor (Figure 7). However, Axe (1905, in Levine 1982:229) proved Galvayne's groove to be an imprecise indicator of equine age.

To counter some of the limitations of aging mature horses, Marsha A. Levine (1982) developed a system for estimating the age of horses based on the crown height of cheekteeth. None of the cheekteeth of the Jamestown horse were extracted from their alveoli to measure the crown height. However, enough of the maxilla around the left upper fourth premolar of the

Jamestown horse had eroded to allow for the crown height to be measured to a height of 16.58 mm. Levine's (1982) method for determining age based on crown height is only to be used on teeth of approximately the same size as the New Forest pony teeth used in her study. The mesio-distal diameter of the left upper fourth premolar of the Jamestown horse was within 1 standard deviation of the mean mesio-distal diameter of the New Forest pony upper fourth premolars (Levine 1982:232, Table 1). Therefore, we can assume that the left upper fourth premolar of the Jamestown horse is the same size as the New Forest pony teeth and obtain an age of 20+ for the Jamestown horse (Levine 1982:249, App. IIIa).

Similar to tooth eruption and wear, epiphyseal fusion is most useful for aging relatively young horses. All of the postcranial bones of horses typically fuse by five years of age (Silver 1970:285-286, Table A). All of the bones of the Jamestown horse were fully fused including the centrum epiphyses of the vertebrae, which are typically the last postcranial bones to fuse. The sutures of the facial bones were also fused on the left half of the cranium (the right half of the cranium was crushed). Silver (1970:289, Table B) notes that these bones fuse "in old age." The parietal bones are some of the best cranial bones for assessing age in older horses, but, unfortunately, these bones did not survive intact enough to be assessed for fusion.

The pelvis of the horse can be used to distinguish between the remains of mares (female horses), stallions (intact male horses), and even geldings (castrated male horses) (Pamela J. Cross, personal communication; Sisson and Grossman 1953:111-112). Unfortunately, a large portion of the right half of the pelvis had been sheared off and the pubic symphysis did not survive. Despite these limitations, the pelvis does suggest that the individual is a male due to the relatively contracted shape of the greater sciatic notch. The presence of four fully developed canine teeth (Figure 7) supports the identification of this horse as a male. Canine teeth erupt at four to five years of age in both stallions and geldings but are only present in 20-25% of all mares (Evans 2000:33). If canine teeth are present in mares, they tend to be smaller than and not as well-developed as those seen in male horses. From the presence of canine teeth alone and the shape of the pelvic outlet, though, one cannot determine if the Jamestown horse was a stallion or a gelding.

Figure 7. The red arrow points to "Galvayne's groove" on the right upper third incisor of the Jamestown horse. Notice also the well-developed canine teeth, suggesting that the Jamestown horse is a male.

Size of the Individual

Measurements of the long bones were used to estimate the Jamestown horse's height at the withers (shoulders). Measurements were taken using Von den Driesch's (2004) methodology. These measurements were then inputted into Vitt's (1952:172-173) methodology for estimating the withers height. From this, the Jamestown horse can be said to be "Taller than Average" (Table 1), standing approximately 14.1 to 15 hands (144 to 152cm) at the withers. Cross (2011:193) writes that lighter horses measuring around 13 to 15 hands at the withers weigh approximately 300 to 500 kg. As the skeletal remains of the Jamestown horse were relatively gracile, it can be assumed that it weighed approximately 400 to 500 kg while alive.

Although both humeri resulted in a size category of "Average" and a number of the size category classifications were based off of estimates of greatest lengths, the appointment of a "Taller than Average" size for the Jamestown horse is justified. Six of the eight measurements resulted in a "Taller than Average" size, including all three of the actual greatest length measurements. Additionally, Vitt (1952:172-173) writes that the radius and tibia are the best isolated elements for height determination because the lengths of the upper and lower leg elements tend to show the most variation. The right radius of the Jamestown horse was one of the three complete elements which resulted in a size of 144 to 152 cm at the withers.

Table 1. Calculation of Withers Height of the Jamestown Horse

Element	Side	Length (mm)*	Corresponding Height at Withers (cm)	Size Category
Humerus	L	[295.0]	136-144	Average
Humerus	R	[295.5]	136-144	Average
Radius	R	356.5	144-152	Taller than Average
Metacarpal III	R	239.47	144-152	Taller than Average
Tibia	L	[377.0]	144-152	Taller than Average
Tibia	R	[379.0]	144-152	Taller than Average
Metatarsal III	L	276.58	144-152	Taller than Average
Metatarsal III	R	[284.78]	144-152	Taller than Average

* Values listed in brackets are estimates of the greatest length of the element because of breakage or degradation of the articular surfaces.

Pathologies

It appears that the Jamestown horse was in good health at the time of the death, or at least did not suffer from any chronic ailments which would leave obvious manifestations on the skeleton. In fact, given its advanced age, the skeleton of the Jamestown horse presented surprisingly minor skeletal pathologies.

The most severe pathologies of the Jamestown horse were observed in the teeth. As stated above, both upper first molars were lost pre-mortem. Additionally, both lower second premolars exhibited extreme wear in the form of beveling, resulting in dentine exposure on the mesial (anterior) surface of the teeth as well as the occlusal (chewing) surface (Figure 8).

The postcranial skeleton of the Jamestown horse exhibited minor remodeling of some joints and some rugosity at muscle attachment sites. Exostoses, or new bone formation, were present on the right rear second phalanx, the right metacarpal, and the right radius. Lipping—the extension of the articular surface—was observed on the cervical, thoracic, and lumbar vertebrae, the right calcaneus, both metatarsals, and the proximal end of the left radius. The most severe joint remodeling occurred in the lumbar vertebrae, as the fifth and sixth lumbar vertebrae had fused (Figure 9). The articular processes on the dorsal surface were completely fused together as were the transverse processes. When viewing the ventral side of the lumbar vertebrae, it appears that the vertebral bodies were nearly completely fused. Additionally, the left side transverse processes of the sixth lumbar vertebra had fused to the adjacent portion of the sacrum. Because of the fragile nature of the vertebrae, not all of the sediment was removed from the surface of the bone during conservation, thus obscuring some of the joint surfaces and making it difficult to determine exactly where the fusions of vertebral bodies had occurred. Rugose muscle attachment sites were present on both scapulae, the right humerus, the plantar surfaces of the bones of the right rear limb, the plantar surface of the left tibia, and the left ischiatic crest. Also, the exterior surface of the left ischium was noticeably porous and inflamed (Figure 10).

Figure 8. Close-up of the right lower second premolar, showing the beveling and dentine exposure on the mesial surface.

Figure 9. Ventral view of the fifth and sixth lumbar vertebrae (L5 and L6, respectively) and the sacrum, showing the locations of fusion in the joints.

Figure 10. The left ischium, showing porosity on the ischiatic spine.

Fleshing out the Jamestown Horse

Through analyses of the skeletal remains of different animals, including horses, zooarchaeologists can develop "osteobiographies," or life histories of the animals they study. Details such as the age, sex, size, and general health of the individuals under study come together with archaeological and historical data to paint a picture of the individuals' lives. While this osteobiography of the Jamestown horse is far from definitive, it does offer some insights into the life and times of an elderly male horse on Jamestown Island in the late-eighteenth century.

The beveling observed on the lower second premolars of the Jamestown horse likely resulted from the use of a metal bit (Anthony and Brown 1989; Olsen 2006:94). Bit wear, as defined by Brown and Anthony (1998:331) is "the damage that occurs on the occlusal (chewing) surfaces of the second premolar teeth…when a horse chews the bit." This damage can be caused by both bar bits and jointed bits, as they can both be gripped in the second premolar teeth (Brown and Anthony 1998:333). Some beveling of the lower second premolars is caused by normal occlusion with the upper second premolars. Brown and Anthony (1998) state that bevels (the height difference between the occlusal surface on the mesial edge and the top of the second and third lingual cusps of the tooth) of less than 3 mm are associated with normal tooth wear, whereas those greater than 3 mm are associated with bit wear. The bevel of the Jamestown horse's left lower second premolar was approximately 7 mm, suggesting that it was caused by a bit. However, both Levine (1999:33) and Bendrey (2007) warn that this form of beveling could still be caused by tooth wear between abnormally occluding upper and lower second premolars. Unfortunately, the Jamestown horse's right upper second premolar is completely absent and its left upper second premolar is broken, leaving only the posterior cusp. Without the anterior cusps of the upper premolars, it is difficult to say if abnormal occlusion contributed to the bevel.

The large amount of exposed dentine on the mesial (anterior) surface of the right lower second premolar (Figure 8), however, does point to the use of a bit during the Jamestown horse's lifetime. Bendrey (2007) suggests that bit wear is best observed as exposed cementum and dentine on the mesial (anterior) surface of the lower second premolars, as opposed to the presence of a beveled occlusal surface. Bendrey (2007) also suggests that damage to the diastema is evidence of the use of a bit, as is the location in the horse's mouth where the bit usually rests. While the Jamestown horse's diastemata showed no kind of damage or remodeling, the extreme beveling and especially the mesial dentine exposure can be taken as convincing proof that the Jamestown horse was regularly bitted.

Bit wear alone cannot be used to determine if the Jamestown horse was used more for riding or for traction, as both activities regularly used bits in the Anglo-American tradition (Bendrey 2007:1049; Brownrigg 2006:170). By pairing bit wear analyses with analyses of other skeletal manifestations, though, one can better assess whether a horse was used more for riding or more for traction. For example, Janeczek et al.'s (2010) investigation of a Roman Period horse in southwestern Slovakia showed that the horse exhibited bit wear, pathological changes to the ventral ridge of the mandible, and proliferative changes to the last thoracic and many of the lumbar vertebrae. Janeczek et al. (2010:332) interpret this horse as a riding horse as opposed to a driving horse.

Riding and traction put different strains on a horse's body than do more natural activities. Furthermore, there are differences between those stresses associated with riding and those associated with traction. These stresses can manifest themselves in the bones of a horse if that individual was used primarily for one activity or the other (Levine et al. 2005:95; Rooney 1997:444). Shoulder and hip injuries are characteristic of traction, whereas injuries to the caudal thoracic and lumbar vertebrae are more associated with riding (Levine et al. 2000; Olsen 2006). Traction is also more likely to lead to increased rugosity of muscle attachment sites than is riding (Olsen 2006:94). Like bit wear, though, pathologies of the lower legs can be associated with either traction or riding, as they are likely the result of working on hard ground, such as roadways (Levine et al. 2000: 125).

Distinguishing between horses used for riding and those used for traction can have social implications. Kawami (2006:333) writes that riding presents an "active image" in contrast to the relatively static or passive image of a passenger in a cart or chariot. In the case of the Jamestown horse, however, it is not clear whether the horse was used primarily for traction or for riding. Rather, it appears that the Jamestown horse may have been a multipurpose animal, performing a bit of each task, but never worked extremely hard. The fusion of the fifth and sixth lumbar vertebrae in the Jamestown horse may be associated with its use as a riding animal as fusion in the lumbar vertebrae is often associated with riding (Bartosiewicz and Bartosiewicz 2002). On the other hand, the rugose muscle attachment sites, especially those on the hind limbs, suggest that the Jamestown horse was used as a traction animal. As these muscle attachment sites were not exceedingly well-developed, it would seem that if the Jamestown horse was used as a traction animal, it was used as a carriage horse rather than a plow horse.

Although injuries to the shoulder and hip joints are associated with traction (Levine et al. 2000), the porosity observed on the exterior of the left acetabulum and ischiatic spine of the Jamestown horse is not an injury to the joint itself. Rather, this pathology is likely osteoperiostitis brought about by a non-specific infection. Unlike osteomyelitis (where the disease begins in the marrow cavity), osteoperiostitis causes inflammation of the bone when the disease starts in the periosteum (Baker and Brothwell 1980:63). Osteoperiostitis can develop as a result of recumbency in modern animals, particularly in sows. Essentially, the osteoperiostitis develops after bed sores form over pressure points and become infected, eventually spreading to the periosteum surrounding the bone. In sows, this is seen in the scapulae, radii, ulnae, and tibiae (Baker and Brothwell 1980:75). The osteoperiostitis seen in the left innominate of the Jamestown horse does not fit this pattern. Additionally, recumbency in horses would not likely result in osteoperiostitis because recumbent horses usually succumb to pneumonia before any sort of recumbency-related infections could manifest themselves skeletally (Baker and Brothwell 1980:75). Rather, the osteoperiostis in the Jamestown horse may be related to its use as a carriage horse. Ill-fitting tack can result in sores which may become infected and ultimately lead to osteoperiostitis (eg., Janeczek et al. 2010:332). The loin strap of horse harnesses from the eighteenth century and today (Figure 11) typically falls slightly in front of the hip joint. However, if the harness did not fit properly, the loin strap could lie over the area of the hip joint and, if the harness was too tight, create a sore which could eventually lead to the infection of the underlying bone. If the loin straps were too tight on the Jamestown horse, one would expect sores to develop on each hip. However, given the fragmentary nature of the right innominate and both femurs, it is impossible to determine if this was the case.

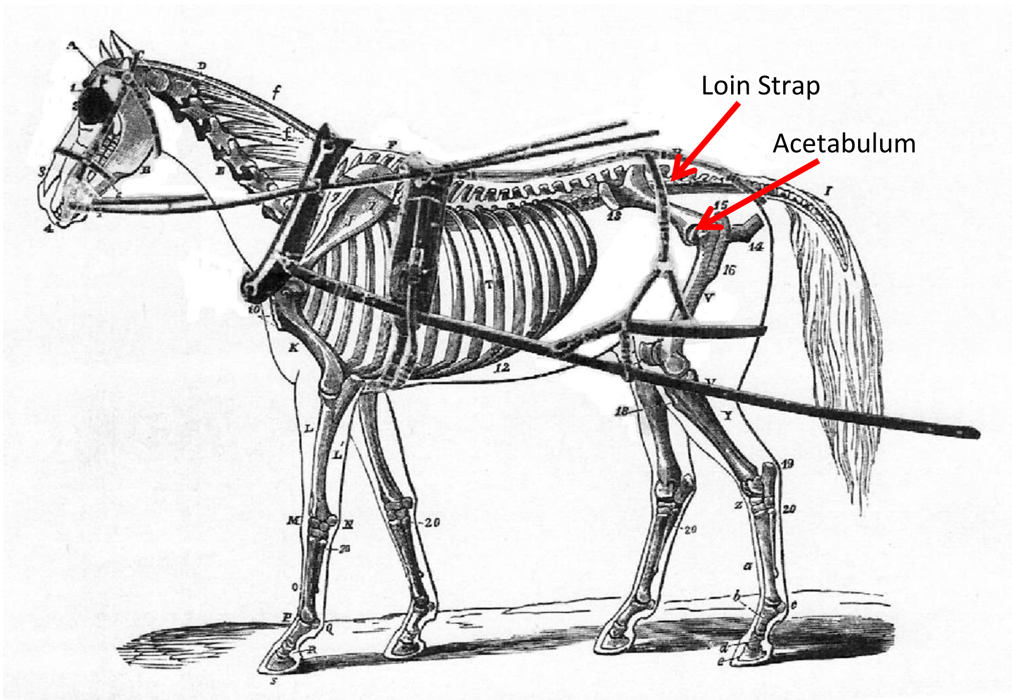

Figure 11. Skeleton of the horse with a basic harness, showing the proximity of the loin strap to the acetabulum.

Conclusions

The late-eighteenth-century horse recovered from Jamestown Island presents an interesting case study in the human-horse relationship. This elderly male horse was likely used as a transportation animal rather than as a plow animal. The fusion of lumbar vertebrae suggests that the horse was a riding animal while increased rugosity of muscle attachment sites and a non-specific infection of the hip suggest that the horse was used as a cart horse. Whether ridden or driven, the Jamestown horse did not exhibit pathologies suggestive of extremely hard labor and there was no evidence of perimortem trauma. Rather, it appears that the Jamestown horse was used for light labor and died of natural causes associated with old age before being placed in a ditch and buried. Additional research into this ditch and its proximity to the seventeenth-century church at Jamestown may reveal even more information on the symbolic relationships between eighteenth-century Virginians and their equines.

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