Title

An osteobiography of a 19th-century dog from Toronto, Canada

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Abstract

A 19th-century dog burial uncovered from a historical homelot in Toronto, Canada, provided a unique opportunity to reconstruct the individual's osteobiography. Of particular interest are the dog's very large size and a suite of skeletal pathologies. Recovery of a nearly complete skeleton combined with the use of x-rays and micro-computed tomography (micro-CT) allowed for a discriminating differential diagnoses. Stable isotope analyses were applied to investigate questions of diet. Results reveal an individual who suffered greatly from disease towards the end of his life and hint at its owners attitudes towards dogs. The interdisciplinary approach applied to this case study highlights the potential information obtainable from pet burials. We argue that better analyses and reporting of pet burials will help address research questions targeting broader themes related to human-animal relationships.

1 Introduction

Traditionally, historical period zooarchaeological research has focussed on themes of diet and economy; however, recent trends in zooarchaeological theory and practice, influenced by ideas emanating through an engagement with the field of animal studies, are demanding alternative perspectives (Thomas & Fothergill, 2014). The significance of animal agency and the complexity of human-animal relationships are being recognized increasingly (Overton & Hamilakis, 2013; Russell, 2012; Sykes, 2014). Following Kopytoff (1986) and Morris (2011), this paper adopts a biographical approach to the study of archaeological remains as a way of exploring these relationships through the consideration of the life and death histories of individual animals. Careful skeletal analysis including investigation of diseases and injuries experienced by an animal, combined with archaeological context and historical documents, informs upon the interaction between individual people and animals. This in turn permits reflection on the contingency and complexity of human-animal relationships.

A dog burial recovered from a mid-19th-century, Euro-Canadian homelot in Toronto, Ontario, provided an ideal opportunity to employ an osteobiographical approach and investigate human-dog relationships. The temporal context is important here because the 19th century marked a period of transformation in human-animal relationships (Ritvo, 1994; Thomas, 2005; Thomas & Fothergill, 2014). Through the Victorian period in Britain, dogs were regularly considered as part of the domestic realm, forming deep bonds with their owners. By the late Victorian period, some pet dogs were cared for in life and death in a way that better befitted one's best friend (Howell, 2002). Concurrently, designated pet cemeteries first appeared in English cities, marking a departure from previous practice in

which the deposition of animals, including pets, likely reflected functional necessities rather than spiritual beliefs. Despite the significance of this change within the context of contemporary attitudes towards pet animals, the archaeological study of this phenomenon has been sorely neglected (Thomas, 2005; 2009). The purpose of this case study is to: 1) draw upon archaeological and biomedical information in order to construct a biography of an individual dog; and 2) Consider how detailed analyses of pet burials, commonly identified on archaeological sites from this period, would significantly contribute to our understanding of human-dog relationships in the mid-19th century.

2 Materials

Located at the intersection of King Street West and Bathurst Street in the city of Toronto, the Bell Site (AjGu-68) represents a homelot developed on land originally intended as a military reserve. The reserve was deemed redundant after the War of 1812 and earmarked for subdivision and sale. This particular homelot was first sold in 1840 to Thomas Bell Jr., a local land agent and accountant who would later become an alderman serving on the Toronto city council. Thomas was a member of one of the oldest families to settle in York/Toronto and owned a few vacant lots and houses throughout the city. By 1842, he and his wife Katherine had built a small, timber-frame house on the homelot. In 1858, a larger house was erected immediately west of the original one. Thomas died in 1857 but Katherine lived here until her death in 1864. The buildings were then briefly occupied by a succession of tenants (William McCune, a driver, and M. Octavius Miller, Captain of the military store staff) and vacated by 1869. The original house and outbuildings were demolished in 1870 upon sale of the property (ASI, 2012: 1-2).

Archaeological excavations in 2011 identified the remains of the original homelot, which lay buried beneath a car park. Planned development led to salvage excavations of the initial residential structure and other features related to the 1840-1870 occupation. Associated artefacts and historical documents suggest the Bells were fairly affluent members of society (ASI, 2012: 44).

2.1 Dog burial

Identified in the backyard of the homelot was a single dog burial. The dog was fully articulated and buried in a flexed position, with the right side of the body on the ground and its head facing west (Figure 1). The shallow burial (~17cm below surface) was excavated by hand and all soil was screened through a 6mm wire mesh. Most of the bones were recovered whole while more fragile elements such as the skull and scapulae were somewhat fragmented by excavation and post-depositional taphonomic processes. Elements of the left forelimb featured post-depositional fragmentation as the result of a pathology leading to increased fragility of the bones. The dog's pelvic area was slightly raised in its burial position and was consequently vulnerable to disturbance. Bones missing from this area include lumbar vertebrae three to five, the sacrum, all caudal vertebrae, innominate bones, the left femur and the right proximal femur. Most of the left hind paw and a few of the left rib shafts were also absent. These bones may have disappeared as a result of 1870s demolition activities or, more likely, taken during mechanical removal of top soil prior to archaeological excavations. Nine indeterminate pieces of rusted metal, presumed to be iron, were recovered from the neck area. Similar metal concretions were identified on the axis, left parietal and left mandible. Energy dispersive x-ray fluorescence (EDXRF) analysis of the concretion that appears on the left, lateral surface of the axis identified it as iron oxide. These are likely the remains of a dog collar or iron chain placed around his neck.

3 Methods

Species identification was achieved through macroscopic examination of the specimen and comparison with materials held in the Howard G. Savage Zooarchaeological Reference Collection at the University of Toronto. Distinctive morphological characteristics were used to differentiate between members of the genus and identify this individual as a dog (*Canis familiaris*) (Benecke, 1987; Krantz, 1959; Lawrence & Bossert, 1967; Lupo & Janetski 1994; Morey & Wiant, 1992; Yates, 2000). The dog's age at death was determined based on the state of epiphyseal fusion (Hare, 1959; Seoudi, 1948; Silver, 1969; Smith & Allcock, 1960; Sumner-Smith, 1966) combined with dental eruption and wear patterns (Horard-Herbin, 2000; Stiner, 1994). Pathology was recorded macroscopically using a descriptive recording protocol modelled after Vann and Thomas (2006).

Biometric analysis of the axial and appendicular skeleton was undertaken using the standards set forth in von den Driesch (1976). Withers height (height at the dorsal aspect of the shoulders) was calculated based on regression formulae developed by Harcourt (1974) and applied to all complete long bones. To investigate phenotypic resemblances to modern breeds, skull measurements were taken following Phillips *et al.* (2009) and subjected to discriminant function analysis (using SPSS 22 for Windows) along with data from over 300 reference specimens from 64 different large breeds housed at the Albert-Heim-Foundation for canine research, Natural History Museum in Bern. Results are used to suggest similarities to modern breeds rather than claim direct breed assignation.

The radii, ulnae, humeri and right tibia were radiographed using a mobile x-ray unit (60 KvP; 64 mAs; 0.025 s; Xograph Dragon, University of Leicester, School of Archaeology and Ancient History, Leicester, UK). Bones exhibiting pathology were radiographed

alongside the contralateral bone to exclude the possibility that radiolucencies and radiodensities were caused by taphonomic factors (Mays, 2012).

High resolution micro-computed tomography (micro-CT) images were taken of the left humerus, left radius and skull (Nikon Metrology XTH 225 micro-CT scanner, with a Paxscan detector, University of Leicester, Department of Engineering, Leicester, UK). Micro-CT offers greater spatial resolution than possible with clinical computed tomography; however, the exact resolution is difficult to quantify as it is dependent on a large number of factors (Rutty *et al.*, 2013). The X-ray data were reconstructed using CT-Pro 2.0 (Nikon Metrology UK Ltd) and all 3D rendering and subsequent analysis was performed in VGStudio MAX 2.1 (Volume Graphics GmbH, Germany), and Drishti v2.5.1 (The Australian National University, Australia). We initially conducted our scans with the x-ray voltage and current set at 95KV and 224 μ A, using a 0.5mm thick copper filter. This combination was judged to provide the best x-ray penetration and image contrast when viewed as a live radiograph. However, the images showed some signs of saturation after completion of the scan, and so further scans were conducted at 110kV and 129 μ A with the same filter, to improve image quality. Metadata obtained following the scans provides information on voxel size (3D pixels) which is calculated based on the distance between the sample and the x-ray source. In this case, the voxel sizes ranged between 78.6 and 99 microns.

For the stable isotope analysis, collagen extractions followed well established methods (Brown *et al.*, 1988; Richards & Hedges, 1999). Samples were soaked in a 0.5M hydrochloric acid (HCl) solution (refreshed every 48 hours) at 4°C until fully demineralized. Collagen pseudomorphs were then placed in 0.1M Sodium Hydroxide (NaOH) overnight to remove potential humic acid contaminants (Jørkov *et al.*, 2007; UCI KCCAMS Facility, 2011).

Afterwards, samples were gelatinized in water adjusted to a pH of 3 with 0.5M HCl on a heating block set to 75°C for 48 hours. Gelatins were then Eze Filtered (5-8µm mesh), Ultra Filtered (30kDa), frozen for 24 hours, and lyophilized over 48 hours in a freeze dryer. Replicate isotopic measurements were made using 0.5mg of collagen on an Elementar vario MICRO elemental analyser coupled to an IsoPrime mass spectrometer (University of British Columbia, Department of Anthropology, Vancouver, Canada). Stable carbon and nitrogen isotope values were calibrated to VPDB and AIR, respectively, with USGS40 and USGS41. International and internal reference standards (NIST 1577c bovine liver, SIGMA-ALDRICH methionine, and seal collagen) are also routinely analysed to monitor precision and accuracy. Standard deviations for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of standard materials were better than 0.1‰ and 0.2‰, respectively. Collagen integrity was deemed adequate if samples produced a collagen yield above 1%, a carbon to nitrogen ratio (C:N) between 2.9 and 3.6, and carbon and nitrogen concentrations above 18% and 6%, respectively (De Niro, 1985; van Klinken, 1999).

4 Results

4.1 Age and sex

All long bones were fused indicating this animal was an adult (Hare, 1959; Seoudi, 1948; Silver, 1969; Smith & Allcock, 1960; Sumner-Smith, 1966). The adult dentition was fully erupted which occurs by approximately 28-30 weeks of age in the dog (Hillson, 2005). Macroscopic observations indicate that both lower first premolars were lost ante-mortem allowing enough time for the alveolar bone to begin remodelling. Wear patterns were identified on the teeth and following Stiner's (1994) and Horard-Herbin's (2000) criteria, this

individual's teeth fall under Stage V and Stage E-F respectively, which are consistent with a "prime" aged dog.

Evidence suggests that, after reaching skeletal maturity, this dog lived long enough to develop significant dental wear, lose permanent dentition and begin significant alveolar remodelling. Furthermore, sites of epiphyseal fusion have undergone extensive remodelling and epiphyseal fusion lines are not visible. This evidence presented alongside the degenerative joint disease identified in the skeleton (discussed later) suggests this dog was as a mature to elderly individual when it died.

A baculum was recovered identifying the individual as male.

4.2 Size and breed affiliation

The height of the dog at the withers was approximately 73 to 75 cm (Table 1). Withers height is comparable to giant dog breeds such as the Great Dane, Newfoundland and St. Bernard dogs among others (The Kennel Club, 2003).

Discriminant function analysis shows 89.4% variance explained by the first two functions and plots the archaeological specimen alongside large breeds belonging to the working group of dogs (The Kennel Club, 2003) (Figure 2). The Bell dog plots closest to the group centroids and individual cases for Great Danes, Landseers, Leonbergers, St. Bernards, Newfoundlands and Greater Swiss Mountain dogs, suggesting a closer affinity to these breeds.

4.3 Pathologies

A full description of the lesions identified on the skeleton is presented in Table S1, what follows here is a digest of the primary forms of the pathologies observed.

4.3.1 Degenerative joint disease

Multiple bones on this dog's skeleton display osteophytes and lipping along articular margins. This is especially marked in the spine where every vertebra exhibited evidence of osteophytosis and/or lipping along the margins of vertebral bodies and/or along the margins of the articular facets and tubercles for rib articulation. The majority of recovered rib heads also display slight to moderate osteophytes and/or evidence of lipping. Osteophytes affecting ventrolateral vertebral margins are evidence of a condition known as spondylosis deformans (Thompson, 2007: 157).

Multiple joints exhibit degenerative disease. These include lipping of the left glenoid fossa and both humeral heads, and osteophytosis of the left second cuneiform and the distal end of a proximal phalanx. Degenerative joint disease (mild) and spondylosis deformans are common age-related 'wear and tear' lesions although their onset and progression are influenced by a range of factors including behaviour, genetic predisposition, environment and body mass. Enthesophytes (ossifications at ligament/tendon attachment sites) are present throughout the body (on mandibles, humeri and the right ulna), further supporting our assessment of advanced age.

4.3.2 Periodontal disease

The maxillae and mandibles exhibit extensive periodontal disease signalled by the heavy porosity along the entirety of both upper and lower dental arcades. This is interpreted as advanced gingivitis and probable periostitis-periodontitis. Alveolar pockets are also evident behind the mandibular second premolar. The upper left fourth premolar features a chipped enamel surface that exhibits use wear, indicating the chip occurred ante-mortem. A cloaca has formed in the maxilla, just above this tooth suggesting a bacterial

infection (possibly a result of the chipped tooth) that was quite advanced (Figure 3). Silver (1969) notes that the upper fourth pre-molar of domestic dogs is often subjected to abscesses of the root and that the maxillary bone over the roots can become so eroded that a sinus forms between the alveolus and the exterior surface, as is the case here.

4.3.3 Infection of tympanic bulla

Macroscopic examinations and micro-CT scans reveal significant remodelling of the tympanic bulla and its cavity (Figure 4). Reactive bone formation and destruction of the left tympanic bulla and external acoustic meatus is consistent with chronic osteitis. This lesion may have arisen secondary to bacterial otitis media and/or otitis externa, possibly initiated from chronic yeast infections or foreign bodies in the external ear canal. Inflammation of the external ear or ear canal is common in domestic dogs (Wilcock, 2007).

4.3.4 Periosteal and endosteal reactive bone

Prolific, reactive periosteal new bone formation was evident on the left radius, ulna and carpal accessory (*Os carpi accessorium*) with articular surfaces remaining unaffected (Figures 5a and 6a). Small foci of periosteal reactive bone were also observed on the right ulna (Figure 5b) and on metacarpals of both forelimbs. Endosteal reactive bone formation filled the medullary cavity of the diaphysis of the left radius fragment. Examination of radiographs indicates that the observed endosteal growth extends approximately 3cm within the diaphysis towards the proximal end of the bone (Figure 6b). Imaging indicates the remainder of the marrow cavity in the proximal radius was unaffected.

Periosteal reactive bone formation can be attributed to metabolic disorders (metaphyseal osteopathy, canine panosteitis and hypertrophic osteopathy), neoplasms,

bacterial infections or “non-specific” infections (Weston, 2012). Here, we conduct a differential diagnosis to narrow down the potential cause.

Metaphyseal osteopathy (hypertrophic osteodystrophy) produces bone lesions in larger dogs, resembling those observed in this specimen. However, this condition only affects growing individuals with open physes (Lenehan & Felter, 1985; Thompson, 2007; Woodard, 1997). Metaphyseal osteopathy is unlikely in this case as this dog was skeletally mature at time of death and the diaphysis of the left radius is extensively involved.

Canine panosteitis, an inflammatory bone disease of unknown cause, is another condition stimulating periosteal new bone formation. However, the related bone surface proliferation is typically much less pronounced than that observed in this specimen. An important radiographic hallmark of panosteitis is patchy increased ill-defined densities in long bone marrow cavities, which was not observed. Panosteitis commonly affects younger individuals in certain family lines of modern large breeds of dog, but can be observed at any age (Johnson and Watson, 2000). The pathologies observed on this specimen are inconsistent with this disease.

A third metabolic bone disorder to consider is hypertrophic osteopathy (HO). This disease affects the bones of the lower limbs, such as the radius, ulna, tibia and metapodials and is characterized by diffuse periosteal new bone formation oriented in a roughly perpendicular direction to the diaphysis with coarse osseous exostoses which have a wart- or cauliflower-like appearance, much like those observed in Figures 5a and 6a. The proliferations generally respect the synovial joints and articular surfaces of the bone. The pathogenesis of this disease remains poorly understood but it is known to relate to lesions

in the pleural cavity caused by tumours, bacterial or fungal infections as well as genitourinary tumours (Johnson and Watson, 2000).

The macroscopic appearance of the reactive bone formation and the similarity to previous published cases (Bathurst & Barta, 2004; von Hunnius, 2009) led the archaeologists who first recorded these bones to suggest a possible diagnosis of HO (ASI, 2012). Upon further scrutiny of the skeleton and relevant clinical literature, we identified an issue with this possible diagnosis as some of the symptoms do not fit with the typical presentation of the disease. HO is a symmetrically bilateral disease and similar lesions are not present in the contralateral limb of this dog. Small patches of periosteal reactive bone were identified on metacarpals of both forelimbs and on the ulna of the right forelimb; however, these are very small compared to the extensive lesions observed in the left forelimb.

Neoplasms or bone tumours were carefully considered. However, these tend to include cortical bone destruction resulting in unclear boundaries between the original cortex and the newly deposited bone (Rothschild and Martin, 1992: 167). Metastasis of soft tissue cancers onto the bone results in either lysis or in distinctive periosteal reactions having a sun burst like appearance, neither of which is seen here. Furthermore, primary bone tumours rarely cross joints proximal or distal to an affected bone.

Given the localised extent of the lesions in the left forelimb, an alternative diagnosis is a chronic bacterial or fungal infection secondary to one or multiple penetrating wound(s) centred on the mid-left forearm. It is possible that the overlying soft tissue infections lead to hyperactive new bone formation. Further, the presence of the endosteal new or reactive bone is consistent with an insult injury (i.e., penetrating wound(s), through the cortex of the radius or entry through a vascular channel). Therefore, our suggested diagnosis regarding

the left forelimb include: (1) chronic-active and extensive, periostitis of the left radius, ulna and *Os carpi accessorium*, with new (reactive) bone formation; and (2) chronic-active and focal osteomyelitis with moderate endosteal new (reactive) bone formation in the diaphysis of the left radius.

4.4 Diet and nutrition

To determine whether this individual had a distinctive diet, we submitted two samples for stable isotope analyses. Biological tissues such as bone are constructed and maintained using materials derived from foods consumed by the individual. Foods can have distinctive isotope signatures which can be identified in analyses, affording the opportunity to assess if this dog's diet was consistent with other animals living in the same region or, rather, if it was afforded a diet that was in some way distinctive (Katzenberg, 2008). Guiry (2012, 2013) reviews the role of dogs in stable isotope bone chemistry and paleodietary reconstruction.

Using stable carbon and nitrogen isotope analyses we analysed collagen from a bone (left *os carpi ulnare*) and tooth (right lower canine). Due to different remodelling characteristics between these tissues, the isotope values from the bone and tooth should reflect the dog's diet in later and earlier (post weaning) life, respectively. To help contextualize these data, we also analysed an additional loose dog bone (an isolated bone recovered from the original A-horizon associated with the 1840-1870 occupation and without evidence for special treatment by its owners) and bones from three individual cattle (*Bos taurus*) from the site. The loose dog bone was intended to provide a comparison for the interred dog's values. The cattle were analysed to provide a rough isotopic baseline for herbivore diets in the area. Six analyses were performed in total and the results are

presented in Table 2 and Figure 7. These results suggest the individual recovered in the burial did not have a diet that was atypical of 19th-century dogs living in urban areas based on comparisons with the other dog specimen from this site, to others from urban sites (e.g., Guiry *et al.*, 2014) and to early results of ongoing work in southern Ontario by one of this paper's co-authors (Guiry). Moreover, isotopic values from early and late forming tissues are similar suggesting that this individual's diet was (in terms of stable isotopes) consistent throughout his life.

5 Discussion and conclusions

Taking an interdisciplinary approach to the construction of an osteobiography permits us to understand the activities that took place to create the burial and postulate what this dog meant to those who interacted with him (Morris, 2011). Cranial morphology suggests he belonged to one or a mixture of the working class group of giant breeds. Little is known on the subject of dog breeds from this time period in Toronto and archaeological analyses of pet burials rarely go beyond species identification. Newfoundland dogs represent one of the few breeds mentioned in early 19th-century documents, although these likely reference large dogs rather than the breed standards we associate with the name today (Grier, 2006: 35). They were favoured for hunting deer and managing cattle and pigs according to personal letters penned by the Cooper brothers in nearby Adelaide township in 1832, 1833 and 1838 (Cameron *et al.*, 2000). The Bell Site dog is unlikely to have served as a farm animal given its burial in an urban homelot. Fox and deer hunting with dogs were popular pastimes among the city's political and entrepreneurial elite, many of whom were members of the Toronto Hunt Club (Joyce, 1997: 94-95). Other pursuits, such as bull-baiting and dog fighting were popular among the working class until city by-laws in 1864 and 1876 aimed to

stop these activities (Joyce, 1997: 94). The osteobiography of this individual does not support life or death as a fighting dog, but Thomas Bell Jr.'s affluence and political position is typical of a member of the Toronto Hunt Club and this dog may have served for hunting purposes. Other possible functions for a dog of this size living in the city include hauling/pulling carts, security and/or companionship. Such a large dog would have been a rather imposing figure to anyone who came across his path, regardless of his demeanour. It is unlikely the dog was ever left to roam free about the neighbourhood as legislation was put in place in 1834 to "prevent and regulate the running at large of dogs"¹. In 1836, a new dog licensing system was introduced requiring city residents to tag and collar their dogs (City of Toronto Archives, By-law 23 in Kheraj, 2013).

Large breeds of modern dogs live relatively short lives (as short as 6 years) (Galis *et al.*, 2007) and are particularly susceptible to a number of diseases, including those identified here. Multiple degenerative joint diseases likely resulted in pain and difficulty or limitations in movement. Severe periodontal disease, a chipped tooth and associated bacterial infection probably resulted in a painful eating experience. An advanced ear infection likely caused deafness in the left ear and he may have walked around with his head tilted to that side and exhibited behaviours such as head shaking and scratching. His ear infection would have carried a foul odour and periodontal disease likely gave him bad breath, rendering him unpleasant to be around. A penetrating wound to his left forelimb could have been the result of a number of causes (e.g., a dog bite or being stuck with a nail), which led to a chronic infection and increasing discomfort as the body reacted to the infection.

Inflammation of the left forelimb likely resulted in this dog walking with a limp. This dog

¹ "An act to extend the Limits of the Town of York; to erect the said Town into a City; and to Incorporate it under the name of the City of Toronto," 6 March 1834, *Statutes of His Majesty's province of Upper Canada* (Toronto: G. Tiffany, 1834) 73; 81. Cited in Kheraj (2013: 129).

would have been very sick over a period of perhaps 12-16 weeks as a result of a sub-chronic stage infection and degenerative process, and therefore could have experienced other soft tissue problems not observable in archaeological remains.

The inter-disciplinary approach used here provided us with a wider range of information to re-construct the osteobiography while advanced radiographic imaging techniques provided better information for the differential diagnosis. This case study highlights the potential information obtainable from 19th-century pet burials and the need for more detailed analyses of such deposits. A greater sample of pet burials from across the city and province would help address research questions targeting broader themes, such as the treatment of pets (in life and after death) and human-animal relationships in general. In late Victorian England, the practice of pet burials is reminiscent of the increasingly popular belief that heaven was a reflection of one's home. Pet animals who served as part of the family home on earth would also be reunited with their owners in the afterlife. For this to happen, these creatures must have souls; consequently, pet burials came to hold significantly greater meaning and functioned as more than just good hygiene practice (Howell, 2002).

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7 Supporting Information

Table S1: Summary and description of skeletal pathologies.

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Table legends

Table 1: Estimated height at the withers, from Harcourt (1974)

Table 2: Stable isotope values for dog burial and other specimens from the Bell site

Table S1: Summary and description of skeletal pathologies.

Figure legends

Figure 1: Dog burial. Scale bars display 10cm intervals, trowel points north. Image is courtesy of Archaeological Services Inc.

Figure 2: Scatter plot of the Bell Site cranium and group centroid values of selected dog breeds on the two first canonical discriminant functions.

Figure 3: Lateral surface of left maxilla, premolars and molars. Note the porosity observed along the alveolar margin. Arrow points to the cloaca that formed above the fourth, upper premolar.

Figure 4: Radiograph of cranium. Arrow points to advanced reactive bone formation and destruction of the left tympanic bulla.

Figure 5: a) Medial surface of left ulna with active periosteal reactive bone formation along the diaphysis; b) lateral surface of right ulna, arrow points to the small locus of active periosteal reactive bone formation.

Figure 6: a) 3D rendering of anterior surface of left radius exhibiting periosteal reactive bone formation. b) Transverse section of left radius showing periosteal and endosteal reactive bone formation.

Figure 7: Stable isotope values for dog burial and other specimens from the Bell site.