Meaner Than A Junkyard Dog: Osteological and Isotopic Insights into Three Canid Burials from 1890s San Jose, California

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In September 2017, archaeological investigations associated with construction activities at MIRO Towers in San Jose, California, uncovered a burial feature containing the remains of a young adult female dog and her two 5-12-week-old pups. Stratigraphy and associated artifacts indicate a burial date in the 1890s. Historical research indicates that this address was the location of a junkyard at the time the burial occurred, suggesting these canids may have served as guard dogs within the junkyard. This article describes the find and subsequent osteological and isotopic laboratory analyses that provide insight into late nineteenth century canid diet and living conditions in the southern San Francisco Bay Area. Stable isotope data indicate that the dogs ate a diet rich in meat, and that the pups were either still breastfeeding or recently weaned prior to death. One of the pups displays multiple healed rib fractures, suggesting it may have been kicked or fell on its side. No other skeletal traumas were visible, and a cause of death is not discernible for these otherwise healthy dogs, one in her prime and two at the beginning of their lives.

Ahead of construction activities for the MIRO Towers in downtown San Jose, William Self Associates (WSA) conducted archaeological testing of sediments within approximately 1.4 acres of land encompassing nine parcels on the north side of East Santa Clara Street, between N. 4th and N. 5th streets in San Jose, California (see Figure 1). A range of late nineteenth and early twentieth century historic artifacts were discovered during excavation and subsequent monitoring. One pit feature was of particular note; it contained the remains of three canids, one adult female dog and two puppies that had been interred together.

Following discussions between faculty at the University of California, Davis (UC Davis), and archaeologists at WSA, and given long-standing interests in North American canids at UC Davis (e.g., Byrd et al. 2013; Brown et al. 2013, 2015; Kemp et al. 2017), the remains of the three MIRO Towers individuals were transported to the university for further analysis. Zooarchaeological and isotopic studies were conducted to help contextualize the results from the archaeological field report, and this article summarizes our findings. The dog remains have been accessioned into the UC Davis Department of Anthropology's Zooarchaeology Lab comparative skeletal collection and will assist future generations of zooarchaeologists in the identification of canid remains. They are available to other researchers for additional study.

Figure 1. Map of the San Francisco Bay Area, showing the location of MIRO Towers.

BACKGROUND

A study of Sanborn Fire Insurance Maps from 1884, 1891, 1915, and 1950 shows that the character of the city block associated with the dog burial feature changed substantially over time, from mostly residential to more business-oriented buildings. During the mid-nineteenth to early twentieth century, structures were built around the perimeter of the block, with the central portion mostly open. The location where the dogs were found was a junkyard during most of this period. Documents indicate that the Markovitz brothers owned the junkyard in 1891, although the property changed hands in the years following.

Historical artifacts associated with the dog skeletons included shell, a variety of faunal remains (cow, sheep/goat, chicken), ironstone ceramics, glazed whiteware, and two glass olive-green bottle kick-ups with large mamelons that are likely from champagne bottles based on their size. Several graphite or carbon rods were recovered, which were probably parts of early batteries, as well as a porcelain tube used in Leclanché wet cell batteries. Together, the burial context, stratigraphy, and associated artifacts indicate that the dog burial dates to the 1890s.

The burial pit contained the remains of one large adult female and two juveniles. The adult had been buried with the spine oriented roughly northeast-southwest (head towards the southwest). This orientation would have placed the dogs roughly parallel to E. Santa Clara St. and perpendicular to 4th and 5th Streets. The two juveniles were placed above (south) and below (north) the body of the adult, with the latter between the fore and hind legs (Figure 2).

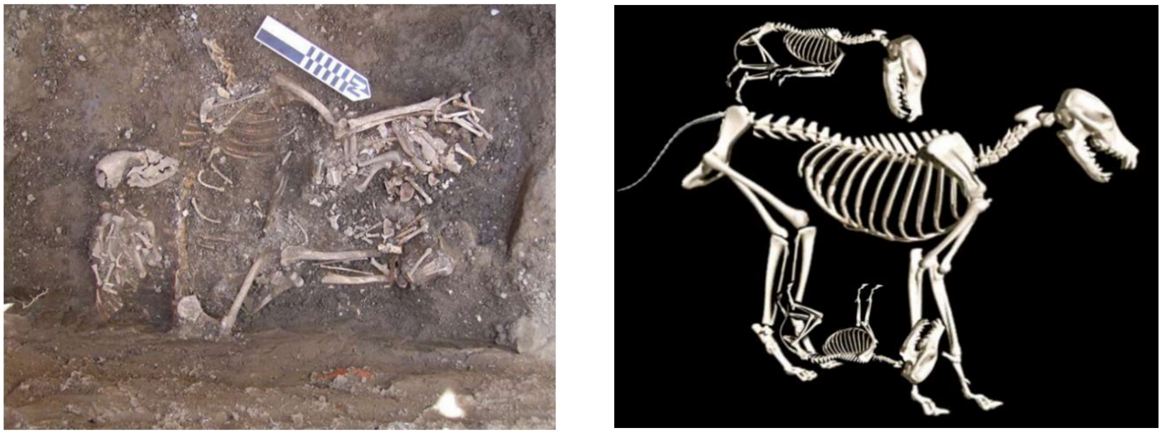

Figure 2. Field photo and reconstruction of burial position for the three MIRO Towers dogs.

METHODS

Differentiating between wild and domesticated canids in archaeological contexts is difficult. The most definitive technique is the use of ancient DNA (Brown et al. 2013; Byrd et al. 2013; Verginelli et al. 2005). However, even here results can be tenuous as there can be cross breeding between "wild" and "domesticated" populations, resulting in gene flow and hybridization (Adams et al. 2003; Andersone et al. 2002). DNA testing is also expensive and was not performed here.

The size of faunal remains can help differentiate between canid (sub)species, but is also problematic as dog breeds are highly variable. However, dog crania and mandibles are distinct from the remains of similarly sized coyotes. For example, the mandibular body of coyotes is much straighter and thinner than those of dogs, and the horn of the coronoid process is straight rather than angled distally (e.g., Crockford 2009).

Compared to specimens of both dogs and coyotes in the UC Davis Zooarchaeology Lab, the remains from the MIRO Towers project are clearly dogs. Analysis of the dog burial follows (Crockford 2009). The recovered skeletal remains, particularly the fragile axial elements such as the crania, scapulae, innominate (pelvis), and ribs from each of the dogs were highly fragmented from initial excavation methods (i.e., bull-dozers). Because of the fragmentary nature of the collection, the specimens were refitted and reassembled (with Elmer's water-soluble glue) before determining the number of identified specimens (NISP) and estimating the minimum number of elements (MNE). A specimen is defined as a bone, tooth, or fragment thereof; quantification methods follow Lyman (2008), wherein NISP counts do not include loose or fragmentary teeth. Skeletal element measurement follows the standard for animal bones from zooarchaeological assemblages (von den Driesch 1976). The remains were accessioned with the following catalog numbers: adult dog = UCDZL-1224; juvenile dog north = UCDZL-1244; juvenile dog south = UCDZL-1245).

Approximately 1-2 g samples of bone were taken from each individual dog. To isolate collagen, we followed a modified Longin (1971) procedure. Bone was cleaned of any surface contamination by removing the outer 0.5 mm of all exposed surfaces using a hand-held drill, and then sonicating the sample in deionized H_2O (three five-minute baths, with the dH_2O replaced after each bath). The sample was left in an open container until completely dry, weighed, and demineralized with a solution of 0.5M hydrochloric acid (HCl). HCl was changed every other day until the sample was completely demineralized (generally, one to two weeks). The bone was then washed in dH_2O and soaked in 0.125M NaOH (sodium hydroxide) for 24 hours to remove humic acids. The sample was rinsed again with dH_2O to remove any residual NaOH.

Slightly acidic pH3 water was added to the vial and the sample placed in a 70-90°C oven for approximately 24 hours to solubilize collagen. The solubilized collagen was separated from any residual material by pipetting into a clean vial. Finally, the solubilized collagen was freeze dried to remove the water and isolate the collagen fraction.

Collagen $^{13}C/^{12}C$ (reported as $\delta^{13}C$) and nitrogen $^{15}N/^{14}N$ (reported as $\delta^{15}N$) were measured by continuous-flow mass spectrometry (PDZ Europa ANCA-GSL elemental analyzer interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer) at the Stable Isotope Facility, University of California, Davis. Carbon isotopes ratios are reported expressed in permil notation (parts per thousand) relative to the Pee Dee Belemnite standard (arbitrarily set at 0‰), while nitrogen isotope ratios are expressed against N_2 in modern atmospheric air (also arbitrarily set to 0‰). Sample quality was evaluated by subjectively examining the collagen yield as well as the atomic C/N ratio, which should be between 2.9 and 3.7 for well-preserved bone (DeNiro 1985).

Because the carbon and nitrogen used in synthesizing mammalian bone tissues are gained through dietary sources, these isotopes can be used to trace certain aspects of an animal's paleodiet. In mammals, $\delta^{13}C$ discerns between terrestrial and marine resources, and between C3 plant resources such as wheat, and C4 plant resources such as maize (Chisholm et al. 1982; Ehleringer et al. 1993; Farquhar et al. 1989; Schoeninger et al. 1983). These signatures can be passed up the food chain. Thus, cows fed maize will have significantly higher $\delta^{13}C$, as will dogs consuming the meat of such cows. Previous studies have shown that wild canids in California do not consume marine foods (Reid 2014), while humans can provision domesticated dogs with such foods (Rick et al. 2008). Further, previous research shows that there are very few economically important C4 plant resources native to central California (Cloern et al. 2002). For these reasons, we expect that any elevation in $\delta^{13}C$ in the dogs in this study would be due to provisioning with marine foods and/or corn-fed mammals.

$\delta^{15}N$ provides an estimate of the average trophic level of dietary protein (DeNiro and Epstein 1981; Schoeninger et al. 1983). Thus, an animal feeding on plants will have lower $\delta^{15}N$ than an animal feeding on meat. As well, a nursing dog will be elevated in $\delta^{15}N$ relative to the mother. Coyotes are opportunistic foragers and prefer meat, but will eat a range of plants as well (Berger et al. 2008; Reid 2014; Seamster et al. 2014). As a result, coyotes display lower $\delta^{15}N$ than other top-level carnivores (Warsen et al. 2014).

RESULTS

After refitting and reconstruction of the fragmentary skeletal remains, the NISP count for the adult dog is 224, for the North puppy is 212, and for the South puppy is 298. All skeletal elements for the adult dog were fused, whereas all skeletal elements for the puppies were unfused, and thus the number of specimens should be higher for the puppies than the adult if all bones were recovered (Figure 3). To determine how much of each dog was preserved, or recovered, during excavation, and to account for biases associated with unfused elements, we compared the MNE across the dogs (Table 1). Overall, 73% of the adult dog, 48% of the North puppy, and 61% of the South puppy is represented in the assemblage curated at UC Davis.

All deciduous teeth are replaced by permanent adult teeth between four and seven months of age (Crockford 2009) and the long bones are completely fused by 12 months (Chapman 1965). Right and left halves of the innominate fuse at the pubic symphysis in mature adult animals (Crockford 2009), but the pubis of this adult dog is unfused. There is slight wear on the tips of the canines and the highest cusps of the molars and premolars; the ridges on the cusps of the incisors have started to wear away. Given the absence of any arthritic lipping, lack of pubic symphysis fusion, and minimal tooth wear, we estimate the age of this dog to be between three and five years. This was a very healthy dog with no evidence of skeletal trauma consistent with a particular cause of death.

Deciduous canines and incisors begin to erupt at three weeks of age followed by the deciduous premolars between three and five weeks of age. There is no deciduous first premolar, but the adult PM1 erupts at between three and four months of age. The PM1 alveolus is visible, but the tooth remains in the crypt. Thus, based on dental eruption, both puppies are older than five weeks but younger than three months. At some point in the short life of the North pup, four ribs were broken midshaft (three shown in Figure 4). Given their location, either the pup was kicked or fell and landed on its side. Because the breaks were healed, this trauma was not the pup's cause of death. No other pathological condition or trauma was noted on the puppy skeletal remains.

Figure 3. Comparison of the mandible (left side of image) and femur and humerus (right side of image; femur on top of humerus) for the three MIRO Towers dogs (Top = North dog; Middle = Adult dog; Bottom = South dog). Note the juveniles' unfused long bone diaphyses.

The adult dog exhibits several cranial characteristics suggesting that it is female: (1) a less prominent sagittal crest that is formed well posterior to bregma; (2) a less prominent and straighter nuchal crest; and (3) a less distinct condyloid ridge on the mandible (Shigehara et al. 1997). Because the pubis bones are fragmented, we could not assess the subpubic angle. Absence of a baculum in this nearly complete skeleton also suggests female.

Shoulder height was estimated for the adult dog based on long bone regression formulae developed by Harcourt (1974) and based on modern European dog breeds (Table 2). We estimate the shoulder height of the dog to have been 61.5 cm or 24 inches. Based on American Kennel Club heights for female breeds (Worthington 2008), this dog is within the range of a Bull Mastiff (61-66 cm), Doberman Pinscher (61-66 cm), Neopolitan Mastiff (61-73.5 cm), or Rhodesian Ridgeback (61-66 cm). Female German Shepherd (57.5 cm) and Labrador Retriever (54-59.5 cm) breeds are generally smaller.

Face shape and size is more varied than any other part of the dog skeleton and can be used to examine breeds (e.g., Tourigny et al. 2016). Unfortunately, the adult dog's maxilla is highly fragmented; thus, assessing skull length, palate and snout shape by means of indices was not possible. However, cranial and mandibular measurements (Table 3), particularly of the cheek tooth row of the skull breadth, suggests a relatively long-muzzled dog with a broad skull. Coupled with the shoulder height, this dog would have been a tall and relatively robust female.

Stable isotope results are provided in Table 4. Collagen yield was excellent in the adult and north pup (below the adult), but was only moderate in the south pup (above the adult). Atomic C/N indicators are within the acceptable range of values reported by DeNiro (1985) for well-preserved collagen, suggesting that the isotopic values reported are reliable. As well, %C and %N values are within the range expected for collagen in well-preserved archaeological bone (Ambrose 1990).

Table 1. Minimum Number of Skeletal Elements Recovered from Nineteenth Century San Jose Junkyard Dog Burial.

Skeletal Element	Adult Dog	North Puppy	South Puppy
cranium (1)	1	1	1
mandible (2)	2	2	2
cervical (7)	7	7	7
thoracic (13)	11	7	13
rib (26)	22	18	26
sternum (8)	6	0	4
lumbar (7)	6	3	7
sacrum (1)	1	1	1
caudal (13)	5	0	0
scapula (2)	2	2	2
humerus (2)	2	2	2
radius (2)	2	2	2
ulna (2)	2	2	2
carpal (12)	7	2	2
metacarpal (10)	9	8	6
innominate (2)	2	2	2
femur (2)	2	2	2
patella (2)	1	1	2
tibia (2)	2	2	2
fibula (2)	2	2	1
tarsal (14)	10	5	6
metatarsal (8)	8	6	5
phalanges (26)	9	3	4
Total (166)	**121**	**80**	**101**

Figure 4. Juvenile dog North: proximal and midshaft portions of three ribs with healed fractures at midshaft (indicated by arrows).

Table 2. Adult Dog Long Bone (Right Side) and Shoulder Height Estimate.

Skeletal Element	Greatest Length (GL = mm)	Breadth, Distal End (BD = mm)	Breadth, Proximal End (BP = mm)	Mid-Shaft Diameter (MSD = mm)	Index MSDx 100/GL	Estimated Shoulder Height (cm)
humerus	184.0	34.8	45.5*	12.7	6.9	60.5
radius	183.0	28.0	20.1	13.9	7.6	60.2
ulna	218.0	--	--	11.8	5.4	61.2
femur	204.0	35.1	43.6	13.7	6.7	62.8
tibia	212.0	27.0	40.2	13.8	6.5	62.9
humerus + radius	367.0	--	--	--	--	60.1
femur + tibia	416.0	--	--	--	--	63.0
Average	**--**	**--**	**--**	**--**	**--**	**61.5**

Notes: Data adapted from von den Driesch (1976) and Harcourt (1974); *Depth, proximal end (Dp).

$\delta^{13}C$ and $\delta^{15}N$ values for the three MIRO Towers dogs are plotted in Figure 5. We are unaware of previously published isotopic studies of historic period archaeological dogs in California. However, the UC Davis Archaeometry Lab has analyzed several mission period and precontact period canid samples from central California (Late Holocene) that include both domesticated dogs and coyotes (domestication based on genetic signatures; includes data from Byrd et al. [2013] and additional unpublished data). $\delta^{13}C$ and $\delta^{15}N$ values for these samples are also plotted in Figure 4 to contextualize the MIRO Towers samples. We also plot previously published isotopic values for a set of Pleistocene dire wolf samples from southern California (Coltrain et al. 2004) and the value for a nineteenth century dog burial from Toronto, Canada (Tourigny et al. 2016). As shown, the MIRO Towers dog isotope values overlap with those recorded for most precontact domesticated dogs, mission period canids, and dire wolves, but not with precontact period coyotes from central California, consistent with our conclusion that these individuals represent domesticated dogs rather than wild canids.

DISCUSSION AND CONCLUSIONS

The burial of a large, apparently healthy, young adult female dog with two small pups in a junkyard context dating to the 1890s provides insight into human-dog relations in historic American period central California. No signs of skeletal trauma point to a particular cause of death, such as gunshot or bludgeoning. Likely causes of death, therefore, include virulent disease (such as rabies), poisoning, and drowning. Grier (2009) noted that fear of rabies in nineteenth century American cities prompted occasional roundups and executions of stray dogs, often by drowning. A brief survey of newspaper stories from the late 1800s in the Bay Area (see https://cdnc.ucr.edu/cgi-bin/cdnc) shows that aggressive dogs and dog bites are often mentioned, suggesting that strays were an issue in the region. Poisonings of dogs are also occasionally reported (e.g., Sausalito News from July 15, 1899, see https://cdnc.ucr.edu/cgi-bin/cdnc?a=d&d=SN18990715.1.3&). However, we were unable to find mention of a specific case in the San Jose region. Unfortunately, lacking additional chemical studies, we cannot determine a specific cause of death for the three MIRO Towers dogs.

Figure 5 shows that the two juveniles are enriched in $\delta^{15}N$ relative to the adult female by 1.2 and 1.6‰, but overlap in $\delta^{13}C$. Due to chemical processes within the body, wherein lighter ^{14}N is preferentially excreted during the formation of uric acids prior to tissue formation, breast milk (a tissue) is enriched in ^{15}N relative to the diet of that individual. Therefore, bone collagen in animals consuming significant amounts of breast milk will be higher in $\delta^{15}N$ than animals consuming a solid diet. Because bone collagen

Table 3. Adult Dog Cranial and Mandibular Measurements Compared to Archaeological Precontact Dogs from the Pacific Northwest and the Southeast.

MEASUREMENT	MM	PNW RANGE	SE RANGE
Cranium		*female*	*female*
#15 (length of cheek tooth row, M3-P1)	68.3	47.8-57.0	40.8-59.4
#16 (length of molar row)	17.6	17.7-18.6	13.4-28.8
#17 (length of premolar row)	51.6	36.4-44.4	29.1-46.9
#18L (length of carnassial)	16.7	--	12.8-19.4
#18GB (greatest breadth carnassial)	10.1	--	7.4-10.3
#20L (length of M1)	12.1	--	9.0-13.2
#20B (breadth of M1)	15.9	--	11.8-15.1
#21L (length of M2)	7.1	--	4.8-9.0
#21B (breadth of M2)	9.4	--	5.9-9.6
#23 (greatest mastoid breadth)	63.4	59.4-62.0	--
#25 (greatest breadth occipital condyles)	38.7	33.0-36.5	36.5
#26 (greatest breadth paraoccipital processes)	60.4	--	--
#27 (greatest breadth foramen magnum)	20.8	16.9-19.1	19.1
#28 (height of foramen magnum)	17.9	--	--
#38 (skull height)	57.6	--	--
#40 (height of occipital triangle)	45.3	--	--
Mandibular		*M/F*	*female*
#4 (condyle process to arboral border of canine)	127.5	85.0-131.9	--
#5 (indentation to arboral border of canine)	121.4	85.2-125.9	73.2-100.8
#7 (M3 to arboral border of canine)	82.7	63.8-84.0	48.2-76.1
#8 (length of cheek tooth row, M3-P1)	76.3	66.5-78.3	46.2-68.4
#9 (length of cheek tooth row, M3-P2)	69.1	60.0-73.9	42.3-63.9
#10 (length of molar row)	34.3	29.2-39.0	21.9-33.4
#11 (length of premolar row, P1-P4)	42.2	36.2-42.4	24.9-35.6
#12 (length of premolar row, P2-P4)	34.9	28.8-38.9	21.1-31.2
#13L (length of the M1)	20.7	--	15.1-22
#13B (breadth of the M1)	7.7	--	6.4-8.4
#14 (length of the M1 alveolus)	19.7	18.1-25.6	--
#15L (length of the M2)	9.2	7.5-9.1	5.7-8.1
#15B (breadth of the M2)	6.9	5.6-6.7	4.4-7.3
#16L (length of the M3)	5.3	--	--
#16B (breadth of the M3)	4.2	--	--

Note: Data adapted from Crockford (1997) and Worthington (2008).

Table 4. Stable Isotope Results from Bone Collagen Extracted from the Three MIRO Towers Dogs.

DOG SAMPLE	δ^{13}C	δ^{15}N	C/N	%C	%N
adult female	-18.6	8.8	3.2	39.0%	14.4%
juvenile north (below)	-18.2	10.0	3.2	39.2%	14.3%
juvenile south (above)	-18.7	10.4	3.3	34.4%	12.2%

turns over quickly in the bones of growing animals, this breastfeeding "signature" is quickly erased as an animal transitions to solid foods. The higher δ^{15}N in the pups is consistent with the interpretation that these dogs were either still nursing at or were weaned just before the time of death. In wolf populations, weaning

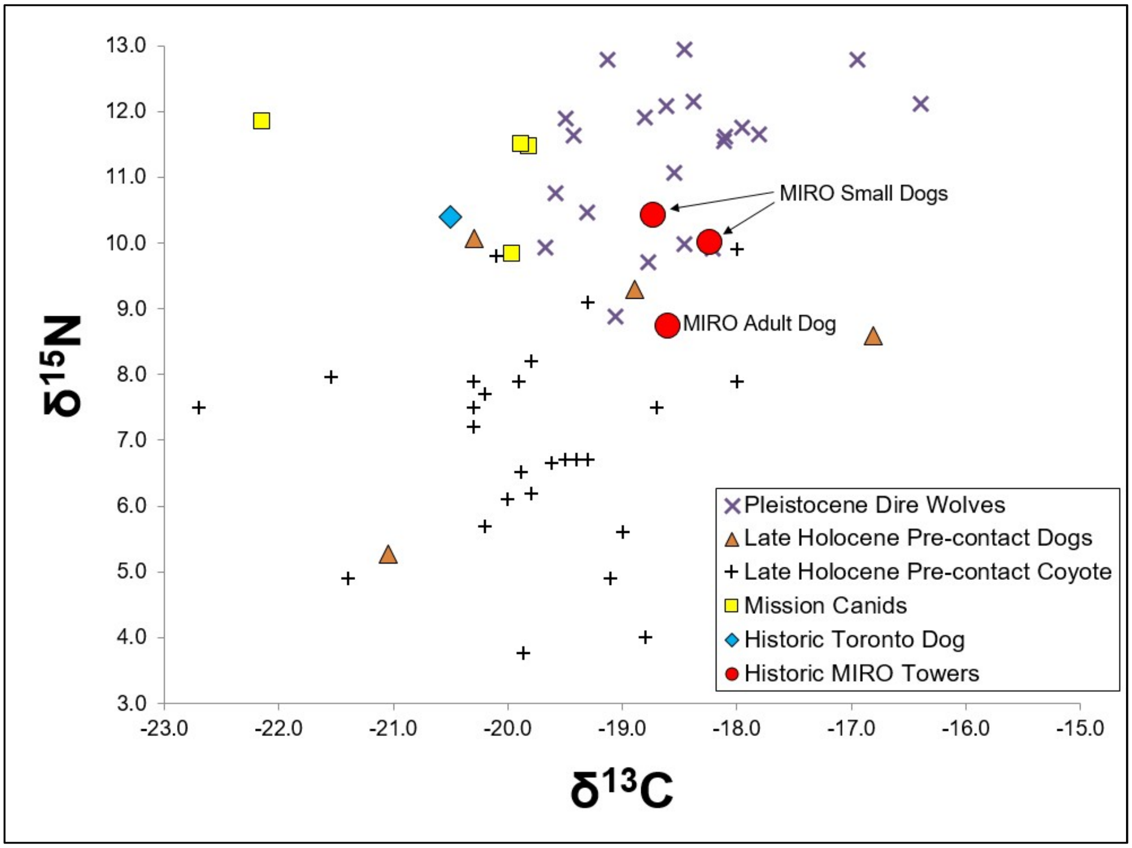

Figure 5. $\delta^{13}C$ and $\delta^{15}N$ values for the three MIRO Towers dogs and other canid samples.

is initiated in week five with nursing declining significantly by week eight and completed by age 10 weeks (Packard et al. 1992). In domesticated dogs, puppies can be weaned to solid food as early as two weeks. Prior to this point, they will regurgitate the solids. Their milk-to-solid ratio is highly variable within and between litters from two to seven weeks (Malm and Jensen 1996), but generally ends by 8-10 weeks. Milk consumption in the latter weeks is also constrained by human behavior (i.e., pups are taken away from their mother). These values are consistent with the age estimates (5-12 weeks) for the two pups.

High $\delta^{15}N$ values in the adult dog indicates that the MIRO Towers dogs had a diet rich in meat, similar in composition to domesticated dogs from precontact sites in central California, canids (likely domesticated dogs) from missions in central California, and late Pleistocene dire wolves from southern California. The generally low $\delta^{13}C$ values indicate that these dogs did not consume significant amounts of seafood or maize-derived foods (including, for example, corn-fed pork or beef). That is, the stable isotope data suggest that the dogs were fed with high-quality foods.

In sum, the evidence for significant investment in the provisioning and the careful positioning and burial of the dogs in a formal grave, as opposed to haphazardly tossing them into a pit or disposition in a landfill, suggests that these animals had value to their owners. The premature death, then, of one productive adult and two juveniles would have been a significant loss to the owners.

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