AN X-RAY ANALYSIS OF DOG MANDIBLES FROM THE BLACK EARTH SITE

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In the study of skeletal remains from archaeological sites, x-ray analysis can provide additional insights into scientific observations made with only the naked eye. X-rays, which are absorbed by the bone to create a picture image, reveal the size, shape, and position of internal structures. To expand our knowledge of domestic dog (Canis familiaris) populations that lived thousands of years ago alongside their human companions at the Black Earth site in southern Illinois, we performed an x-ray analysis of dog mandibles (lower jaws) to learn more about the overall health of these ancient canines. This study, combined with other lines of evidence, gives us a better understanding of the dynamic relationships that existed between the human occupants of this ancient settlement and their four-legged companions.

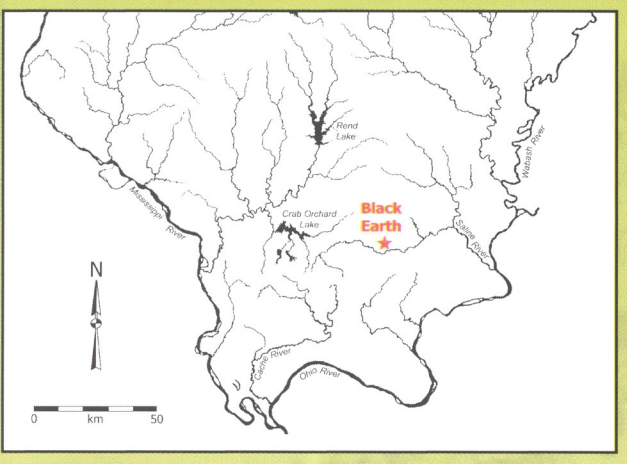


Figure 1: Location of the Black Earth Site in Southern Illinois. Courtesy of the authors.

DOG BURIALS AT BLACK EARTH

The Black Earth site, one of three large Native American villages in the Carrier Mills Archaeological District, is located along the Saline River in Saline County, Illinois (Figure 1). The settlement was intensely excavated by the Center for Archaeological Investigations at Southern Illinois University Carbondale from 1978-1979, when the skeletal remains of five intentionally buried dogs were recovered. Two additional dog burials, partially to nearly complete skeletons, were identified during an undergraduate research project conducted by Rosemary Bolin and Heather Lapham in 2015. These dogs were carefully and conscientiously laid to rest upon death by the site's human inhabitants (Figure 2).

This special treatment, in the form of intentional burial, speaks to the special status some dogs held to the humans who cared for them. The dogs range in age from juvenile animals (2 to 4 months of age) to older adults. In addition to the seven dog burials, isolated skeletal remains of domestic dogs were found throughout the site, some of which are included in this study. The skeletal remains from both burial and isolated deposits date from the Middle Archaic period (8,000 to 5,000 years ago) through the Woodland period (3,000 to 1,250 years ago).

SELECTING DOG MANDIBLES

Nine mandibles were selected from seven different dogs for x-ray analysis. Six mandibles came from intentional burials and three came from isolated refuse contexts. X-ray images were taken by Kim Floerchinger (D.V.M.) at the Animal Medical Center of Sauk Village. X-ray imaging is a helpful analytical tool that can be used toward two broad goals: first, to confirm or deny observations made with the naked eye or under a handheld microscope; and second, to identify new information, including additional pathological changes and anomalies, not visible during skeletal analysis. Examples of both findings are described below.

X-ray imaging confirmed antemortem (before death) tooth loss and subsequent alveolar (tooth socket) remodeling in four dog mandibles, all of which showed outward signs of this condition during initial laboratory analysis of the skeletal remains. The right mandible of an older adult animal (Dog Burial 3) is shown in Figure 3a. The first premolar tooth (P1) is visibly absent and bone remodeling (A) is apparent on the surface of the bone. The x-ray of the mandible, shown in Figure 3b, shows a hazy area of bone (B) that is less dense than the surrounding bone, indicating new growth where the P1 once sat. As a comparison, the third molar tooth (M3) was lost postmortem and the x-ray image of an alveolus with no bone remodeling can be seen in Figure 3b. The M3 alveolus x-ray image is dark and well defined because there is an open hole

Figure 2: A Dog Burial from the Black Earth Site. Courtesy of Center for Archaeological Investigations, Southern Illinois University Carbondale.

where the tooth root once attached to the mandibular body. As a small tooth with a single, short root it may have fallen out during excavation or from other disturbances. In addition, tooth crowding (C) is a common pathological change seen in most of the adult dog mandibles examined in this study.

(Upper) Figure 3a: The Right Mandible from Dog Burial 3 with Remodeled Lower First Premolar (P1) Alveolus.
(Lower) Figure 3b: The X-ray Image of the Mandible from Dog Burial 3. Courtesy of the authors.

COMMON TOOTH LOSS AND ANOMALIES

Figure 4a shows the right mandible of an adult canine (Dog Burial 1) missing its first and second premolar teeth. A visual inspection of the mandible indicates the second premolar (P2) was lost postmortem (Figure 4a). The first premolar (P1) was either present and lost antemortem or the tooth failed to develop and its absence is representative of congenital tooth loss. Congenital P1 tooth loss can be a common occurrence among some dog populations in the Americas due to a shortening jaw and crowding of the teeth, which happens as a result of domestication.

The x-ray, shown in Figure 4b, provides evidence that the P1 tooth did exist, but that it was lost sometime during the animal's life. We detected a hazy, concave area (B) at the top of the mandible indicative of new bone growth where the P1 once sat. Based on visual inspection and the mandible the x-ray image (Figure 4a), it appears this dog lost its P1 antemortem, possibly due to trauma, which also removed a small section of bone on the right side (A). Bone remodeling around the P1 occurred in such a way that a concave area is still visible on the mandible.

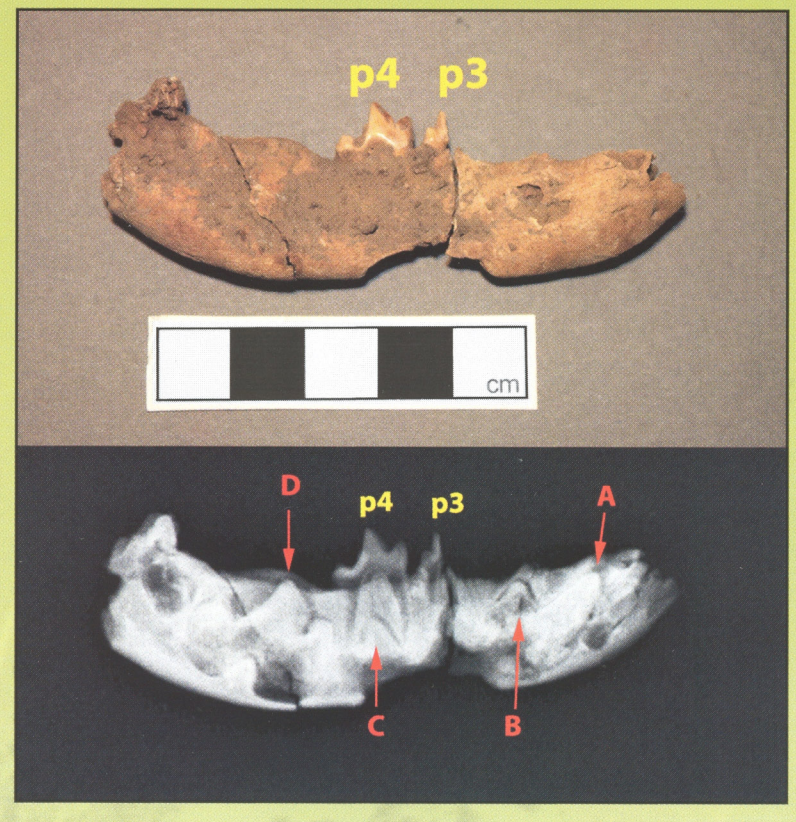
X-ray imaging also allowed us to identify pathological changes and dental anomalies not visible to the naked eye during skeletal analysis. The right mandible of Dog Burial 1 also shows signs of horizontal bone loss (Figure 4b), the deterioration of bone caused by a combination of bacteria-induced inflammation of the gums and tissues surrounding the teeth. This results in bone breakdown, also known as periodontal disease, and can be seen in the x-ray image as the less dense areas of bone (C and D) beneath the third and fourth premolar teeth (P3 and P4). The bone became so thin that it appears to be absent in some areas of the x-rayed mandible, however visual examination (depicted in Figure 4a) shows that bone is indeed present there. Horizontal bone loss was also identified in other adult dog mandibles.

AGE ASSESSMENT

In another example, x-ray imaging allowed us to more accurately assess the age of a young dog. Figure 5a shows the right mandible of a juvenile animal (a dog burial found in Test Pit 3), with the deciduous third and fourth premolar (p3 and p4) teeth visible. The mandible shows numerous permanent

(Right) Figure 4a: The Right Mandible from Dog Burial 1 with Remodeled Lower First Premolar (P1) Alveolus.
(Lower) Figure 4b: The X-ray Image of the Mandible from Dog Burial 1. Courtesy of the authors.

teeth still encased in bone beneath the mandibular surface (Figure 5b). The permanent canine (A), second premolar (B), fourth premolar (C), and first molar (D) remain in crypt, hidden beneath the mandibular surface. The combination of erupted deciduous teeth and unerupted permanent teeth indicate the puppy was between 2 to 4 months of age at death. The x-ray image allowed us to refine the age estimate for this puppy after an initial assessment.



(Upper) Figure 5a: The Right Mandible from the Test Pit 3 Dog Burial. (Lower) Figure 5b: The X-ray Image of the Mandible from the Test Pit 3 Dog Burial. Courtesy of the authors.

DENTAL HEALTH

An x-ray analysis of dog mandibles from the Black Earth site served to clarify, confirm, and add new details to our visual inspection of the specimens. Combining both techniques gave us greater insights into the dental health of these ancient dogs. We confirmed that congenital loss of the lower permanent first premolar tooth did not occur among the dogs in our (small) sample. All the dogs had this tooth at one point in their lives, although several individuals lost it prior to their deaths. Several of the adult dogs showed pathological changes confirmed by or diagnosed through x-ray analysis. Horizontal bone loss, a result of bacterial inflammation, was found in two adult dogs and tooth crowding was seen in all but one adult dog. X-ray analysis of a juvenile dog located teeth hidden below the mandible's surface, which in turn allowed us to more accurately determine the puppy's age.

Roughly half of the dogs studied displayed antemortem tooth loss, which suggests they were performing acts that damaged their teeth, such as hunting prey for food and chewing bones (hunted or scavenged) to extract nutrients. Wear to the occlusal surface of the teeth and horizontal bone loss along the gum line in older adult animals provides additional evidence of damage from usage, trauma, and disease. Bone loss indicative of periodontal disease can be caused by a number of different factors including the animal's age, chewing behavior, grooming habits, health, and genetic predisposition to various conditions. The disease can also lead to secondary health issues, such as heart disease, because bacteria can spread from the mouth to other areas of the body, including the heart and lungs. Whether these pathological changes occurred from hunting prey, intensive chewing, or some other activity we can only guess, however they may have affected the overall health of the animal.

INFORMATION GAINED

When considered alongside other lines of evidence, the information gained through x-ray analysis enhances our understanding of canine life histories and their relationship with the human inhabitants of the Black Earth site. Food stress may be one factor that contributed to the dental health of the Black Earth dogs. Robert J. Losey and colleagues suggested in a 2014 article that dogs were able to successfully live among humans because they could scavenge and hunt food for themselves during times of food scarcity.

Tooth loss and oral disease identified among the dogs in our study suggest these animals subsisted on a diet that combined hunted and scavenged foods with scraps tossed to them by the human occupants of the Black Earth site. Because dogs could feed themselves they created little to no burden for their human companions, yet dogs clearly contributed something to human society. These contributions were acknowledged at the Black Earth site in the careful and intentional burial of dogs upon death.

How and what these canines contributed to the community is not easily identified in the archaeological record. Further research into the varied ways dogs served the human occupants of the Black Earth settlement will allow us to more fully understand the dynamic relationship that existed between humans and their canine companions thousands of years ago in southern Illinois.

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