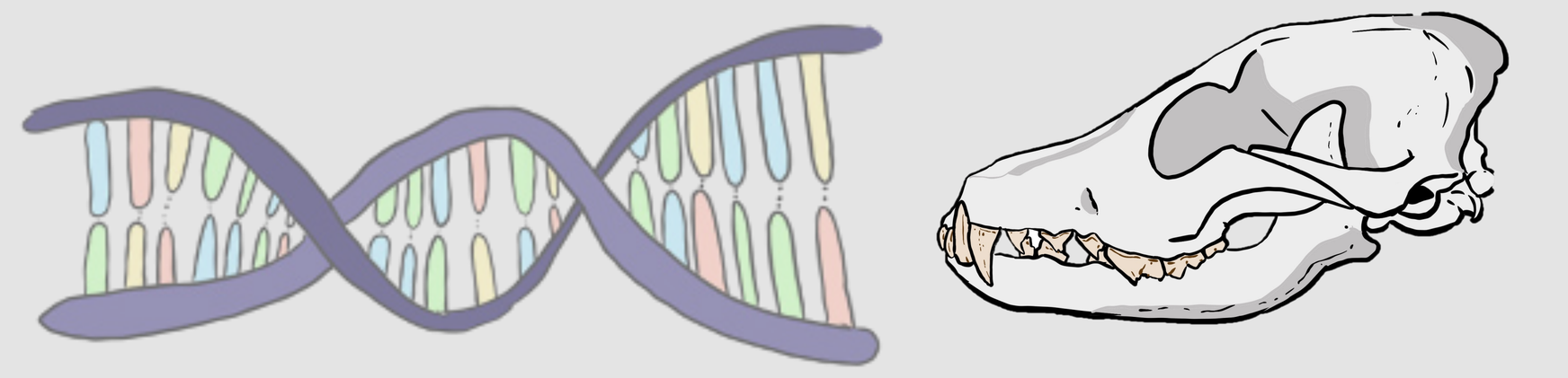
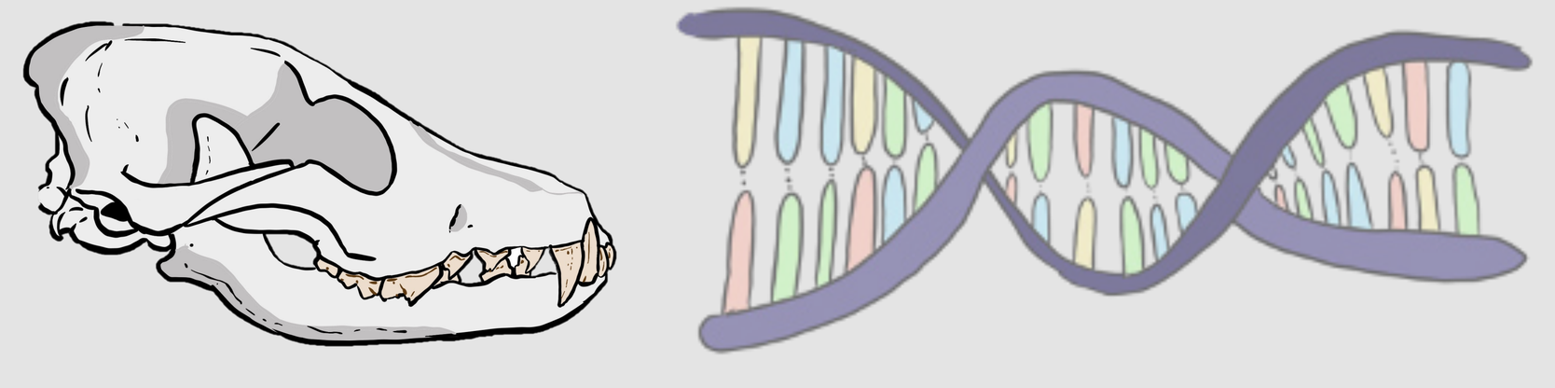


Exploring Human-Canid Relationships of the 17th Century Northern Rockies



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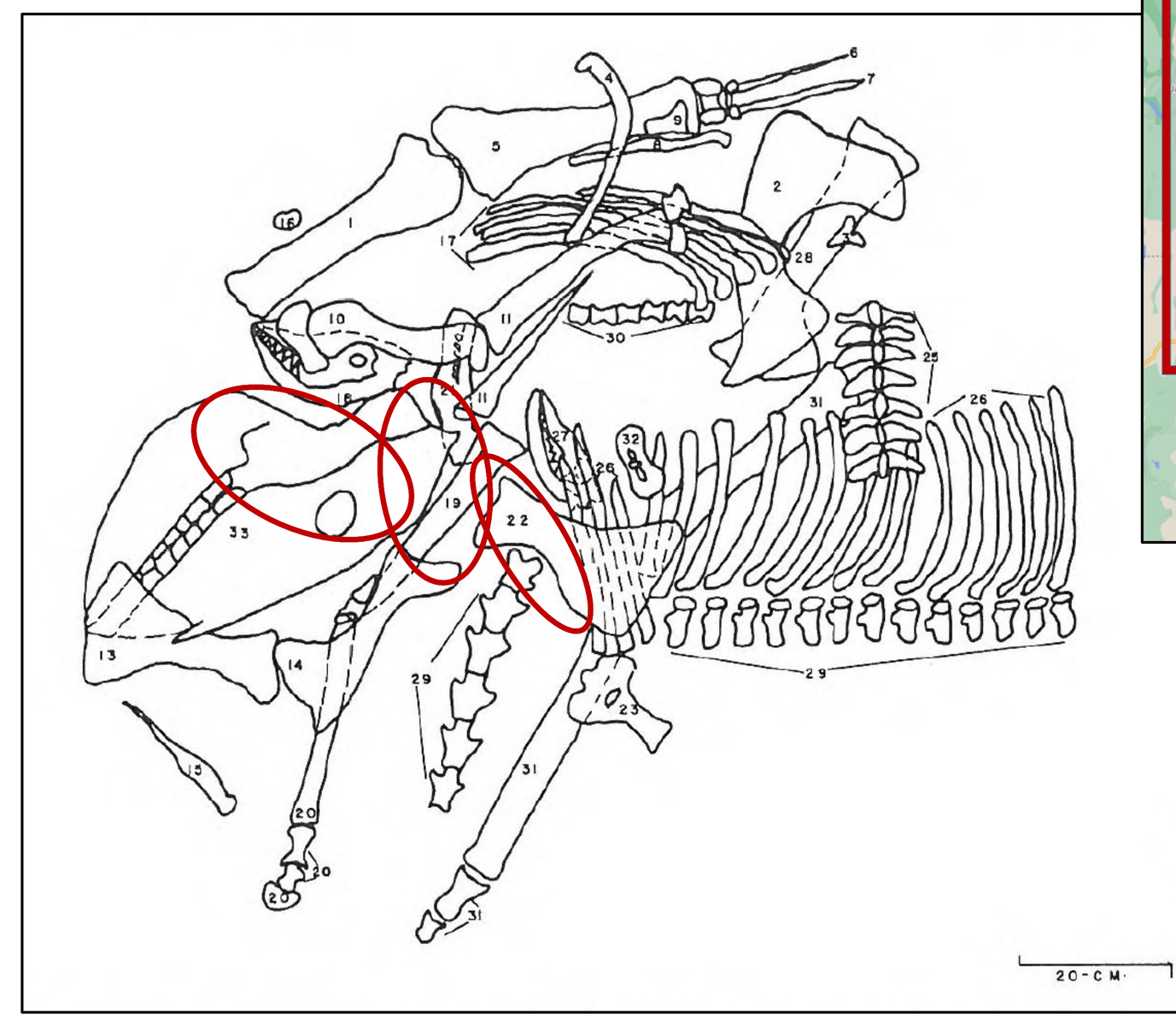
ABSTRACT

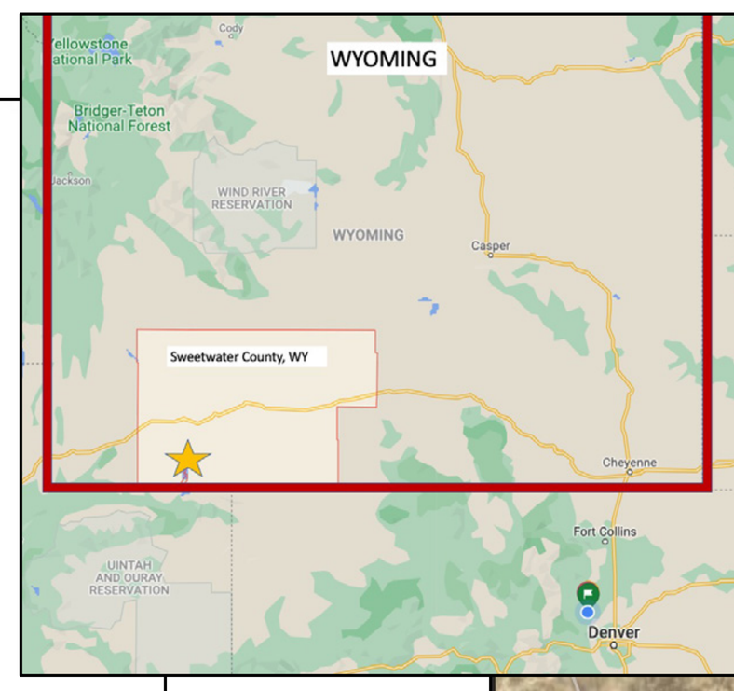
Prior to European colonization, domestic and wild taxa played a variety of unique roles in North American cultures: in some Plains cultures, dogs served as beasts of burden on long journeys, while wild canids were honored for their hunting prowess and intelligence. However, the colonial extinction of Indigenous dogs after European contact and the ambiguity of morphological distinctions of canids in Plains archaeological sites can make it difficult to characterize human-canid relationships and understand how these relationships changed with introduction of new domesticates—particularly the domestic horse, which transformed many Plains societies in recent centuries. At the site of Black's Fork, WY, a ritual inhumation of one of the continent's earliest Indigenous domestic horses was found in conjunction with the remains of three canid skulls identified as coyote but presenting ambiguous morphological traits also suggestive of dog. This site provides an important opportunity to explore the relationship between newly introduced domesticates and human-animal relationships. First, to identify species, we conducted detailed morphological and osteological analysis, using structured light scanning to conduct 3D measurements. We then extracted DNA from a molar in each individual and sequenced mitogenome-enriched DNA to assist in species identification, explore the potential of hybrid individuals, and identify relationship between specimens. Analyses of the mitochondrial DNA (mtDNA) suggest that all three samples are coyote in origin, indicating at least female coyote parentage. To assess life history and interaction with humans, we performed taphonomic and osteological analyses. MtDNA analysis confirmed the most matches with the coyote mitochondrial index genome, confirming, at least, female coyote parentage. Results indicated that these canids died healthy, gracile adults without dental pathology or obvious trauma. Canids were butchered and disarticulated from their post cranial skeletons with a sharp, metal tool. Despite the presence of intermediate morphological traits, the presence of coyote mtDNA, lack of dental pathology, and general good health of these canids suggests that the Black's Fork canids were coyotes or coyote-dog hybrids likely subsisting on wild food sources. Further research is necessary to explore the association between domestic horses and wild canids, and its significance for the transition to horse pastoralism in the northern Rockies.

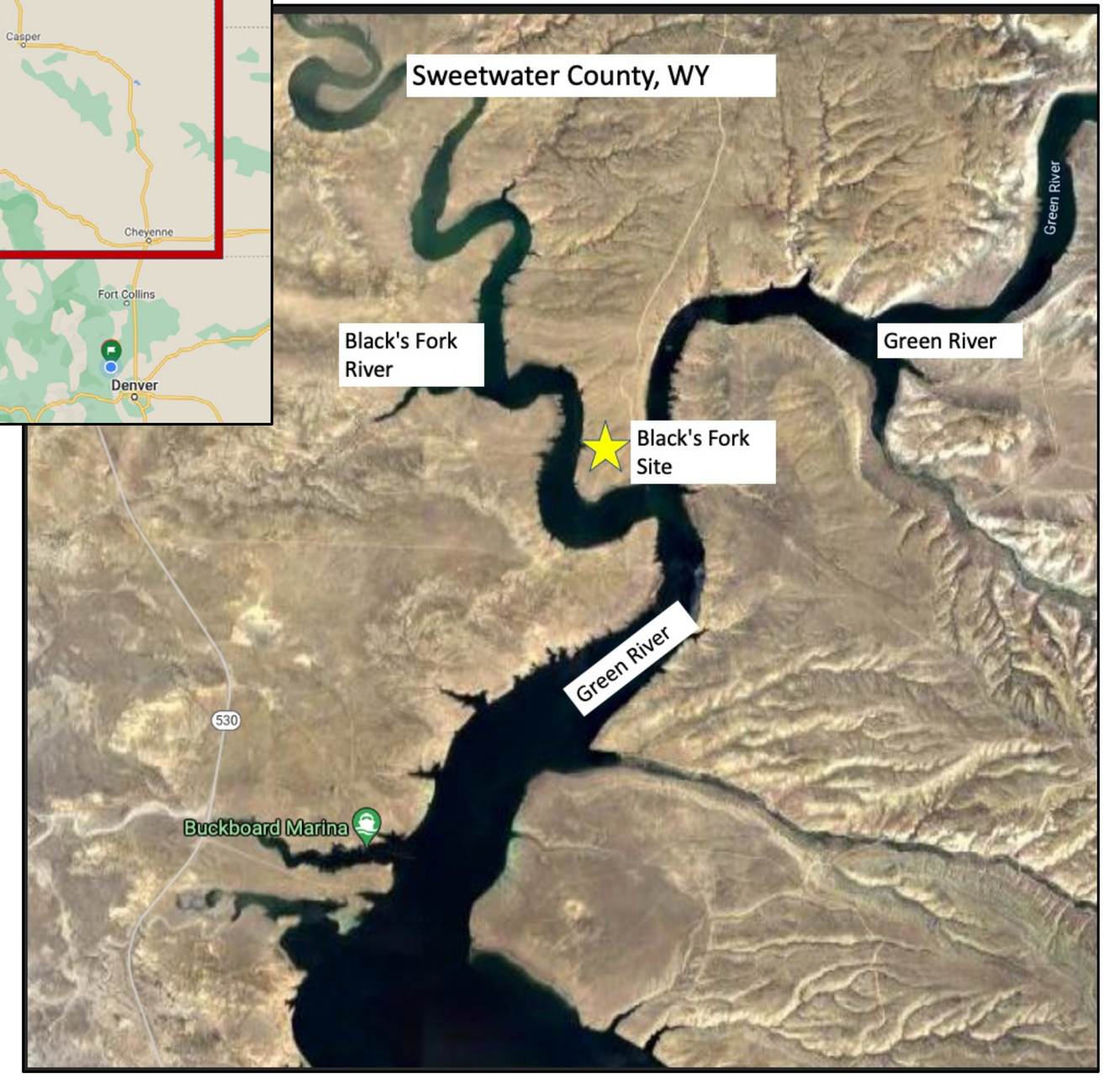
SUMMARY OF THE BLACK'S FORK SITE

- Black's Fork is an early historic site in Southwestern Wyoming, a region which borders the Great Plains. Weather can be extremely cold and arid, leading to excellent preservation of remains. (Eckles et al. 1994; Thornhill 2021)
- Dating confirms a median date for skeletal remains of 1640, making this one of the earliest Indigenous domestic horse interments on the continent. (Thornhill 2021)
- Insect activity puts time of horse's death in early summer or late spring and confirms that the horse died on site (Lockwood et al. 1994). Canids were identified in 1994 as coyotes with cut marks to two canid skulls present on the tympanic bulbs, created with a metal instrument. (Eckles et al. 1994; Thornhill 2021)
- Butchery on the horse at Black's Fork does not indicate consumption and does not indicate that the horse was butchered in styles typical of the place and time for large game. (Eckles et al. 1994; Thornhill 2021) suggesting ritual butchery, rather than butchery for consumption (Thornhill 2021).
- Lab analysis of the canid skulls identified features typically associated with domesticated dogs (steep forehead, alignment of posterior pallet with the back of the second molars, lower premolar length). Suggesting these canids may be coyote-dog hybrids (Bowler-Monagle 2020).



A diagram of the Black's Fork horse interment with canid remains circled in red. *Visual is taken from the paper An Early Historic Period Horse Skeleton from Wyoming by Eckles et. al., 1994. Circles added by Sarah Buckser for this poster.*





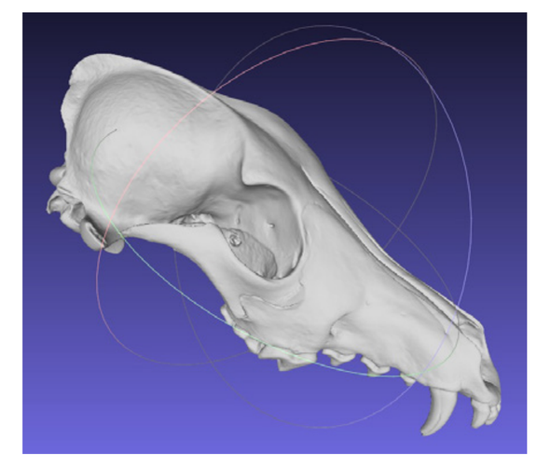
Site 48SW8319 shown on a map of Wyoming and a terrain map of Sweetwater County, WY.

MATERIALS AND METHODS

- OSTEOLOGICAL AND MORPHOLOGICAL ANALYSIS
  - Taphonomic analysis - staining, trauma, human modification, insect activity, weathering, abiotic modification, plant activity
  - Osteological - tooth wear, tooth decay, skull shape, orbital angle, pathology, age and sex estimate, pathology, degree of cranial suture fusion assessed
  - Morphological – morphology of skull, dentition, mandibular body

Osteological and morphological analyses were performed in the CU Boulder Museum of Natural History

- 3D SCANNING AND MEASUREMENTS
  - Creation of true-to-size digital, 3D models with structured light scanning (two hemimandibles and one cranium per canid)
  - Articulated and measured in Blender and MeshLab using point and click measuring function
  - Measured – orbital angle, mesio-distal diameter of maxillary p4, skull length, snout index (widest diameter of pallet divided by length of skull), mandibular M1 mesio-distal diameter, skull height
  - Measurements chosen show promise in differentiating canid species after re-evaluation in recent scholarship (Fisher 2019; Janssens et al. 2016, 2019)



Screen shot of the digital model for specimen 23, taken in MeshLab.

- GENETIC ANALYSIS OF MITCHONDRIAL DNA – Performed at the Laboratory of Molecular Anthropology and Microbiome Research at University of Oklahoma
  - Sampled dentine of left, mandibular M2 tooth, digested samples of dentine, removed MtDNA with magnetic beads
  - MtDNA amplified and cleaned up, length of fragments measured using gel electrophoresis in agar gel, concentration of samples measured using Qubit
  - Negatives maintained through entire process, tested alongside samples to check for contamination
  - Final samples sequenced and compared to reference sequences of coyote, gray wolf, and dog
  - All extraction work performed in clean room. Amplification, clean up and sequencing performed with equipment cleaned with bleach and/pr ethanoyl and water.

To prevent contamination, MtDNA samples were extracted in a clean room while wearing Tyvek suits over sterile scrubs, several pairs of gloves sanitized with bleach, face masks, goggles, and sterile clogs.

MAMR

RESULTS

1. MORPHOLOGICAL AND OSTEOLOGICAL

Table 1: Weathering and Non-Human activity on each skeletal element

Specimen	Weathering Stage	Staining	Insect Activity	Root Etching
Cranium of Specimen 22	2	Black, stippled staining present on all surfaces of the cranium, but concentrated on right half of rostrum, right palatine, right zygomatic, right tympanic bulb, incisors and base of canine teeth. Ocher colored staining on the left half of the rostrum, left eye socket, and left tympanic bulb. Dark brown staining between cusps on all teeth.	Absent	Mild root etching above P14.
Right Hemi-mandible of Specimen 22	1	Heavy, black, stippled staining in the right masseteric fossa and bone surrounding M1 and M2.	Absent	Very faint root etching on body inferior surface of mandible body
Left Hemi-mandible of Specimen 22	1	Minimal black stippled staining present on the masseteric fossa. Black staining on mesial/labial surface of teeth. Minimal staining on molars between cusps, light brown. Black staining at the base of canine tooth.	Absent	Very faint root etching on body inferior surface of mandible body
Cranium of Specimen 23	2	Black staining, stippled appearance (like black mold). Concentrated on right side of rostrum, right zygomatic, right tympanic bulb. Dark brown staining at gumline and in cusps of M1,M2, M18, and M20 most affected.	Absent	Mild root etching across many surfaces, deeper root etching on right tympanic bulb, right zygomatic, and right, distal side of rostrum.
Right Hemi-mandible of Specimen 23	1	Black, stippled staining concentrated on lateral side, but is present on medial surface. Dark brown staining along gumline. Minimal staining on molars between cusps, light brown . Black staining at the base of canine tooth.	Absent	Mild root etching on inferior surface of mandible body
Left Hemi-mandible of Specimen 23	1	Absence of stippled staining, but the anterior, lateral surface is stained grey. Brown staining along gumline, with patches of dark brown by mesial surface of M21, M22, and M23. Black staining at the base of canine tooth.	Absent	Mild root etching on inferior surface of mandible body
Cranium of Specimen 25	3	Black, stippled staining on superior surface of Incisives, nasals, maxillae, frontals, zygomatics, parietals, occipital. Ocher colored, thumbprint sized, circular stains above left carnassial, on left maxilla where maxilla meets palatine, and in front of left infraorbital foramen. This may be a result of varnish painted on teeth. Light brown staining between cusps of M1, M2, M18 and M20.	Small, circular holes across frontalis bones, parietals, nasalis, and zygomatics	Deep root etching above left carnassial tooth, right tympanic bulb, and right side of the braincase.
Right Hemi-mandible of Specimen 25	2	Black stippled staining on inferior surface of body of mandible. Ocher colored standing along gumline and on the mesial surfaces of M21, M22, and M23. The latera and medial surfaces of the mandibular body and the ramus are in excellent condition and free of black or dark brown staining. Black staining on incisors and at base of canine tooth.	Absent	Mild root etching on medial side of mandibular body and on superior half of ramus
Left Hemi-mandible of Specimen 25	1	Black, stippled staining on inferior surface of body and on superior, medial surface of ramus. Black staining on incisors and canine tooth, with dark brown staining on all premolars. Grey, stippled staining in the masseteric fossa.	Absent	Mild root etching on of mandibular body

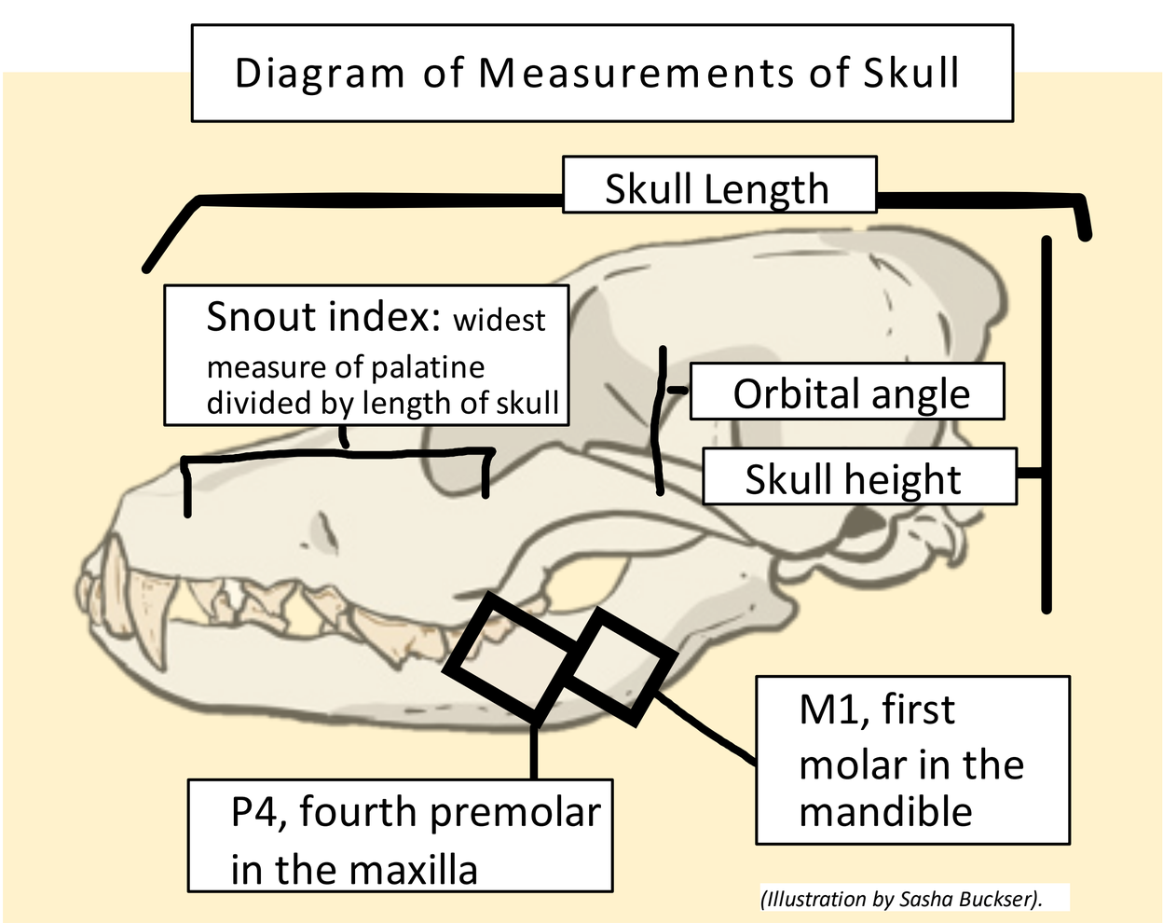
An example of the black stippled staining

Incisors of all three canids and the molars of canid 23 show enamel infraction, evidenced by the parallel fracturing of enamel that has accumulated black staining.

Typically enamel infraction is associated with the immense bite force necessary to subdue prey. The incidence of enamel infraction in modern dogs is low. Infraction is still often seen in modern wild canids (Soukup et. a., 2015).

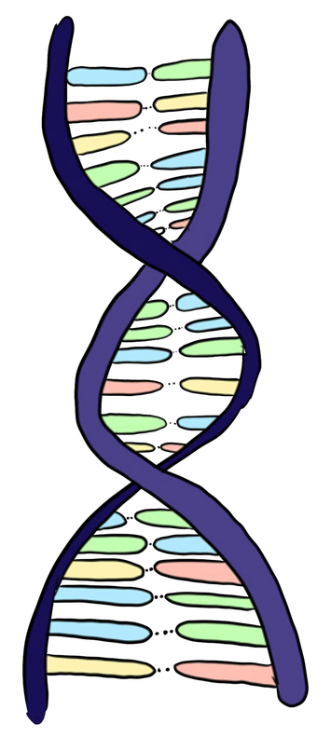
Table 2: Measurements of digital models compared with measurements from published literature

Measurement	Specimen 22	Specimen 23	Specimen 25	Coyote (Bee and Hall 1951)(Appendix B)	Archaeological dog (Janssens et al. 2019; Schimming and Silva 2013)	Archaeological coydog (Bee and Hall 1951)
Orbital Angle	47.5 degrees	49.5 degrees	45.5 degrees	44.4 degrees	49-55 degrees	46 degrees
Mesio-distal diameter of maxillary P4	18.5 mm	20.3 mm	18.8 mm	*19.3 mm*	21.1 mm	-
Skull length	183.2 mm	202.2 mm	198.8 mm	*203.8 mm*	213.5 mm	-
Snout width index	0.42	0.56	0.48	*0.37*	0.40	-
Mandibular M1 mesio-distal diameter	21.4 mm	22.3 mm	21 mm	*22.1 mm*	17-24 mm	-
Skull height	62.7 mm	66.2 mm	64.4 mm	*58.1 mm*	61.1 mm	-

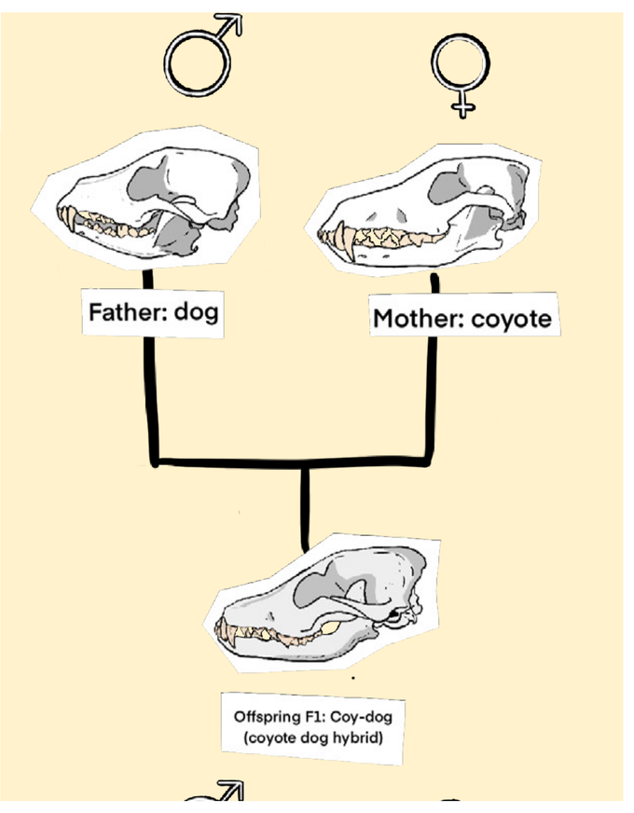


2. GENETIC RESULTS

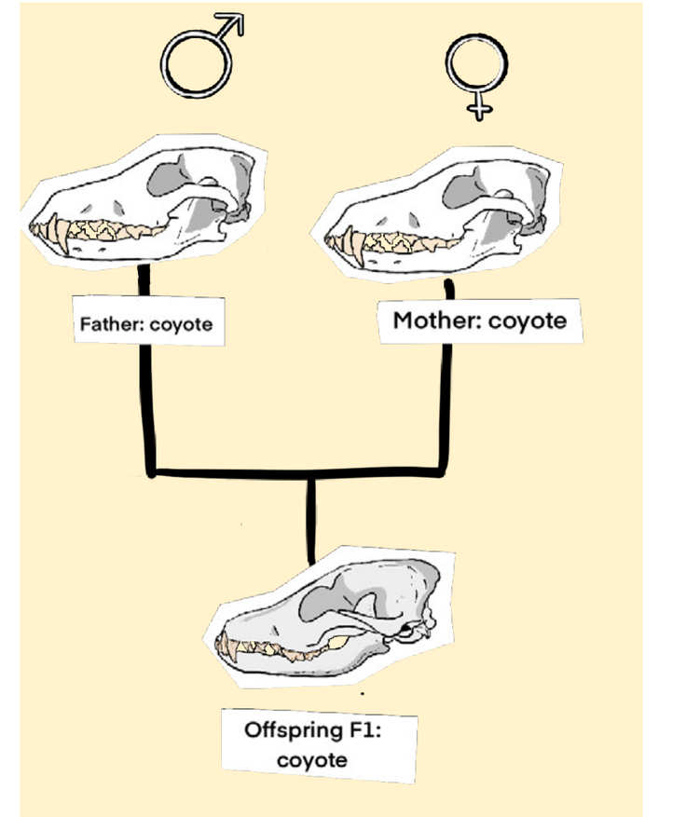
(Illustrations by Sasha Buckser).



- Like soft tissue at this site, the cold arid climate preserved DNA exceptionally well, allowing for minimal degradation, comparable to a more modern sample. This allowed many matches to be found and contamination to be easily removed with analytic software.
- When mitochondrial DNA was compared to reference sequences from the NCBI database for coyote, gray wolf, and dog, the most matches were that of coyote for all three specimens, indicating at least female coyote parentage.
- Mitochondrial DNA only reflects maternal heritage. It is possible that these individuals may be hybrids with a domesticated dog for a father, or full coyote individuals. There is also a possibility that they may be wolf, coyote hybrids, but morphology conflicts with this option. Possible family trees are on the right.

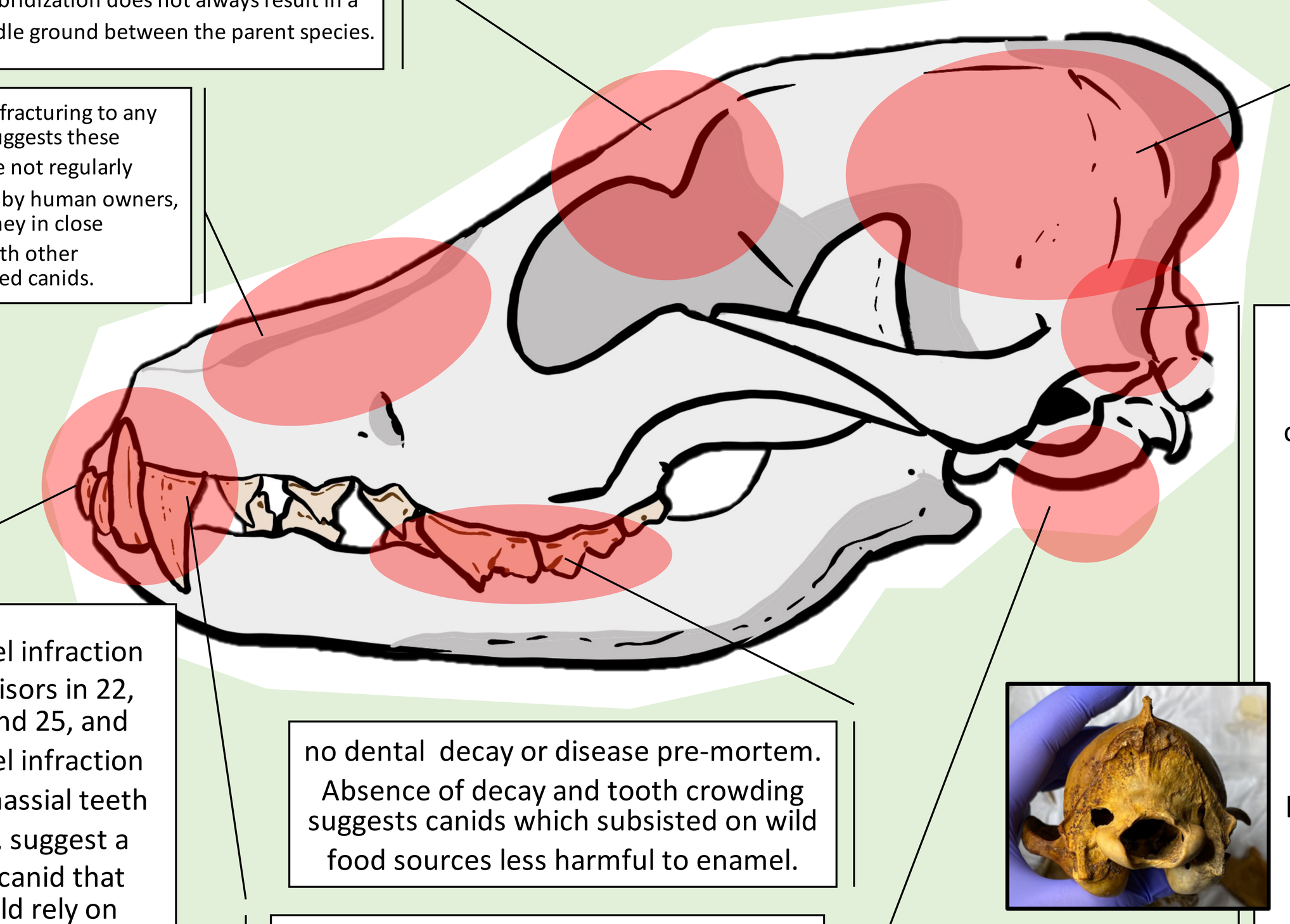


Family Tree, hybrid



Family Tree, coyote

DISCUSSION



Forehead angles for 22 and 23 are steeper than 25, but it is important to remember hybridization does not always result in a middle ground between the parent species.

The lack of fracturing to any rostrums suggests these canids were not regularly disciplined by human owners, nor were they in close quarters with other domesticated canids.

The brain cases for all three canids were widest at the base of the temporals. This is consistent with a coyote ID.

Specimen 23 had a circular hole in the back of its occipital . Margins of the fracture suggest it happen at the time of death or directly after, while the bone was still wet. This may be the result of the metal instrument used to disarticulate slipping or a result of a slip during the killing process. It may also be unrelated to human activity. .

Enamel infraction of incisors in 22, 23, and 25, and enamel infraction of carnassial teeth in 23, suggest a wild canid that would rely on significant bite force to seize prey or consume hard organic objects.

no dental decay or disease pre-mortem. Absence of decay and tooth crowding suggests canids which subsisted on wild food sources less harmful to enamel.

Morphology of teeth in Canid 25 suggest male sex. Unable to determine sex for canid 23 and 22. All canids show adult eruption of and wear on teeth. Canid 23 and 22 show little to no wear on tooth cusps, suggesting a young adult age. Specimen 25 shows = more cusp wear, suggesting an adult age.

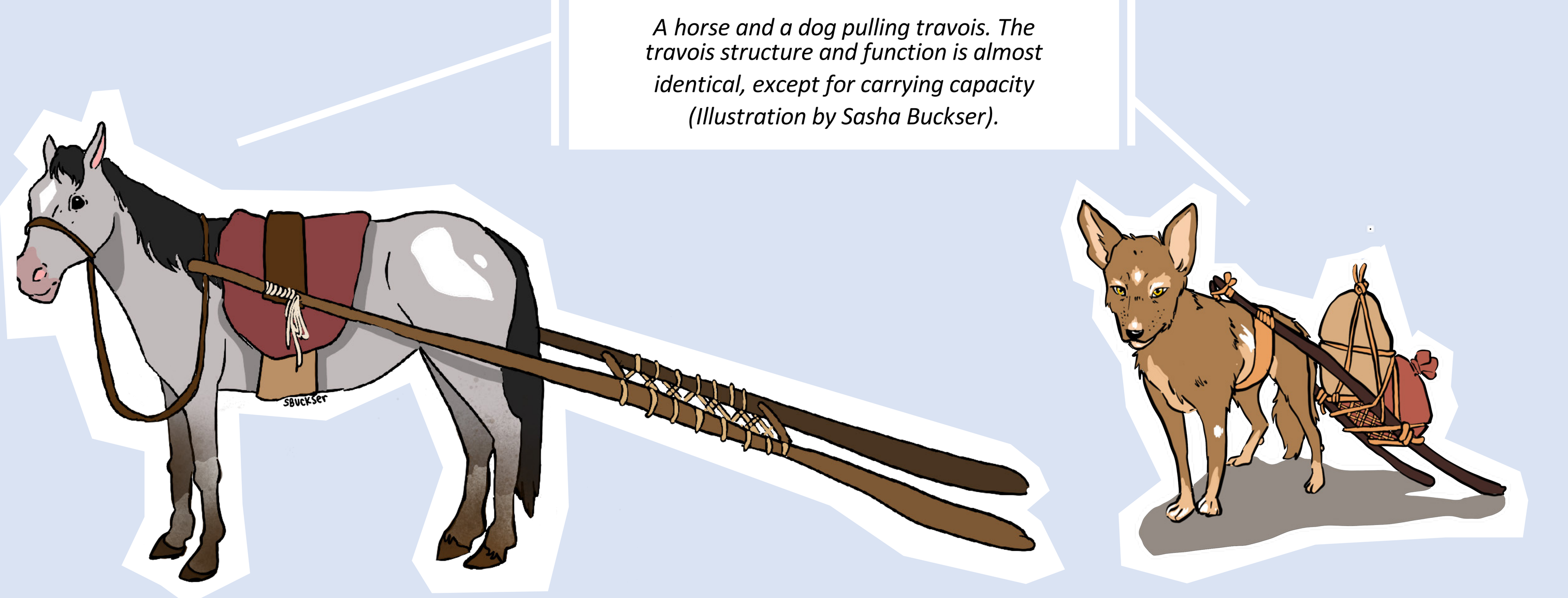
Cut marks on the tympanic bulbs of 23 and 25 indicate skulls were disarticulated from post cranial skeleton with sharp metal instrument. Lack of cutmarks to any other part of the skull or mandibles suggests that this was the only butchery performed on the skulls, and they were likely not butchered for their meat or skin.

(Illustration by Sasha Buckser).

- Evidence suggests all three Black's Fork canids were coyotes or wild coyote-dog hybrids.
  - Doesn't preclude involvement with humans--ethnohistoric sources report wild canids with low cortisol levels integrating into human culture. (Fogg et al. 2015)
- Morphological and osteological evidence support canids with little dependency on humans de to lack of dental pathology, lack of rostrum fractures, and enamel infraction (Losey et al. 2014)
- Lack of fracturing to rostrum and facial bones indicated these canids were not struck in the snout, a common method of disciplining dogs of this time period (Losey et al. 2014; Soukup et. a., 2015)
- Gracility and coyote MtDNA matches suggest wild canids, likely full coyotes, subsisting on wild food sources and dying in young adulthood.
  - 25, displays tooth wear and cranial suture fusion, of an older canid than 22 and 23 and is the only skull placed face down in the interment –older, more gracile, and with a gentler forehead slope than 22 and 23, 25 may have appeared most coyote-like
- Cut marks on the tympanic bulbs and the absence of cut marks on mandibles or craniofacial region suggest canid skulls being disarticulated from post cranial skeletons and placed without de-fleshing
  - Stippled black staining supports –concentrated on areas furthest underground where soft tissue remains the longest
- Meaning of the association of the canid remains and the Black's Fork horse will require much further research to understand, but evidence and ethnohistoric sources suggest two possible themes:
  - Coyote-Dog Hybrids: association may be related to the shifting of roles from dogs to horses (Bowler-Monagle 2019; Bethke and Burtt 2020).
  - Coyotes: may be related to hunting or ritual, coyotes and wolves in early American Northern Rockies served as important figures in mythology and religion, often illustrating hunting skill, intelligence, strategy (Fogg et al. 2015; Hodge 2019)

CONCLUSION

In this project we examined canid remains to identify species and life history, providing more information about a key site in the transition to equestrian culture in early-historic North America. Genetic and morphological information suggest that these were wild coyotes or coyote-dog hybrids similar in behavior and appearance to wild coyotes. Further research will be needed to determine what the association of the Black's Fork canids and horse remains represent. However, a review of ethnohistoric sources suggest that the presence of these canid skulls demonstrate symbolism in this interment related to the transition to equestrian culture during the early-historic period in North America. The Black's Fork canids serve as an important example of utilizing canid remains to understand site context, and a reminder of the deep and vital relationship between Indigenous peoples of early North America and the canids surrounding them.



A horse and a dog pulling travois. The travois structure and function is almost identical, except for carrying capacity (Illustration by Sasha Buckser).

WORKS CITED

- Bethke, Brandi, and Amanda Burtt (editors)
  2020 *Dogs: Archaeology Beyond Domestication*. University Press of Florida, Gainsville, FL.
- Eckles, David, Jeffrey Lockwood, Rabinder Kumar, Dale Wedel, and Danny Walker
  1994. An Early Historic Period Horse Skeleton From Southwestern Wyoming. *The Wyoming Archaeologist* 38(Fall 1994):55–68.
- Fisher, Abigail E.
  2019. When is a wolf a dog? Combined geometric morphometrics and stable isotope analyses for differentiating wild from domestic canids on the Northern Plains. *Plains Anthropologist* 64(252):316–349. DOI:10.1080/00320447.2018.1548064.
- Fogg, Brandy, Nimachia Howe, and Raymond Pierotti
  2015. Relationships Between Indigenous American Peoples and Wolves 1: Wolves as Teachers and Guides. *Journal of Ethnobiology* 35(2):262–285. DOI:10.2993/etbi-35-02-262-285.1
- Hodge, Adam R.
  2019. *Ecology and ethnogenesis: an environmental history of the Wind River Shoshones, 1000-1868*. Early American places. Co-published by the University of Nebraska Press and the American Philosophical Society, Lincoln, Nebraska.
- Janssens, Luc, e, Inge Spanoghe, Rebecca Miller, and Stefan Van Dongen
  2016. Can orbital angle morphology distinguish dogs from wolves? *Zoomorphology* 135(1):149–158. DOI:http://dx.doi.org.colorado.idm.oclc.org/10.1007/s00435-015-0294-3.
- Janssens, Luc, e, Verhaert, Leen, Berkowic, Daniel, and Dominque Adriaens
  2016.A Standardized framework for examination of oral lesions in wolf skulls (Carnivora: Canidae: *Canis lupus*). *Journal of Mammalogy*. 97(4): 1111-1124 DOI:10.1093/jmammal/gyw058
- Janssens, Luc, Angela Perri, Philippe Crombé, Stefan Van Dongen, and Dennis Lawler
  2019. An evaluation of classical morphologic and morphometric parameters reported to distinguish wolves and dogs. *Journal of Archaeological Science: Reports* 23:501–533. DOI:10.1016/j.jasrep.2018.10.012.
- Lockwood, Jeffery, Rabinder Kumar, and David Eckles
  1994. Myster of the Slaughtered Horse: Solving a 400-Year-Old Death with Forensic Entemology. *American Entomologist* 1994(Winter):210–215.
- Losey, Robert J., Erin Jessup, Tatiana Nomokonova, and Mikhail Sablin
  2014. Craniomandibular Trauma and Tooth Loss in Northern Dogs and Wolves: Implications for the Archaeological Study of Dog Husbandry and Domestication. *PLOS ONE* 9(6):e99746. DOI:10.1371/journal.pone.0099746.
- Monagle, Victoria
  - 2019. Do hunter-gatherer sites in Wester North America Indicate the Use of Hunting Dogs. University of New Mexico, Albuquerque, NM
  - 2020 Unpublished Supplementary Appendix , Canids from Black's Fork and species identifications.
- Taylor, William, Timothy Treal, Isaac Hart, Emily Lena Jones, Joan Brenner-Coltrain, Jessica Thompson Jobe, Brooks B. Britt, H. Gregory McDonald, Yue Li, Chengrui Zhang, Petrus Le Roux, Carlton Quinn Shield Chief Gover, Stéphanie Schiavinato, Ludovic Orlando, and Patrick Roberts
  2021. Interdisciplinary Analysis of the Lehi Horse: Implications for Early Historic Horse Cultures of the North American West. *American Antiquity* 86(3):465–485. DOI:10.1017/aaq.2020.109.
- Thornhill, Cassidee A.
  2021. Reanalysis of equid faunal remains from the Blacks Fork River site (48SW8319): A unique look at a protohistoric horse in Wyoming. *Plains Anthropologist* 66(257):58–73. DOI:10.1080/00320447.2020.1819180
- Soukup, Jason W., Hetzel, Scott and Annie Paul
  2015. Classification and Epidemiology of Traumatic Dentoalveolar Injuries In Dogs and Cats: 959 Injuries in 660 Patient Visits (2004-2012). *J VET DENT* 32(Spring): 6-14

Drawn visuals and maps (with exception of burial diagram) by Sasha Buckser

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