NORTHEAST WILDLIFE DNA LABORATORY
APPLIED DNA SCIENCES, EAST STROUDSBURG UNIVERSITY, 562 INDEPENDENCE ROAD, SUITE 114,
EAST STROUDSBURG, PA 18301
570-422-7892

DNA EVALUATION REPORT

Submitted by:
Kelcey Burguess
Black Bear Biologist
New Jersey Division of Fish and Wildlife

Case Number 14-1964
Laboratory ID NJ-BB-H-030
Nature of Incident: Fatal Black Bear Attack
Services Requested: Matching and Identification

Date Received at DNA Lab: 9/22/2014

Description of Evidence Submitted: Morphological analysis of bear skull in Appendix A. Evidence log can be found in Appendix B

Summary of Results: September 22, 2014. Three swabs submitted from black bear included: mouth, front right paw and front left paw (H-030mouth, H-030RTpaw and H-030LTpaw). Samples were tested for the presence of human blood using Hexagon Obti test strips. All three swabs tested positive for the presence of human blood (Figure 1). September 23, 2014. Contents from the suspected bears stomach (001A) (Figure 2), esophagus (019A) and oral cavity (024) were submitted for evaluation. The contents found in the black bears stomach are illustrated in Figure 3. Human tissue was identified by a positive Hexagon Obti test result (Figure 4). Clothing found in suspected black bears stomach was identified by comparison to evidence submitted of victims clothing (Figure 5). Clothing in stomach content totaled 61.02 grams or 3% of total weight. Hair found in the suspected black bears stomach was morphologically compared (hairdatabase.com). Morphological features identified the hair as belonging to human (Figure 6). Content of suspected black bears esophagus (Figure 7) is broken down into present weight in Figure 8. A total of 12.9 grams or 61% of the esophagus content tested positive for the presence of human tissue. The content of the oral cavity is represented in Figure 9. Positive human tissue (95% or 67.8 grams) was identified using Hexagon Obti test strips. Suspected black bears paws were submitted for examination where dry blood swabs were taken from all four paws and stored at -20^{o}C. A second confirmation test was completed to confirm the presence of human blood on the bear's paws. As similar to evidence submitted in Figure 1, samples from the front right paw and front left paw were analyzed with Hexagon Obti test strips. Results were positive and consistent with the initial two swabs submitted (H-030RTpaw and H-030LTpaw) (Figure 10). A total of twelve swabs (Figure 11) from victims bite wounds were submitted for DNA analysis and comparison to suspected black bears genetic profile. Results of swabs along with the black bears genotypic profile (Table 1) indicate the presence of two individuals. The results indicate a mixture of human DNA and bear DNA. The highly polymorphic microsatellites utilized for black bears are also able to amplify human DNA with less accuracy, thus, human DNA will amplify one or two alleles per loci whereas the black bear can amplify up to 12 alleles per loci. To confirm the mixture of DNA profiles, a tissue sample from the victim was evaluated with the black bear multiplex (Table 1). Results indicate a mixture of black bear and victim DNA. A final analysis on the black bear DNA was completed to determine the location of origin of the suspected black bear. The black bears profile was analyzed in the genotypic database of 329 New Jersey black bears and 31 eastern Pennsylvania black bear genetic profiles. Program STRUCTURE was utilized to determine the approximate origin of the black bear dependent on allelic frequencies (Figure 12) (Pritchard *et al.* 2000; Falush *et al.* 2003).

Figure 1: Preliminary test results from three initial swabs taken from the suspected black bears mouth, right paw and left paw. Swabs were tested for the presence of human blood using Hexagon Obti test strips. A positive result is indicated by the presence of two blue lines. All three swabs with their corresponding test strip indicated a positive result for the presence of human blood.

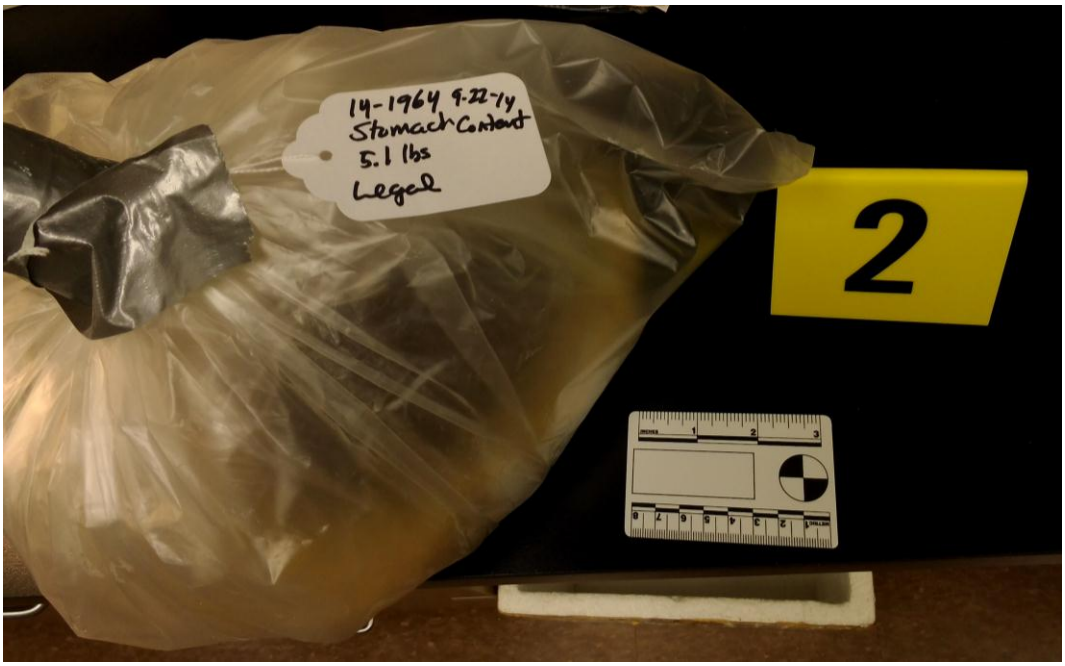

Figure 2: Stomach contents of suspected black bear submitted for analysis.

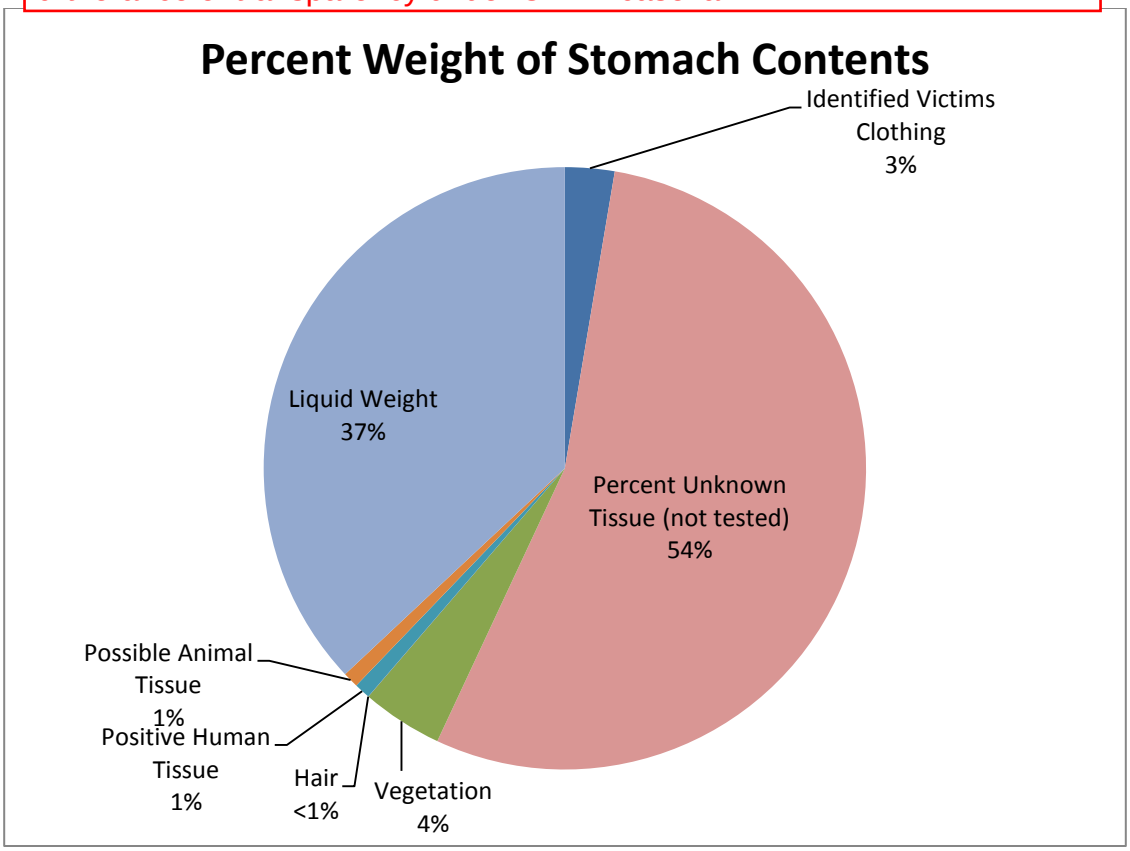

Figure 3: Pie chart representing the stomach content of bear submitted for examination. Human tissue was identified using Hexagon Obti test strips. A total of 1% of positive human tissue was identified. A total weight of 1,248.06 grams (54% of stomach content) of unknown tissue was found in the stomach of suspected bear but was not tested. A total of 61.02grams of victims clothing was identified in stomach content and totaled in 3% of the stomach content. Animal tissue was identified with Hexagon Obti test strips by a negative result for the presence of human blood (1%, or 19.28grams).

Figure 4: Tissue found in the stomach content of suspected black bear tested poisitive Hexagon Obti test strip for human. A positive test results is indicated by the presence of two blue lines shown above.

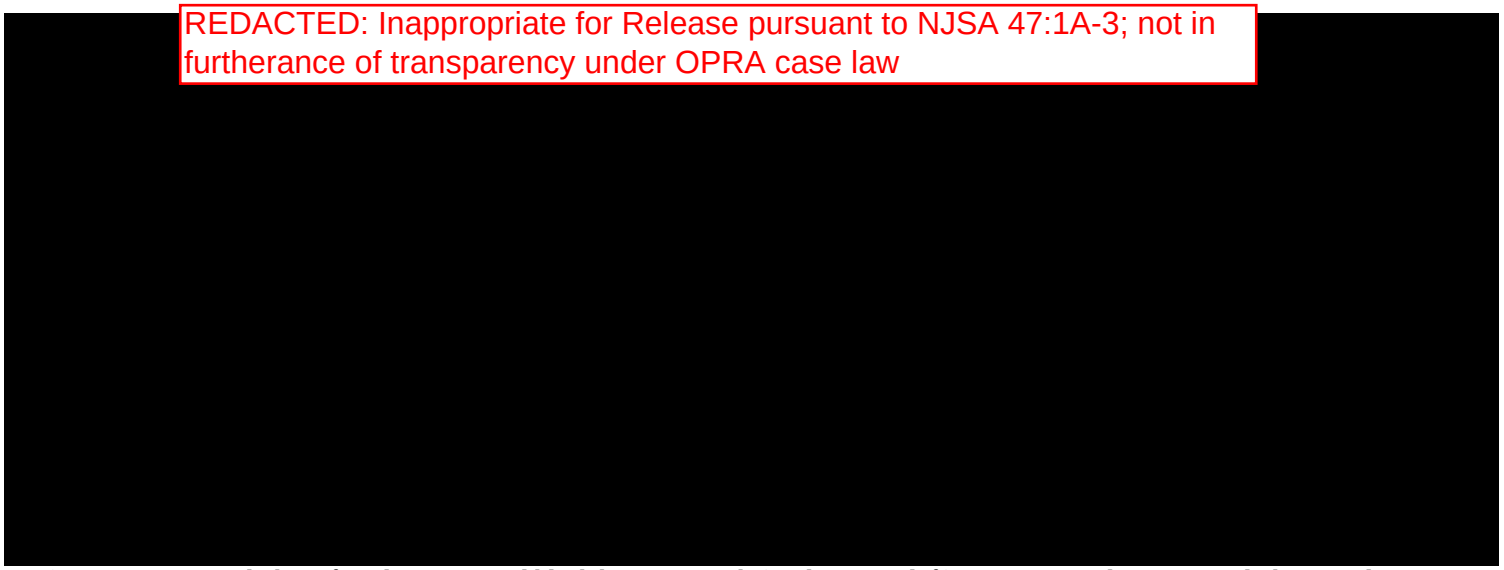

Figure 5: Victims clothing found in suspected black bears stomach (evidence #3; left) was compared to victims clothing evidence submittion (E-1). Right; represents the comparison in clothing found in the bears stomach to submitted evidence E-1.

Figure 6: Morphological comparison of known human hair (top) and hair found in black bears stomach contents (bottom). The human hair found in the black bears stomach has a dark fragmented medulla with a dark outer cuticle. It was consistent with human hair using the hairdatabase.com.

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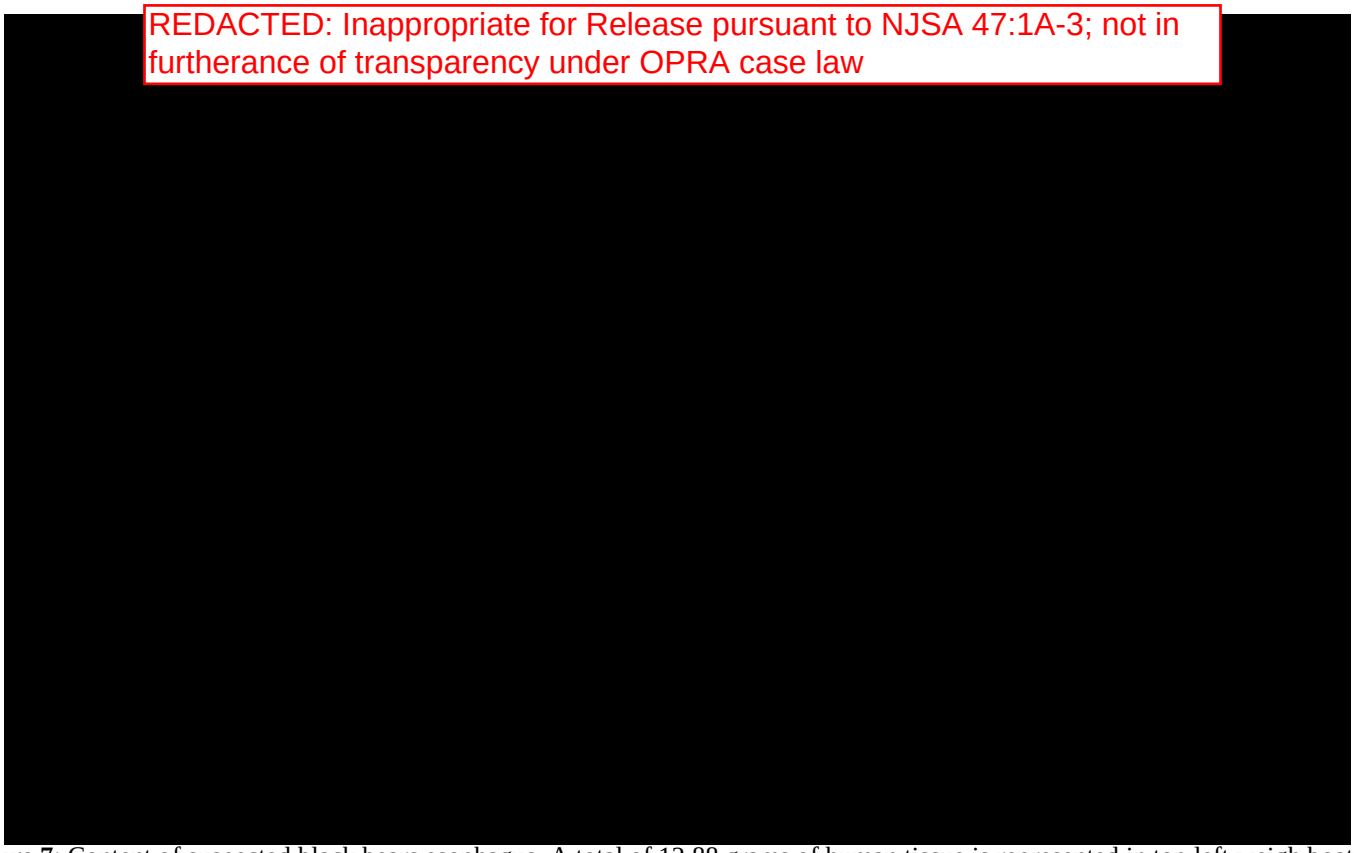


Figure 7: Content of suspected black bears esophagus. A total of 12.88 grams of human tissue is represented in top left weigh boat. Weigh boat to the right represents vegatation found in esophagus (1.26 grams or 6% content weight) and bottom left weigh boat represents the unknown tissue that was not tested (3.1 grams or 14% content weight).

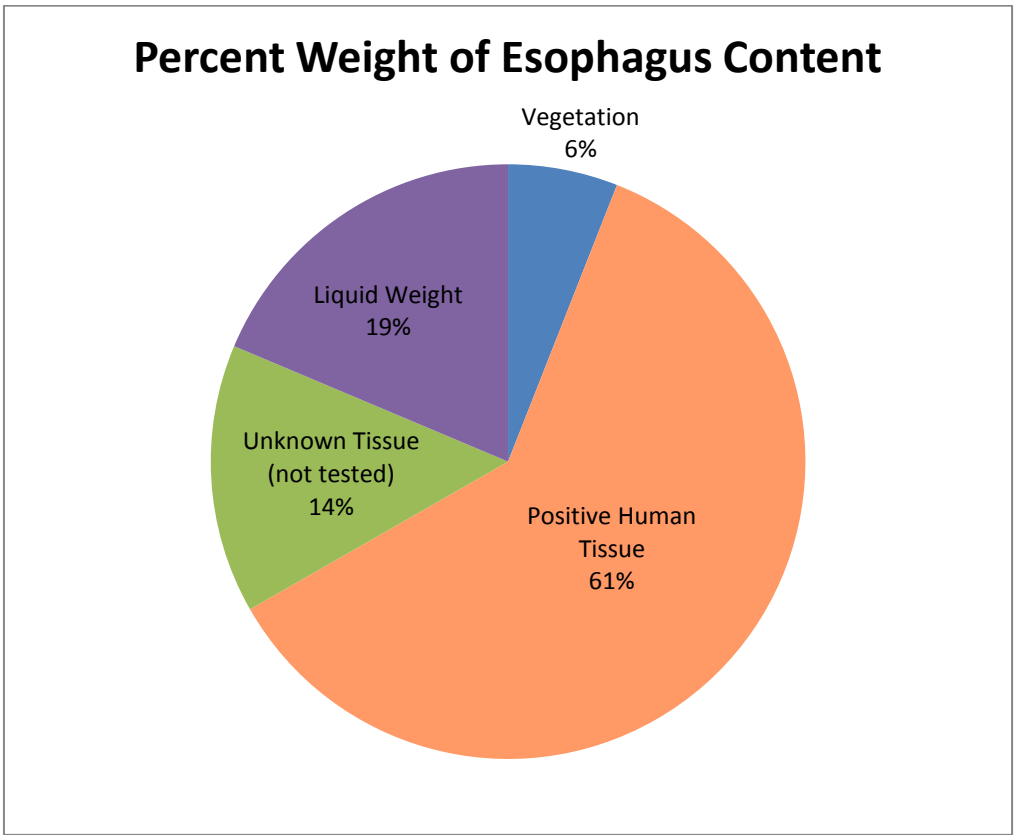


Figure 8: Pie chart break down of the contents examined in the suspected black bears esophagus. Positive identified human tissue was tested using Hexagon Obti test strips. A total of 61% or 12.88 grams of identified positive human tissue was found in the esophagus content. Tissue not tested was identified as unknown and resulted in a weight of 3.1 grams or a total of 14% content weight.

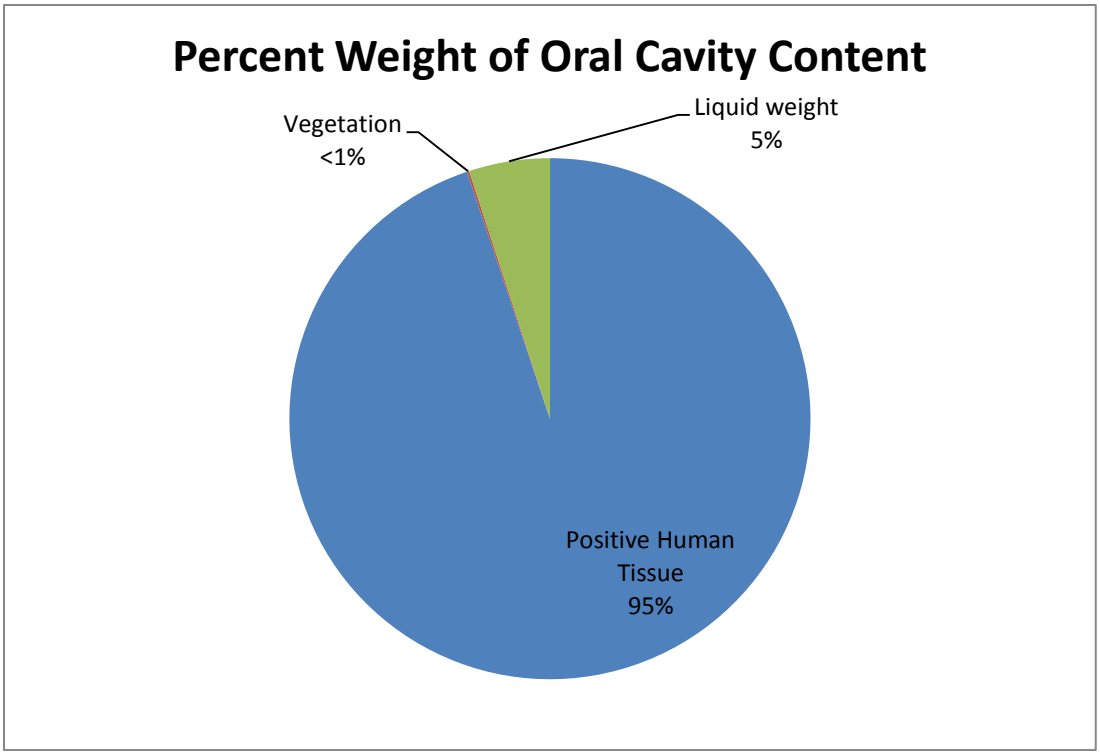


Figure 9: Pie chart break down of the contents examined in the suspected black bears oral cavity. A total of 67.84 grams or 95% content weight of tissue tested positive for human blood using Hexagon Obti test strips. The remaining weight found in the oral cavity was liquid weight and less than 1% vegetation.

Figure 10: (Left) Front paws of suspected black bear. Dry blood swabs were taken from the claws of the front paws and tested with Hexagon Obti test strips (right). Both front paws tested positive for the presence of human blood. Results were consisted with the initial blood swabs, Figure 1, (H-030RTpaw and H-030LTpaw).

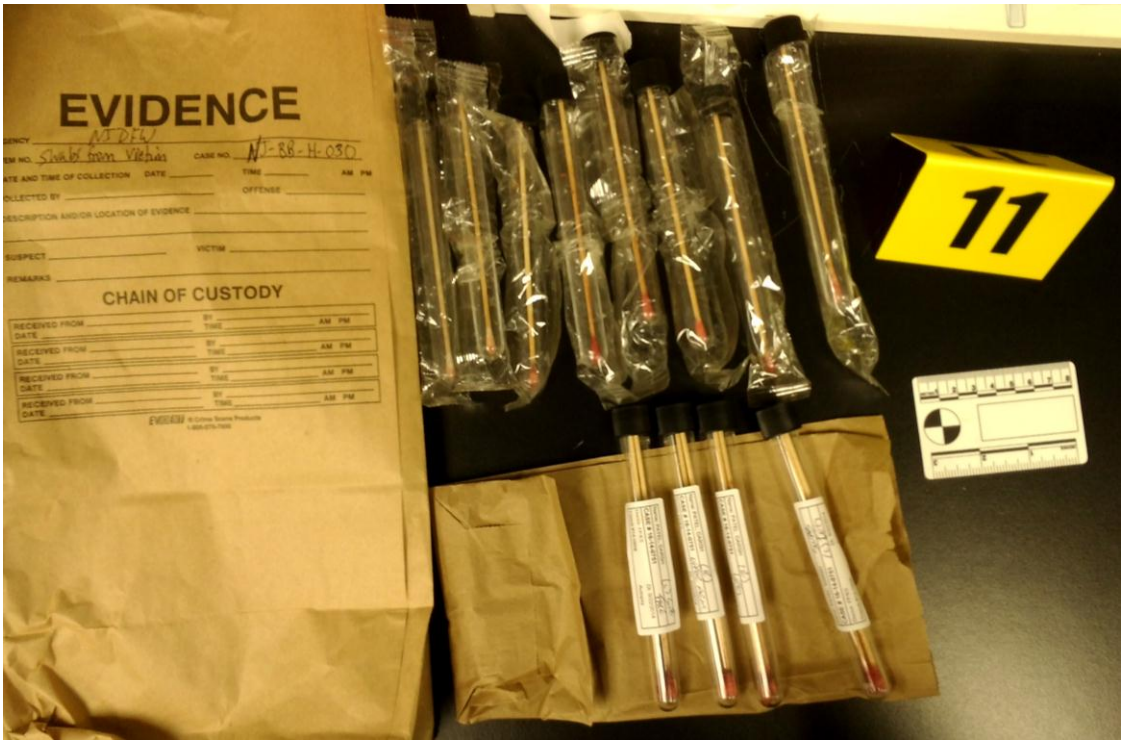


Figure 11: Swabs of victims bite wounds submitted for DNA analysis. Swabs were analyzed to construct a genotypic profile of the suspected black bear from salvia left in victims wound.

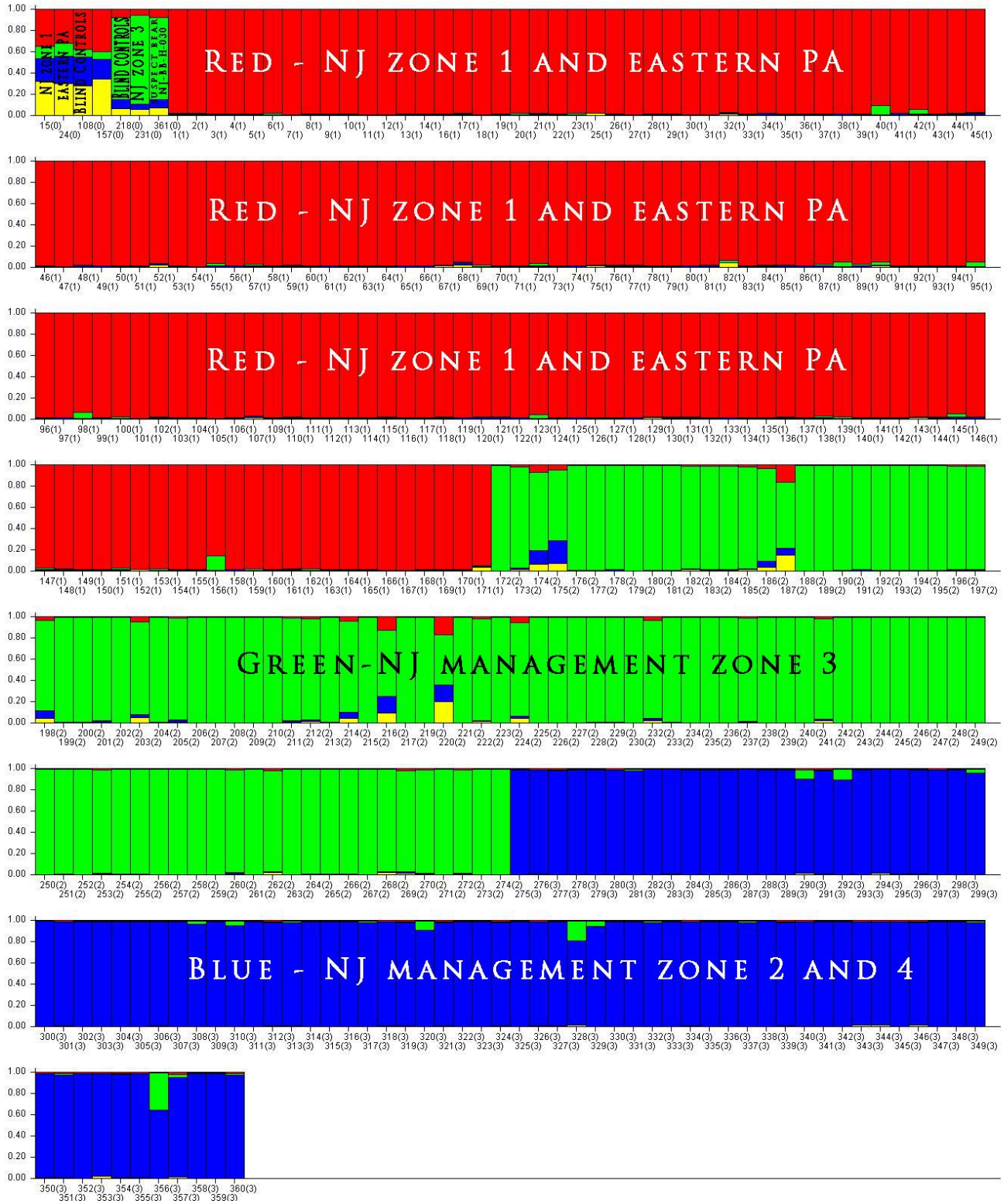


Figure 12: Graphical output of STRUCTURE's Bayesian clustering method where each individual is represented by a bar. The height of the bar (y-axis) indicates the magnitude of the Q-value for that particular clustering assignment. Q-values range from 0.000, which indicates no probability of clustering, up to 1.000, which indicates a 100% probability with clustering to a particular group. Populations are indicated by a color and are determined by the allelic frequency of the assigned population. Blind controls from known eastern PA, NJ zone 1 and NJ zone 3 black bears were utilized to ensure proper assignment of individuals to populations. A total of 329 bears from NJ assigned to their management zones were used to train program STRUCTURE on the allele frequencies of the population. A total of 31 black bears from eastern PA were also used to train STRUCTURE on allele frequencies. For this simulation, suspected black bears origin was examined. The Q-value or the probability of the suspect bear belonging to New Jersey management zone 3 is 76.6 percent (seventh bar from top right).

Table 1: Genotypic profiles of suspected black bear (Bear) and 12 victim swabs (VS01A-VS12) submitted for genotypic comparison. A combination of human and black bear amplification occurred resulting in a mixture of genotypic profiles. Alleles highlighted in blue indicate human alleles of the victims that were amplified. Regions highlighted in yellow are alleles that belong to the suspected black bear.

	G10P		G10H		CXX20		MU23		MU59		MU50		G10O		G10J		UamA107	
Bear	170	178	238	258	120	140	162	174	238	238	140	140	206	216	90	102	158	164
VS01A					140	148	154	154					216	216	108	108		
VS01B					128	148	154	154							108	108		
VS02A					148	148	154	154							108	108	168	168
VS02B					148	148	154	154							108	108	168	168
VS03A					148	148									108	108	168	168
VS03B					148	148									108	108		
VS04A					148	148									108	108		
VS04B					148	148									108	108	168	168
VS05					148	148									86	108	168	168
VS06							174	174							108	108		
VS07															108	108		
VS08			222	222	148	148	154	154							108	108	168	168
VS09	178	178	222	222	148	148	154	170	234	238	138	138	202	206	108	108	168	168
VS10					148	148	154	170			138	138			108	108	168	168
VS11					148	148							216	216	108	108		
VS12					148	148	154	170			138	138	216	216	108	108	168	168
Victim					148	148	172	172							90	108	168	168
Human Sample					148	148					124	124			108	108	168	168

Detailed Explanation of Methods:

Preliminary analysis of all the samples collected from the black bear mouth and front paws was completed using Hexagon Obti test strips. The test strips can detect trace amounts of human blood by an immunochromatographic method. In the presence of human hemoglobin, monoclonal anti-human antibodies tagged with a blue color particle, form a complex which migrates along the test strip where it then binds to a second antibody resulting in a blue color change at the test line (labeled T) indicating a positive result (Hochmeister *et al.* 1999). This method was utilized to test tissue found in the stomach, esophagus and oral cavity.

Contents of the stomach, esophagus and oral cavity were weighted and separated into categories; vegetation, tissue, clothing, hair and animal organs. A final weight of each category was collected and recorded. Analysis of the tissue found was completed following the Hexagon Obti protocol. Clothing found in the black bears stomach was compared with clothing submitted. Morphological examination of the hair was completed using hairdatabase.com which analyzes hair characteristics of 80 potential species. The hair morphology was consistent with human and identified as belonging to a human.

The black bears four paws were examined for the presence of dry blood and tissue. Dry blood swabs were collected from all four paws and the two front paws were tested with Hexagon Obti test strips following protocol. A muscle sample was collected from the bear's back right paw and used for DNA analysis. Extraction of DNA was completed under sterile conditions following laboratory SOPs. DNA extraction for the black bear tissue and twelve victim swabs were completed using a Qiagen DNeasy Blood and Tissue DNA Extraction Kit. Samples were purified using a Qiagen DNA purification kit and analyzed using a nine microsatellite multiplex reaction following standard protocol as derived by Chinnici, 2014. Samples were analyzed using an Applied Biosystems Genetic Analyzer 3130.

Summary of Results:

Analysis of the suspected black bears front right and left paws had presence of human blood. Analysis of the black bears stomach content indicated the presence of both human tissue which was confirmed by the Hexagon Obti test strips, the presence of the victims clothing which was matched to evidence number 018C and the presence of human hair (Figure 4, 5 and 6, respectively). Analysis of the esophagus and oral content also indicated the presence of human tissue. A final genetic analysis of DNA pulled from the victims bite wounds indicated a partial profile for the suspected black bear with a mixture of human DNA.

Literature Cited

Chinnici N (2014) Genetic Structure of the American Black Bear (Ursus americanus) in New Jersey. East Stroudsburg University.

Falush D, Stephens M, Pritchard JK (2003) Inference of population structure using multilocus genotype data: linked loci and correlated allele frequencies. *Genetics*, **164**, 1567–1587.

Hochmeister MN, Budowle B, Sparkes R *et al.* (1999) Validation studies of an immunochromatographic 1-step test for the forensic identification of human blood. *Journal of forensic sciences*, **44**.

Pritchard JK, Stephens M, Donnelly P (2000) Inference of population structure using multilocus genotype data. *Genetics*, **155**, 945–959.

Nicole L. Chinnici, M.S.
DNA Technician

Jane E. Huffman, MS, PhD, MPH
Laboratory Director

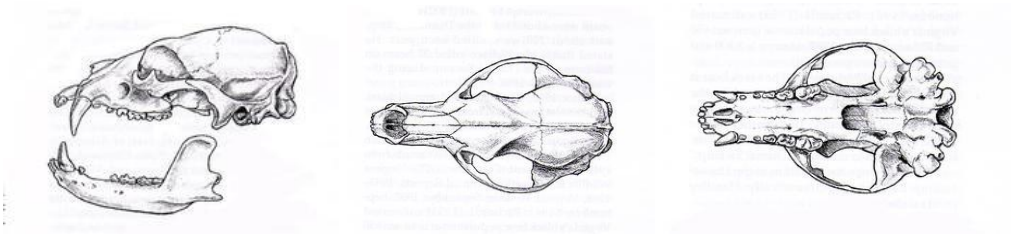
Appendix A:

NORTHEAST WILDLIFE DNA LABORATORY

Received By: Jane E. Huffman 9/27/14
Technician: Jane E. Huffman
Laboratory Case #: NJ-BB-H-030

Description of Evidence: Morphological examination to document maxillary and mandibular dentition of black bear skull NJ-BB-H-030.

Figure 1: NJ-BB-030 Left and right lateral view of skull and mandible.



A **B** **C**

Figure 2: (A) Left lateral view of skull and mandible, (2B) dorsal view of skull, (2C) ventral view of skull.

Methods
Measurements:

Figure 3: NJ-BB-030. Measuring the mandibular canine cusp tip. Intercanine width as measured at the canine cusp tips. Measurement 45.29mm + 1.30mm saw cut width. Intercanine width = 4.659cm. This measurement is appropriate for shallow or superficial bites.

Figure 4: NJ-BB-030 Shows the intercanine width (mandible) as measured on the mesial most aspect of the canines, as would be appropriate for a deep bite. Measurement 17.19mm + 1.30mm saw cut width. Intercanine width = 1.849cm.

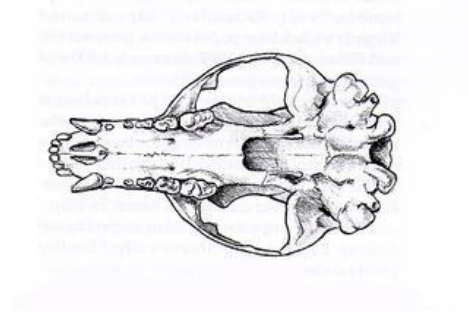


Figure 5: NJ-BB-030 Shows the measurement of the intercanine width (maxilla) on the mesial most aspect of the canines. Measurement 35.27mm + 1.30mm saw cut width. Intercanine width (maxilla) = 3.657cm. This measurement is appropriate for a deep bite.

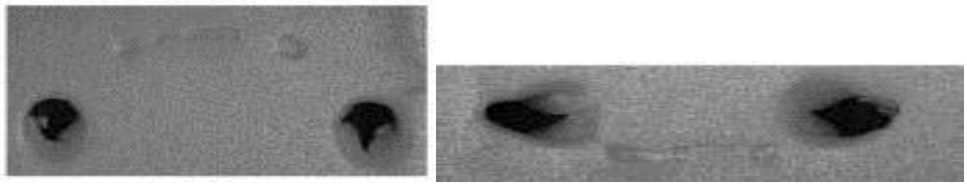


Figure 6: Black bear upper and lower jaw foam impression. The black bear has six incisors and two very large canines per arch. Black bear bite marks possess the dental characteristics necessary for deep gouges and lacerations (Bowers, 2004). The most traumatic type bite, requiring considerable force, is that where a loss of tissue or avulsion actually occurs. This is more common in black bear type animal bites (Stimson and Mertz, 1997).

References:

Bowers CM. Forensic dental evidence. San Diego: Elsevier Academic Press, 2004.

Murmann DC, Brumit PC, Schrader BA, and Senn DR. 2006. A comparison of animal jaws and bite mark patterns. Journal of Forensic Science 51: 846-860.

Stimson PG, Mertz CA. 1997. Bite mark techniques and terminology. In: Stimson PG, Mertz CA, editors. Forensic dentistry. Boca Raton: CRC Press LLC pp. 137–159.

Appendix B: Evidence Log

Laboratory ID #	Picture Evidence #	Description of Evidence	Submitted By	Recovered By	Date	Time (hours)
H-030mouth	1	Initial swab from black bears mouth	Kelcey Burguess	William Stansley	9/22/2014	0915
H-030RTpaw	1	Initial swab from black bears right front paw	Kelcey Burguess	William Stansley	9/22/2014	0915
H-030LFpaw	1	Initial swab from black bears left front paw	Kelcey Burguess	William Stansley	9/22/2014	0915
VS01A and B	11	Victims left side of face swab	Kelcey Burguess	Medical Examiner	9/23/2014	1730
VS02A and B	11	Victims right upper arm swab	Kelcey Burguess	Medical Examiner	9/23/2014	1730
VS03A and B	11	Victims right leg swab	Kelcey Burguess	Medical Examiner	9/23/2014	1730
VS04A and B	11	Victims left leg swab	Kelcey Burguess	Medical Examiner	9/23/2014	1730
VS05-VS12	11	Random swabs of victims bite wounds	Kelcey Burguess	Kelcey Burguess	9/23/2014	1730
026	NA	(9) various tissues from black bear carcass	Kelcey Burguess	Nicole Chinnici	9/23/2014	1730
001A	2	Stomach contents of black bear	Kelcey Burguess	Medical Examiner	9/23/2014	1730
001B	3	Clothing found in black bears stomach content	NA	Nicole Chinnici	9/24/2014	1200
002	NA	Hair found in black bears stomach content	NA	Nicole Chinnici	9/24/2014	1200
003	NA	Positive test strip result from human tissue in bear stomach contents		Nicole Chinnici	9/24/2014	1200
004	NA	Possible human tissue (not tested) found in bears stomach contents	NA	Nicole Chinnici	9/24/2014	1200
005	NA	Possible human tissue (not tested) found in bears stomach contents	NA	Nicole Chinnici	9/24/2014	1200
006	NA	Possible other animal tissue (not tested) found in bears stomach contents	NA		9/24/2014	1200
007	NA	Intestines of various animal species (not tested) found in bears stomach contents	NA	Nicole Chinnici	9/24/2014	1200
008	NA	Vegetation found in black bears stomach contents	NA	Nicole Chinnici	9/24/2014	1200
009	5	Human tissue tested positive with test strip	NA	Nicole Chinnici	9/24/2014	1200
010		Positive test strip from human tissue (009) found in bear sto contents	NA	Nicole Chinnici	9/24/2014	1200
011	NA	Tissue found in bears stomach content (failed testing result With ouchterlony)	NA	Nicole Chinnici	9/24/2014	1200
012	NA	Tissue found in bears stomach content (failed testing result With ouchterlony)	NA	Nicole Chinnici	9/24/2014	1200
013	NA	Tissue found in bears stomach content (failed testing result With ouchterlony)	NA	Nicole Chinnici	9/24/2014	1200

014	NA	Tissue found in bears stomach content (failed testing result With ouchterlony)	NA	Nicole Chinnici	9/24/2014	1200
015	NA	Tissue found in bears stomach content (failed testing result With ouchterlony)	NA	Nicole Chinnici	9/24/2014	1200
016A	6 and 7	Four bear paws	Kelcey Burguess	Nicole Chinnici	9/23/2014	1700
016B	6	Positive test strip result from left front paw	NA	Nicole Chinnici	9/25/2014	1420
016C	NA	(5) samples collected from front left paw	NA	Nicole Chinnici	9/25/2014	1420
016D	NA	(2) swabs collected from front left paw	NA	Nicole Chinnici	9/25/2014	1420
016E	NA	Dry blood and dirt collected from left front paw	NA	Nicole Chinnici	9/25/2014	1420
016F	NA	(2) swabs from right front paw	NA	Nicole Chinnici	9/25/2014	1420
016G	7	Bear muscle tissue sample from back right paw	NA	Nicole Chinnici	9/25/2014	1420
016H	NA	(1) swab from left back paw	NA	Nicole Chinnici	9/25/2014	1420
016I	NA	(1) swab fromright back paw	NA	Nicole Chinnici	9/25/2014	1420
017	NA	Victims scalp	Michael Madonia	Nicole Chinnici	9/24/2014	1800
018A	10	Victims T-Shirt	Michael Madonia	Nicole Chinnici	9/24/2014	1800
018B	NA	Hair from victims shirt	NA	Meaghan Bird	9/26/2014	1200
018C	13	Victims underwear	Michael Madonia	Nicole Chinnici	9/24/2014	1800
019A	8	Esophagus content from black bear	Kelcey Burguess	Nicole Chinnici	9/23/2014	1730
019B	8	Unknown tissue from black bears esophagus content	NA	Nicole Chinnici	9/25/2014	1500
020	8	Vegetation found in black bears esophagus content	NA	Nicole Chinnici	9/25/2014	1500
021	8	Positive test strip test from tissue (025)	NA	Nicole Chinnici	9/25/2014	1500
022	9	Positive human tissue from oral cavity	NA	Nicole Chinnici	9/25/2014	1500
023	9	Positive test strip result from oral cavity	NA	Nicole Chinnici	9/25/2014	1500
024	9	Oral cavity contents	Kelcey Burguess	Nicole Chinnici	9/23/2014	1730
025	8	Positive human tissue from esophagus	NA	Nicole Chinnici	9/25/2014	1500
028	NA	Black Bear skull	Kelcey Burguess	Jane Huffman	9/23/2014	1700
E-1	NA	Victims right shoe	Tom Ombrello	Nicole Chinnici	9/26/2014	1130
E-5	NA	Victims sweat pants	Tom Ombrello	Nicole Chinnici	9/26/2014	1130
E-7	NA	Victims sock	Tom Ombrello	Nicole Chinnici	9/26/2014	1130
E-5C	NA	Victims sock	Tom Ombrello	Nicole Chinnici	9/26/2014	1130
E-10	NA	Victims left shoe	Tom Ombrello	Nicole Chinnici	9/26/2014	1130
027	NA	Victims eye glasses	Tom Ombrello	Nicole Chinnici	9/26/2014	1130

J Forensic Sci, July 2006, Vol. 51, No. 4
doi:10.1111/j.1556 4029.2006.00166.x
Available online at: www.blackwell synergy.com

Denise C. Murmann,[1] *D.D.S.; Paula C. Brumit,*[1] *D.D.S.; Bruce A. Schrader,*[1] *D.D.S.; and David R. Senn,*[1] *D.D.S.*

A Comparison of Animal Jaws and Bite Mark Patterns*

ABSTRACT: The purpose of this study was to compare the jaw shapes and bite mark patterns of wild and domestic animals to assist investigators in their analysis of animal bite marks. The analyses were made on 12 species in the Order Carnivora housed in the Mammalian Collection at the Field Museum of Natural History in Chicago, Illinois. In addition to metric analysis, one skull from each species was photographed as a rep resentative sample with an ABFO No. 2 scale in place. Bite patterns of the maxillary and mandibular dentition were documented using foamed polystyrene exemplars, which were also photographed. A total of 486 specimens were examined to analyze the jaw and bite mark patterns. A modified technique for measuring intercanine distances was developed to more accurately reflect the characteristics seen in animal bite marks. In it, three separate areas were measured on the canines, rather than just the cusp tip. This was to maximize the amount of information acquired from each skull, specifically to accommodate variances in the depth of bite injuries.

KEYWORDS: forensic science, forensic odontology, animal bites, intercanine width, bite marks

It is sadly common for people to die from attacks by humans. In 2002, there were 17,705 homicides in the United States alone (1). It is not common for people to die as the result of attacks from animals. In land animal attacks that result in human death the domestic dog, not a wild animal, is the usual perpetrator. Between 1979 and 1996 the average number of human deaths per year caused by domestic dogs in the United States was 17 (2). Human fatalities caused by wild animal are rare. For example, there are fewer than 12 recorded fatalities caused by mountain lions in North America over the course of more than 100 years (3). Be cause of its rarity, there is a scarcity of information in the liter ature about animal bites that indicates a need for more research in this area. In addition to collecting information that may aid in identification of an animal assailant, the data could be helpful in cases where there has been animal scavenging. This research project focused on the teeth and bite marks of domestic and wild animals, to analyze the differences in them that could be used to identify the type of animal responsible for the bite mark pattern.

The focus of this study was on the Order Carnivora, because of all the mammals of North America, the carnivores are the most likely candidates to bite or kill a human. In this paper, the words Carnivora and carnivore refer to the taxonomic group, and not to the diet of the animal. Bears, for example, are not carnivores in their diet; they are omnivores, eating both meat and vegetation. They are, however, in the Order Carnivora. The taxonomy of the subjects in this study is as follows: Kingdom Animalia, Phylum Chordata, Class Mammalia, and Order Carnivora. As for Family, there were five species from the dog family [*Canidae*], four from the cat family [*Felidae*], two from the bear family [*Ursidae*], and wolverines, which are the largest North American members of the weasel family [*Mustelidae*]. The genus and species designations are listed in parentheses after the common name of the animal. Twelve species of Carnivores were selected for this study.

The shape of the arches and thus the bite mark shapes that result are different between the families we considered. The shape of the anterior portion of the arch of the cat family is very linear. The six incisors are arranged in a straight line. The anterior arch shape in the dog family is very deeply curved. Although biologically un related, members of the bear family and wolverines share very similar arch shapes. Bears and wolverines differ from the cat family and the dog family, but are more like the cat family. The anterior portion of the maxillary arch is slightly curved, and the same region of the mandibular arch is very straight.

While the arch shape helps to differentiate mammalian families, more information is needed to compare members in the same family. You cannot distinguish members from the same Family by the shape of their jaws or bite mark patterns alone. What *is* ob viously different is the size of the jaws. For example, lynx and mountain lion jaw shapes are similar in shape, but differ in di mension. Measurements were taken on the skulls of the animals, to determine size ranges for each species. In some cases, this *can* help distinguish between different sized species in the same family.

While information from the literature on intercanine widths was meager, there was some. Elverne Tonn, D.D.S., gave a presenta tion on this topic at the AAFS Annual Meeting in 2004 (4) and Mark Elbroch, in his book on tracking, included a list of mammals with the distance between the canines noted (5).

Methods

Measurements

The collection of skulls evaluated in this study was from the Mammalian Collection of the Field Museum of Natural History in Chicago, Illinois. A total of 486 specimens were examined and measured. A maximum of three measurements were taken with a Mitutoyo Dial Caliper (Kanagawa, Japan) on the maxilla, and two

[1] The University of Texas Health Science Center at San Antonio (UTHSC SA), Center for Education and Research in Forensics (CERF), Mail Code 7919, 7703 Floyd Curl Drive, San Antonio, TX 78229 3900.

*This work was presented at the American Academy of Forensic Sciences Annual Meeting, February 25, 2005, in New Orleans, LA.

Received 28 July 2005; and in revised form 15 Jan. 2006 and 5 Feb. 2006; accepted 15 April 2006; published 21 June 2006.

FIG. 1 *Measuring the maxillary maximum canine width. The caliper is being moved from the incisal toward the most apical position possible to detect the greatest dimension.*

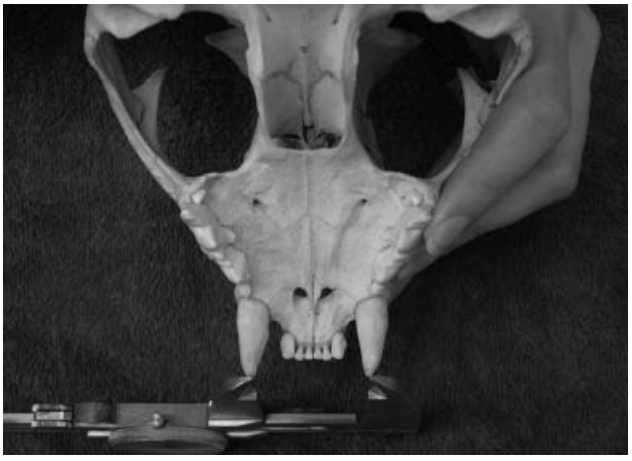


FIG. 2 *Measuring the maxillary canine cusp tip.*

on the mandible, depending upon how intact the speci men was.

Three maxillary measurements were taken: maximum canine width (MCW), canine cusp tip (Tip), and mesial bone height (MBH). MCW was measured at the widest area on the distal of the canines (Fig. 1). In Fig. 1 the caliper is being moved from the incisal toward the most apical position possible to detect the

FIG. 3 *Measuring the maxillary mesial bone height.*

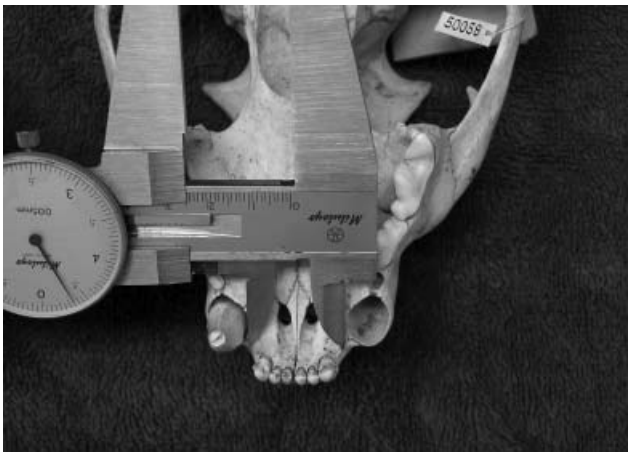


FIG. 4 *The mesial bone height was measured on the skull itself, rather than the canine. This allowed measurements to be taken on skulls that had missing or damaged teeth.*

greatest dimension. This dimension corresponds to the greatest possible lateral extent of a bite mark created by the anterior por tion of the arch. Tip was measured at the tip of the canines (Fig. 2). MBH was taken next to the most mesial portion of the canine, on the alveolar bone, forming the socket around the canine (Fig. 3). It was measured on the bone, rather than the teeth, so that skulls that were missing teeth could still be used (Fig. 4). Because all the specimens in this study were skeletal, the issue of gingival thick ness was not considered here.

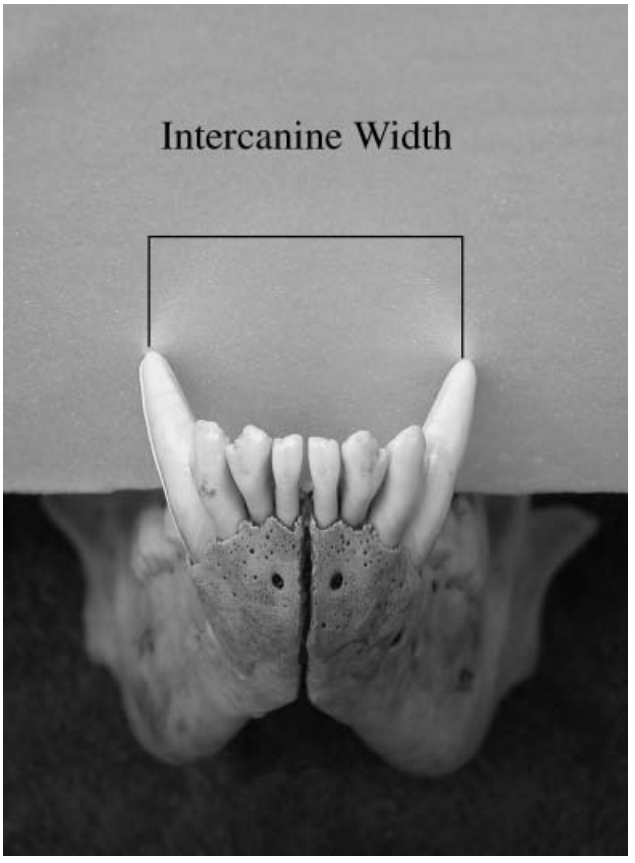


FIG. 5 *Intercanine width as measured at the canine cusp tips, as would be appropriate in a shallow or superficial bite.*

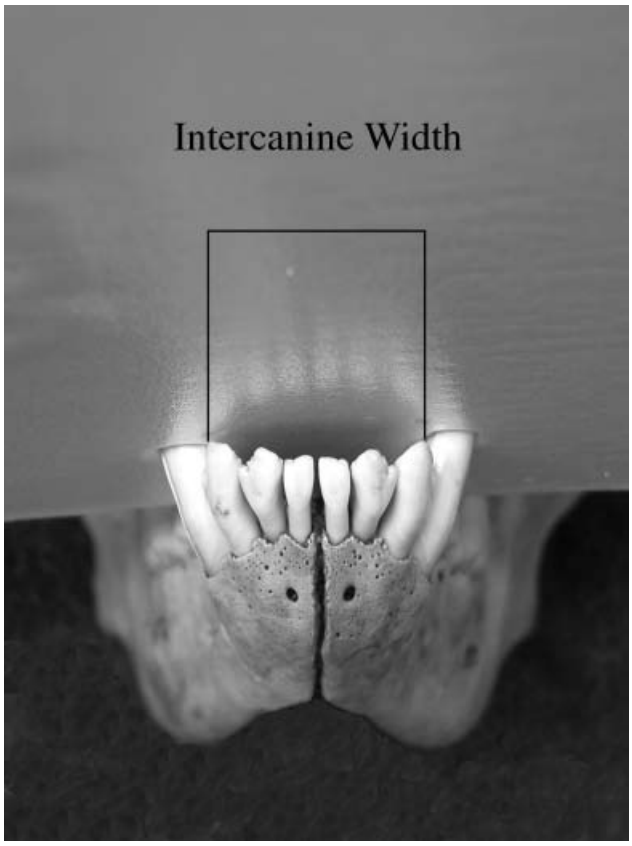


FIG. 6 *Shows the intercanine width as measured on the mesial most aspect of the canines, as would be appropriate for a deep bite.*

In bite mark analysis, it is common to consider the "intercanine width," or "the distance between the canines" of the wound. This information is then compared with the "intercanine width" of a

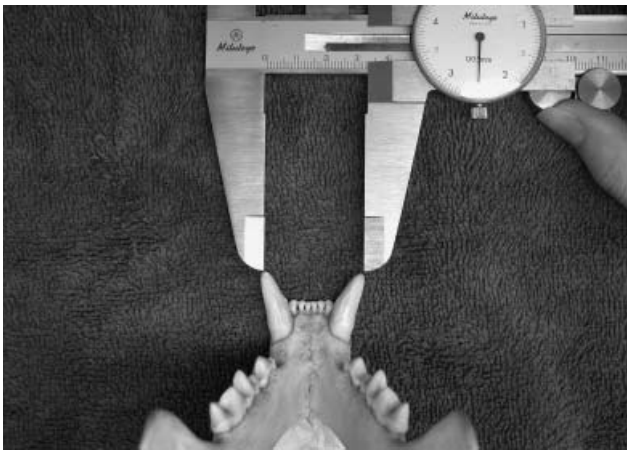


FIG. 7 *Measuring the mandibular canine cusp tip.*

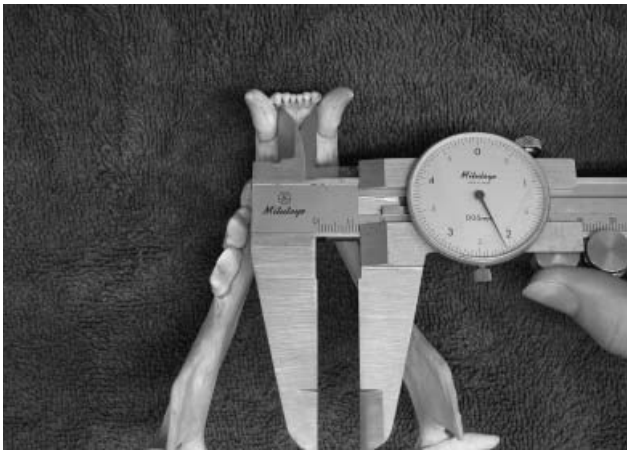


FIG. 8 *Measuring the mandibular mesial bone height.*

TABLE 1 *Domestic cat* (Felis silvestris).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
1	104916	1972	IL	M	2.2	1.8	1.5	N	1.6	0.7	Siamese
2	104909	1972	IL	F	1.1	0.9	0.7	N	0.8	0.5	Juvenile: primary teeth; Burmese
3	152104	1993	IL	M	2.4		1.6	N	1.5	0.6	UR canine tip fx
4	101878	1972	IL	M	1.7	1.4	1.0	N	1.1	0.5	Juvenile: 1° teeth, 2° erupting; Abyssinian
5	104914	?	IL	?	2.0	1.7	1.2	N	1.5	0.5	
6	101955	1972	SC	F	1.8	1.5	1.2	N	1.3	0.5	Persian blue
7	59031	1972	WI	M	2.1	1.8	1.3	N	1.5	0.6	Russian blue
8	60570	1975	IL	M	2.3	2.0	1.4	N		0.6	LR canine tip fx, Russian blue
9	60352	1974	IL	F	2.0	1.6	1.3	Y	1.4	0.6	
10	60353	?	IL	M	2.0	1.7	1.3	N	1.4	0.6	Russian blue
11	60403	1974	IL	F			1.4	Y	1.5	0.6	UL canine tip fx
12	60417	1974	IL	F	1.9	1.5	1.2	N	1.2	0.5	Juvenile: 1° teeth, 2° erupting
13	60442	1975	IL	M	1.5	1.2	1.0	N	0.9	0.6	Juvenile: 1° teeth, 2° erupting
14	60504	1975	IL	F	1.8	1.5	1.2	N	1.3	0.6	
15	60531	1975	IL	M	2.4	2.0	1.5	N	1.7	0.6	Russian blue
16	60580	?	IL	F	2.0	1.7	1.3	N		0.4	LR canine missing; Russian blue
17	60274	1973	IL	M			1.3	Y	1.4	0.5	UR canine missing; Abyssinian
18	60141	1973	IL	M			1.4	Y	1.8	0.7	UR canine fx; Himalayan
19	60103	1973	IL	F	1.8	1.6	1.2	N	1.3	0.5	Russian blue
20	60102	1973	IL	M	2.1	1.8	1.4	N	1.5	0.6	Siamese
21	60089	1973	IL	M	2.4	2.2	1.5	N	1.6	0.6	Burmese
22	57834	1967	IL	M	2.2	1.8	1.4	N	1.5	0.5	Manx
23	58006	1970	IL	F	2.2	1.7	1.3	N	1.4	0.4	Manx
24	57135	1948	?	F	1.9	1.2	1.2	N	1.5	0.6	Manx
25	57153	1949	IL	F	2.0	1.5	1.4	Y	1.5	0.5	

All measurements are in centimeters.
FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 2 *Bobcat* (Lynx rufus).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Lynx rufus baileyi											
1	16005	1904	Mexico	M	3.0	2.5	1.8	N	2.2	0.8	
2	81502	1904	CA	M	2.9	2.3	1.6	N	2.2	0.8	
3	7224	1899	AZ	M	2.6	2.2	1.5	N	2.0	0.7	
Lynx rufus californicus											
4	10879	1902	Mexico	F	2.6	2.1	1.6	N	2.0	0.7	
5	10880	1902	Mexico	F	2.3	1.9	1.1	N	1.2	0.5	Juvenile: all primary teeth
6	81500	1903	CA	?	2.5	1.9	1.4	N	1.9	0.7	
7	16021	?	CA	?	3.1	2.3	1.8	N	2.1	0.7	
8	46833	1934	CA	?	2.9	2.2	1.6	N	2.0	0.8	
9	16020	1901	CA	M	3.0	2.3	1.8	N	2.4	0.8	
Lynx rufus fasciatus											
10	6344	1898	WA	M	3.2	2.7	1.9	N		0.8	LR canine fx
Lynx rufus floridanus											
11	134439	1939	FL	M	2.5	2.1	1.5	N	1.9	0.6	
12	8209	?	FL	?	2.8	2.4	1.5	N	2.0	0.7	
13	84432	1954	FL	F	3.2	2.3	1.8	N		0.8	LL canine tip fx
14	84433	1954	GA	F	2.8	2.1	1.5	N	2.0	0.6	Juvenile but all secondary teeth
15	8209	?	FL	?	2.8	2.3	1.5	N	2.0	0.7	
16	84432	1954	GA	F	3.2	2.4	1.9	N		0.8	LL canine tip fx
17	134439	1939	FL	M	2.5	2.1	1.4	N	1.9	0.7	
18	84433	1954	GA	F	2.8	2.1	1.6	N	2.0	0.7	
19	15029	1892	FL	?	3.4	2.9	2.1	N	2.2		Jaws were tied together, unable to open
20	20778	1914	MS	?	3.2	2.7	1.9	N		0.8	L canine tip fx
21	171159	1985	FL	M	3.2	2.5	1.9	Y	2.1	0.8	
22	171160	1988	FL	M	3.2	2.6	1.8	Y	2.1	0.7	
Lynx rufus gigas											
23	51645	1940	ME	?	3.8	3.1	2.1	N		0.9	LL canine tip fx
24	15700	1907	ME	M	3.1	2.5	1.9	N	2.2	0.8	
25	51642	1940	ME	M	3.4	2.8	2.0	N	2.2	0.8	
Lynx rufus pallescens											
26	90579	1939	ID	M	2.9	2.5	1.8	N	2.2	0.8	
27	42761	1935	SD	?	2.6	2.2	1.6	N	2.0	0.7	
28	156710	?	WY	?	3.1	2.4	1.8	Y	2.0	0.7	
Lynx rufus rufus											
29	44058	1935	MI	F	3.1	2.6	1.9	N	2.2	0.8	
30	123985	1981	MI	M	3.4	2.9	2.1	Y			Half of the mandible missing
31	44077	1936	MI	F	2.8	2.4	1.6	N	2.2	0.8	
Lynx rufus superiorensis											
32	43100	1935	WI	?			2.1	N		0.9	All four canines fx
33	123978	1981	MI	F	3.1	2.6	1.9	Y			Half of the mandible missing
34	165364	1996	MN	F	2.9	2.5	1.8	N	2.3	0.9	
35	165363	1996	MN	M	3.4	2.8	2.1	N	2.4	0.9	
36	18434	1905	MN	F	3.1	2.7	1.8	N	2.3	0.8	
Lynx rufus texensis											
37	129342	1975	TX	M	3.1	2.4	1.9	Y	2.4	0.8	
38	53040	1942	TX	?	2.9	2.5	1.9	N	2.2	0.8	
39	16013	1905	Mexico	M	2.9	2.3	1.7	N	2.1	0.7	

All measurements are in centimeters.

FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

suspected biter. In examining a superficial bite made by a carnivore the distance between the cusp tips may well correspond to the "distance between the canines" as measured in the bite mark. This is the measurement that was used for the widest range of the intercanine widths. However, if there is a deep bite, the MBH is more likely to be the most accurate point to measure.

To further elaborate, Fig. 5 shows a possible positioning of the lower canines for a superficial bite. It is the tips of the canines that are registered in the pattern. Therefore, the distance between the Tip would be the measurement that most accurately reflects the "intercanine width," as found on a bite victim. Figure 6 shows a much deeper bite. The intercanine width measured between the canine injury patterns on the bite victim is not going to correspond to the distance between the cusp tips. The measurement of the MBH and the MCW will more likely correspond to the characteristics of the bite injury. Consequently, for this study both were measured and both numbers were used for the range of possible intercanine widths. The widest Tip measurement was used as the widest intercanine width range, and the smallest MBH was used as the smallest intercanine width.

Unlike the maxillary canines, the mandibular MCW and Tip dimensions are the same, due to the divergence of the mandibular canines (Fig. 7). Therefore, only two measurements are needed on the mandibular arch, the Tip and the MBH (Fig. 8).

Photography

A representative skull for each species was photographed with a Nikon CoolPix 5700 Digital Camera (Tokyo, Japan), mounted on a Kaiser Copy Stand (Buchen, Germany). Because of the variation

TABLE 3 *Lynx* (lynx canadensis).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Lynx canadensis canadensis											
1	138821	1983	Canada	M	3.3	2.8	2.0	N	2.5	0.9	
2	72957	1952	Canada	?	3.0	2.4	1.8	Y	2.2	0.8	
3	129340	1973	Canada	F	2.9	2.4	1.8	Y		0.8	LR canine tip fx
4	129341	1973	Canada	M	3.3	2.6	2.0	N	2.5	0.9	
5	67405	1947	Canada	?	3.0	2.5	1.9				No mandible
6	30397	1928	Canada	?	3.2	2.6	1.9	N	2.4	0.8	
7	43112	?	AK	?	3.2	2.5	2.0	N	2.4	0.9	
8	138836	1988	AK	?	3.2	2.5	2.0	N		0.8	LL canine missing
9	9893	1902	AK	?	2.7	2.2	1.6	N	2.1	0.6	Juvenile: 1° teeth, 2° erupting
10	9895	1902	AK	?	2.9	2.5	1.7	N	2.2	0.6	Juvenile: 1° teeth, 2° erupting
11	51476	1902	AK	?	3.2	2.6	2.0	N	2.5	0.8	
12	9894	1902	AK	?	3.3	2.7	2.0	N	2.5	0.9	
13	138831	1988	AK	M	3.3	2.5	1.9	N		0.7	LL canine missing
14	122724	1979	IL Zoo	F	3.1	2.7	1.9	N	2.2	0.8	
15	9897	1902	AK	?	3.2	2.5	2.0	N	2.5	0.9	
16	9892	1902	AK	?	3.4	2.7	2.0	N		0.8	LL canine tip fx
17	138824	1987	AK	F	2.2	1.8	1.3	N		0.5	LL canine missing; Juvenile: 1° and 2° teeth
18	138826	1987	AK	M	2.7	2.3	1.6	N		0.7	LL canine missing; Juvenile: 1° teeth only
19	138828	1988	AK	M	3.7	3.0	2.3	N		1.0	LL canine missing
20	138832	1988	AK	M	3.3	2.6	2.0	N		0.9	LL canine missing
21	138827	1987	AK	M	3.4	2.8	2.0	N		0.8	LL canine missing
22	9896	1902	AK	?	3.4	2.7	2.0	N	2.5	0.8	
23	138837	1988	AK	?	3.2	2.7	1.9	N		0.8	LL canine missing; LR canine fx off
24	138830	1988	AK	M	3.1	2.6	1.9	N		0.8	LL canine fx off; LR canine missing
25	138823	1988	AK	F	3.2	2.7	2.0	N		0.9	LL canine missing
26	138822	1987	AK	M	3.5	2.9	2.2	N		0.9	LL canine missing
27	138829	1987	AK	F	3.1	2.6	1.8	N		0.7	LL canine missing
28	138835	1988	AK	M	3.5	2.8	2.1	N		0.9	LL canine missing; LR canine fx off
29	138838	?	AK	?	2.6	2.0	1.5	N	2.0	0.6	Juvenile: 1° teeth, 2° erupting
30	138833	1988	AK	?	3.3	2.6	2.0	N		0.8	LL canine missing
31	138834	?	AK	?	3.3	2.7	2.0	N		0.9	LL canine missing
32	138825	1988	AK	F	3.2	2.5	1.9	N		0.8	LL canine missing
33	16022	?	AK	?	2.8	2.2	1.8	N		0.8	LR canine tip fx
34	43111	?	AK	?	3.2	2.5	2.0	Y	2.4	0.9	

All measurements are in centimeters.
FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

in size of breeds, three representative domestic dog skulls were photographed. Each skull was documented from the anterior for an overall view, followed by views of the maxilla and mandible to demonstrate tooth alignment within the arch. To illustrate the bite mark pattern that each animal could potentially produce, exem plars of the maxillary and mandibular dentition were recorded in foamed polystyrene. These sample bite patterns were then photo graphed. Each image of the specimens and exemplars included an ABFO No. 2 Scale (Lightning Powder Co, Jacksonville, FL), which facilitated life size image rendering and comparison when imported into Adobe Photoshop CS (San Jose, CA).

Results

Tables 1 12 show the measurements for each of the 12 species, with subspecies, represented in table headings. Subspecies are usually based on geographic areas, which are reflected under the "Location" column of the table. Damaged or missing skull struc ture precluded some measurements, and this missing data is reflected by a dash ( ). Please note that all measurements are in centimeters.

Tables 13 15 give the ranges for each site measured, by family. Table 13 lists the information for the cat family. Remember, the rationale for taking measurements on the skulls, was to attempt to differentiate between members of the same family, with similar jaw shapes, but varying sizes. The results indicate that there are three categories: small (domestic cat), medium (bobcat and the lynx), and large (mountain lion). Size overlap in bite pattern is observed between categories: the largest domestic cat data is comparable with the smallest bobcat and lynx; the largest bobcat and lynx are similar to the smallest mountain lion. These size overlaps are due partly to the presence of juveniles in the study. Juveniles can bite, so they were included, and noted in the Comments section of Tables 1 12.

Table 14 lists the information for the dog family, which also consists of three categories: small (foxes), medium (coyotes), and large (wolves). Domestic dogs, due to the breeding intervention by humans, range over all the three categories, for example, Toy Poodles to Beagles to Great Danes. Because of the extensive range of domestic dog sizes, if a bite injury or injuries is unwitnessed and concordant with the dog family, domestic dogs should be in cluded with wild canines as potential sources of the bite injuries.

In Table 15, the wolverines and bears are listed together, even though they are unrelated. The largest of the North American weasels, wolverines exhibit bite mark patterns that are similar to bears. Even here, there is some overlap of their size ranges.

Table 16 lists the "intercanine widths" for all 12 species. The range was created by using the smallest MBH to the largest Tip.

Figure 9 shows a compilation of the foamed polystyrene ex emplars by family. The cat family is distinctive, with the incisors in a very linear pattern. The dog family has an arch that is very

TABLE 4 *Mountain Lion* (Puma Concolor).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Puma concolor azteca											
1	9889	1901	Mexico	?	4.7	3.5	2.7	N	3.2	1.2	
2	48864	1938	AZ	?	4.0	2.5	2.5	N	2.8	1.1	Juvenile: mixed dentition
3	48865	1938	AZ	?			2.3	Y	2.7	1.1	Juvenile: mixed dentition; UL canine fx off
4	9888	1901	Mexico	?	4.8	3.9	2.8	N	3.0	1.2	
5	9891	1901	Mexico	?	4.4		2.3	N		1.0	UL and LR canines fx
6	48863	1938	AZ	?	4.5	3.3	2.4	N		1.1	LL canine missing
7	9887	1901	Mexico	?	5.2	4.0	2.8	N	3.3	1.2	
8	9890	1901	Mexico	?	3.3	2.7	2.1	N	2.3	1.3	Juvenile: mixed dentition
9	19136	1904	Mexico	F	4.3	3.4	2.4	N		1.1	LR canine tip fx
10	48862	1938	AZ	?	4.8	3.9	2.7	N	3.3	1.2	
11	74061	1952	AZ	F	4.7	3.6	2.7	N	3.4	1.2	
12	65743	1949	AZ	M	5.5	4.1	3.1	N	3.8	1.3	
13	65742	1949	AZ	F	4.5	3.5	2.5	N	3.2	1.1	
14	51472	1940	AZ	M	5.7	4.2	3.2	N	3.7	1.4	
15	65741	1949	AZ	F	4.6	3.6	2.7	N		1.1	LL canine tip fx
16	74060	1952	AZ	?	4.7	3.6	2.6	N		1.2	LR canine tip fx
17	78092	1951	AZ	F							Too broken to collect any data
18	78091	1951	AZ	F	4.4	3.5	2.5	N	3.0	1.2	
19	74063	1953	NM	M	5.8	4.4	3.1	N	3.9	1.5	
20	74065	1953	NM	M	5.1	3.8	2.5	N	3.5	1.1	
21	78090	1951	NM	M	5.4	4.3	3.0	N	4.0	1.4	
22	74062	1953	NM	F	4.5	3.7	2.4	N	3.1	1.0	
23	74064	1953	NM	M	5.4	4.4	3.0	N		1.3	LR canine fx
Puma concolor californica											
24	16023	?	CA	?	4.7	3.6	2.6	N	3.2	1.2	
Puma concolor coryi											
25	50058	1939	FL	F	4.5	3.4	2.5	N	3.0	1.0	
26	14900	?	FL	M	4.6	3.5	2.6	N	3.2	1.1	
27	14902	?	FL	?	5.0	3.9	2.9	N	3.5	1.2	
Puma concolor kaibabensis											
28	21714	1917	AZ	F	5.3	4.3	3.1	Y		1.4	LR canine tip fx
29	21713	1917	AZ	M	5.5	4.4	3.0	N	3.5	1.3	
30	129339	1974	UT	M	5.7	4.5	3.3	N	4.0	1.5	
Puma concolor missoulensis											
31	7636	1901	MT	?	5.2	4.3	2.9	N	3.6	1.2	
32	15532	?	MT	?	4.9		2.7	N	3.5	1.3	UR canine tip fx
33	14885	?	WA	?	5.4	3.9	3.0	N	3.6	1.3	
Puma concolor oregonensis											
34	16024	1898	Canada	M	5.3	4.0	3.0	N	3.7	1.4	
Puma concolor stanleyana											
35	83480	1955	TX	?	5.3	3.8	2.6	N	3.7	1.1	
36	53035	?	TX	?	5.4	3.7	3.1	Y	3.3	1.3	
37	83479	1955	TX	?	4.7	3.6	2.4	N	3.2	1.0	
38	129338	1975	TX	M	5.4	4.4	2.9	N	3.9	1.2	
39	53034	?	TX	?	4.9	4.1	2.5	N	3.6	1.3	

All measurements are in centimeters.

FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

curved. Wolverines and bears are somewhat between the two, but more similar in anterior arch curvature to the cat family. Souviron, D.D.S., wrote, "Grizzly bear and mountain lion bitemarks are similar in appearance, yet species specific" (6). The patterns seen in the exemplars in this study support that finding.

Figure 10 illustrates a comparison of the bite exemplars of the bear and wolf to a human exemplar. The cat family was not in cluded, as it is so distinctive. It is important to note that humans have four incisors, while carnivores have six. Also note the dif ference in size of the canines. The human exemplar includes the premolars, which makes the arch form appear deeper. However, canine to canine comparison reveals that in the anterior to poste rior dimension the wolf and the bear have much deeper arches.

As a final note, please consider that these photographs and ex emplars are static representations of a dynamic action. As Elverne Tonn mentioned in his paper, this is not the way animal bites look like in reality (7). Because the focus of this paper is to a large extent on the canine puncture wound, it is not intended to illustrate how traumatic animal bites can be. "Animal bite marks, princi pally dogs and carnivorous wildlife, possess the dental character istics necessary for deep gouges and lacerations" (8). "(Dogs' and cats') fang like cuspids and posterior teeth produce multiple, deep, streaked lacerations" (9). "The most traumatic type bite, requiring considerable force, is that where a loss of tissue or av ulsion actually occurs. This is more common in carnivore type animal bites . . . " (10).

The authors of this paper recognize that animal bites can be very violent resulting in extensive injuries requiring great skill to analyze properly. Our goal is to provide an initial study of the characteristics of animal bites and the animals that make them. More data and analysis is needed to approach the beginnings of an understanding of a complex subject.

TABLE 5 *Gray Fox* (Urocyon cinereoargenteus).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Urocyon cinereoargenteus cinereoargenteusm											
1	121664	1980	IL	?	1.7	1.6	1.1	N	1.4	0.6	Juvenile: secondary teeth half erupted
2	121663	1979	IL	M	2.0	1.9	1.1	N	1.8	0.5	
3	123654	1982	IL	M	1.6	1.5	1.1	N	1.3	0.7	Juvenile: primary teeth only
4	64614	1948	IL	F	2.0	2.0	1.2	Y	1.7	0.6	
5	121541	1979	IL	?	2.0	1.8	1.1	N	1.7	0.6	
6	121358	1979	IL	F	2.1	2.1	1.2	N	1.9	0.6	
7	129297	?	IL	F	1.9	1.9	1.2	Y	1.8	0.6	
8	129296	?	IL	M				N	1.6	0.5	Maxilla damaged
9	124592	1983	IL	F	1.8	1.7	1.1	Y		0.6	LL canine missing
10	152093	1992	IL	M	2.1	2.1	1.2	N	1.9	0.7	
11	152094	1992	IL	M	2.2	2.2	1.3	N	2.0	0.7	
12	152095	1991	IL	M	2.1	2.1	1.2	N	1.8	0.6	
13	5704	1898	WV	M	1.8	1.8	1.1				No mandible
14	51854	?	IL	M	2.2	2.2	1.2	N	1.9	0.6	
Urocyon cinereoargenteus floridanus											
15	171145	1999	FL	F	1.9	1.9	1.1	N	1.8	0.6	
16	84435	1954	GA	?	1.9	1.9	1.1	N		0.5	LL canine tip fx
17	84436	1954	FL	?	1.8	1.8	1.0	N	1.7	0.6	
18	84434	1954	GA	M	1.9	1.9	1.1	N	1.7	0.6	
19	171144	1992	FL	M	1.5	1.5	0.9	Y	1.6	0.5	
Urocyon cinereoargenteus fraterculus											
20	49957	1939	Mexico	?	1.7	1.7	0.9	N	1.5	0.5	
Urocyon cinereoargenteus madrensis											
21	9855	1901	Mexico	?	1.9	1.9	1.2	N	1.9	0.5	
22	16007	1904	Mexico	M	1.7	1.7	1.1	N	1.8	0.6	
23	13990	1904	Mexico	F			1.0	N	1.7	0.5	UL canine fx
24	9853	1901	Mexico	?	1.7	1.7	1.0	N	1.6	0.6	
25	13366	1897	Mexico	M	1.7	1.7	1.0	N	1.5	0.5	
26	9854	1901	Mexico	?	1.9	1.9	1.1	N		0.5	LR canine fx
Urocyon cinereoargenteus nigrirostris											
27	51937	1941	Mexico	F	1.8	1.8	1.1	N	1.7	0.6	
28	51393	1940	Mexico	?	1.8	1.8	1.0	Y	1.7	0.5	
29	52222	1941	Mexico	F	1.9	1.9	1.1	N	1.7	0.6	
30	51394	1940	Mexico	?			1.0	N	1.8	0.5	UL canine fx
31	52223	1941	Mexico	F	2.0	2.0	1.1	N	1.8	0.6	
Urocyon cinereoargenteus ocythous											
32	89856	1958	AR	M	2.1	2.1	1.2	N	1.8	0.6	
33	81493	1915	MN	?			1.2	Y	1.7	0.6	UL canine missing
34	160111	1994	MN	F	2.0	2.0	1.2	N	1.7	0.6	
35	175292	2001	MN	?			1.1	N	1.7	0.6	UR canine fx off
36	126807	1984	WI	M	2.2	2.2	1.3	N	2.0	0.6	
37	167190	1998	WI	M	1.9	1.9	1.2	N		0.6	LL canine tip fx
38	178039	2002	WI	M	2.0	2.0	1.2	N	1.8	0.6	
39	141988	?	WI	F	1.8	1.8	1.1	N	1.8	0.6	
Urocyon cinereoargenteus orinomus											
40	14418	1904	Mexico	M	1.9	1.9	1.1	N	1.6	0.5	
41	14421	1904	Mexico	M	1.8	1.8	1.0	N	1.6	0.5	
42	14420	1904	Mexico	F	1.8	1.8	1.0	N	1.5	0.4	
Urocyon cinereoargenteus scottii											
43	18538	1907	AZ	F			0.9	Y	1.5	0.4	UR canine fx half off
44	6501	?	CO	?	1.9	1.9	1.0	N	1.7	0.5	
45	54167	1944	TX	?	1.8	1.8	1.1	N	1.8	0.6	
46	83483	1955	TX	?	1.7	1.7	0.9	N	1.7	0.5	
47	1039	1894	AZ	F	1.6	1.6	0.9	Y	1.4	0.5	
48	129298	1972	TX	M	1.6	1.6	1.0	Y	1.6	0.4	
Urocyon cinereoargenteus townsendi											
49	9590	1901	CA	M	1.9	1.9	1.1	N		0.4	LR canine fx off
50	11750	1902	CA	F	1.8	1.8	1.1	N	1.6	0.5	
51	9591	1901	CA	?	1.7	1.7	1.0	N	1.6	0.5	
52	13365	1903	CA	?	1.8	1.8	1.0	Y	1.7	0.5	

All measurements are in centimeters.

FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 6 *Red Fox* (Vulpes vulpes).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Vulpes vulpes alascensis											
1	74052	1950	AK	F	2.5	2.4	1.4	N	2.2	0.6	
2	16014	?	AK	?	2.4	2.1	1.4	N	2.2	0.5	
3	138812	1987	AK	M	2.7	2.5	1.6	N		0.5	LL canine missing
4	151007	1989	AK	?	2.7	2.5	1.5	N	2.2	0.5	
Vulpes vulpes fulva											
5	63875	1948	IL	M	2.7	2.6	1.4	N		0.6	LR canine missing
6	63874	1948	IL	M	2.2	2.1	1.3	Y	1.8	0.6	
7	171146	1990	FL	F	2.4	2.3	1.2	N	1.8	0.5	
8	63872	1948	IL	M	2.6	2.3	1.5	Y	1.8	0.6	
9	63873	1948	IL	M	2.5	2.4	1.5	Y	1.9	0.6	
10	63871	1948	IL	F			1.2	Y		0.5	UR and LL canine missing
11	175315	2000	IL	M		1.5	1.2	N	1.4		Juvenile: all primary teeth
12	64610	1948	IL	F	2.6	2.1	1.6	Y	2.0	0.6	
13	53986	1944	IL	?	2.5	2.2	1.5	Y	2.0	0.6	
14	158908	1988	IL	F	2.3	2.1	1.4	N	2.0	0.6	
15	167070	1998	IL	M	2.7	2.4	1.5	N		0.6	LR canine fx
16	167071	1998	IL	F	2.0	1.8	1.4	N	1.6	1.0	Juvenile: all primary teeth
17	34867	1930	IL	?	2.4	2.1	1.4	N	1.9	0.6	
18	126806	1985	IL	M	2.2	2.1	1.3	N	1.9	0.5	
19	56876	1947	IL	F	2.3	2.1	1.4	Y	2.2	0.6	
20	53714	1943	IL	M	2.5	2.3	1.4	N	2.0	0.6	
21	53715	1943	IL	F	2.3	2.1	1.3	N	1.8	0.6	
22	123974	1981	MI	?	2.4	2.2	1.5	N	2.1	0.6	
23	123975	?	MI	?	2.2	2.0	1.2	N	1.8	0.5	
24	43962	1935	MI	M	2.4	2.2	1.2	N	2.0	0.5	
25	49060	1887	NY	F			1.1	N	1.7	0.5	UL canine missing
26	172393	1999	MN	M	2.2	2.0	1.4	N		0.6	LL canine tip fx
27	141991	?	WI	M	2.3	2.2	1.3	N	1.9	0.5	
28	167192	1989	WI	F	2.2	2.0	1.3	N	2.0	0.6	
29	52360	1941	WI	M	2.6	2.3	1.5	Y	2.1	0.6	L canines unusu worn; was on fox farm
30	52362	1941	WI	M	2.7	2.3	1.5	N		0.5	U canines worn, L fx; was on a fox farm
31	52377	1941	WI	M	2.5	2.3	1.4	N	2.1	0.5	
32	167193	1998	WI	F			1.5	N	2.0	0.6	UL canine fx
33	104969	1972	WI	F	2.2	2.0	1.3	N	1.7	0.6	
34	104971	1972	WI	F	2.5	2.2	1.5	Y	1.9	0.6	
35	104961	1972	WI	F	2.3	2.1	1.4	Y	1.8	0.6	
36	52361	1941	WI	M	2.5	2.3	1.4	Y	2.0	0.6	
37	52376	1941	WI	M	2.5	2.3	1.3	N	2.0	0.5	
38	154704	1994	WI	F	2.2	2.1	1.3	N	1.9	0.6	
Vulpes vulpes kenaiensis											
39	13372	?	AK	?	2.6	2.3	1.4	N	2.1	0.5	
Vulpes vulpes necator											
40	11751	1903	CA	F	2.3	2.2	1.3	N	1.9	0.4	
41	11754	1903	CA	F	2.2	2.1	1.2	N	1.9	0.4	
42	11752	1903	CA	F	2.2	2.1	1.2	N	1.9	0.4	
43	11753	1903	CA	F	2.1	1.9	1.2	N	1.9	0.5	
Vulpes vulpes regalis											
44	7369	1899	Canada	M	2.6	2.5	1.4	N	2.1	0.5	
45	7480	1900	Canada	F	2.3	2.2	1.4	Y	2.1	0.6	
Vulpes vulpes rubricosa											
46	57124	1947	Canada	?	2.6	2.4	1.5	Y	2.1	0.6	
47	67407	1947	Canada	?	2.2	1.9	1.3	N	1.8	0.5	
48	30374	1928	Canada	M	2.4	2.2	1.4	N	2.0	0.5	
49	30382	1928	Canada	M	2.8	2.7	1.5	Y	2.5	0.7	
50	30386	1928	Canada	M	2.5	2.4	1.3	Y	2.2	0.4	
51	30388	1928	Canada	M	2.7	2.5	1.5	Y	2.4	0.6	
52	51663	1940	ME	?	2.2	2.0	1.3	N	1.9	0.5	
53	51661	1940	ME	?	2.2	2.1	1.3	N	1.9	0.5	
54	51662	1940	ME	?	2.4	2.2	1.3	N	2.0	0.6	

All measurements are in centimeters.

FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 7 *Domestic Dog* (Canis familiaris).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
1	19017	1899	AK	?			2.5	N		1.4	UR and LL canine missing
2	19016	1899	AK	?	3.8	3.4	2.4	N	3.5	1.4	
3	147592	1946	Mexico	?	2.5	2.4	1.9	Y	2.1	0.6	Juvenile: max 1°, mand erupting 2°.
4	54254	1945	AK	M			2.7	N		1.3	Both max canines missing; LL fx; Husky
5	147594	1903	CA	F	2.9	2.7	1.6	N	2.6	0.9	
6	147593	1905	CA	M	2.5	2.3	1.6	N	2.1	0.8	
7	147596	1904	CA	?	3.1	2.8	2.0	N	2.5	0.9	
8	147598	1905	CA	?	4.1	3.9	2.5	Y	3.6	1.4	Bull Terrier
9	147600	1945	IL	M	2.7	2.6	1.6	N	2.3	0.9	Mongrel Terrier
10	147604	1946	IL	M	3.9	3.6	1.7	Y	3.1	1.0	Irish Terrier
11	147609	?	?	M	2.1	2.0	1.4	N	1.8	1.0	Juvenile: all primary teeth
12	147611	?	?	?			1.9				Both max canines missing; no mandible
13	147602	1945	IL	M	3.8	3.7	2.2	Y	3.1	1.1	Mongrel Chow
14	98164	1964	IL	M	5.3	4.8	3.3	Y	4.9	1.7	German Shepherd
15	147595	1904	CA	M	4.6	4.5	2.7	Y	3.5	1.4	Bull Dog
16	168865	1998	IL	F	3.9	3.5	2.3	N	3.4	1.1	
17	147612	?	?	?	2.7	2.6	1.5	N	2.3	0.9	English Terrier
18	146006	1992	IL	M	4.4	3.9	2.8	N	4.0	1.5	German Shepherd dam, Malamute sire
19	147613	?	?	M	3.6	3.4	2.2	N	2.7	1.3	Pug
20	147606	?	NA	?	4.0	3.5	2.4	Y			No ant teeth on mand, the area is healed
21	168862	1998	IL	M	4.5	4.2	2.7	N	4.0	1.5	
22	168860	?	IL	M	4.1	4.1	2.3	N	4.5	1.7	Perio disease moved some teeth
23	168864	1998	IL	M	3.7	3.5	2.4	N		1.6	LR canine tip fx
24	57448	1964	USA	F	3.6	3.4	2.1	Y	2.8	1.1	Malamute
25	168861	?	IL	F	3.4	3.1	2.1	N	2.8	1.1	Shepherd Mix
26	168863	1998	IL	F	3.7	3.6	2.1	N	3.1	1.2	
27	57409	1961	USA	M	4.9	4.7	2.6	Y		1.6	Both lower canines missing; Husky
28	168867	1998	IL	F	3.0	2.8	1.8	N	2.3	0.9	
29	172408	1998	IL	F	3.9	3.6	2.4	N	3.3	1.2	
30	168875	1998	IL	F	2.7	2.6	1.6	N	2.1	0.7	
31	147605	?	NA	?	3.6	3.4	2.3	N	3.2	1.1	
32	140827	?	?	?	2.3	2.1	1.3				No mandible
33	172409	1998	IL	M	2.3	2.3	1.7	N	1.9	1.1	Juvenile: all primary teeth
34	140826	?	?	?	2.2	2.0	1.4				No mandible
35	147608	?	?	?	4.0	3.9	2.1	Y	3.1	1.1	

All measurements are in centimeters.

FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 8 *Coyote* (Canis latrans).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Canis latrans cagottis											
1	16010	1904	Mexico	M	3.2	3.0	1.8	N	2.7	0.8	LL canine tip fx antemortum
2	16009	1904	Mexico	F	3.4	3.2	1.9	N	2.9	0.9	
Canis latrans clepticus											
3	19020	1902	Mexico	F	2.8	2.7	1.6	N	2.6	0.8	
4	16018	1902	Mexico	M	3.1	3.0	1.6	N	2.7	0.7	
Canis latrans frustror											
5	53694	1942	OK	F	3.4	3.2	2.0	Y	2.9	1.0	
6	77209	1951	AK	F	3.4	3.1	1.9	Y	2.8	1.0	
7	53695	1942	OK	M	3.7	3.5	2.0	N	3.0	1.0	
Canis latrans goldmani											
8	16004	1904	Mexico	M	3.7	3.4	2.2	N	3.3	1.0	
9	16003	1904	Mexico	F	3.6	3.5	2.1	N		1.0	LR canine tip fx
10	16002	1904	Mexico	F	3.6	3.3	2.1	N	3.3	1.2	
Canis latrans incolatus											
11	138815	1990	AK	F	3.0	2.9	1.7	N	2.8	0.9	
Canis latrans latrans											
12	7367	1900	Canada	F	3.2	3.1	1.8	N	2.8	0.9	
13	7479	1900	Canada	M	3.0	2.8	1.5	N	2.5	0.8	
14	18984	?	Canada	?	3.2	3.1	1.7	N	2.8	0.9	
15	42747	1935	SD	M	3.7	3.6	2.0	N	3.1	0.9	
16	42748	1935	SD	F	3.3	3.2	1.8	N	2.8	1.0	
17	42767	1935	SD	?	3.2	3.1	1.7	N	2.9	0.8	

TABLE 8 *Continued.*

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Canis latrans lestes											
18	81499	1903	CA	M	2.8	2.8	1.7				Mand glued together poorly; 2° erupting
19	25166	1925	ID	M	3.4	3.3	1.9	Y	3.1	0.9	
20	18986	1903	CA	M	3.2	3.1	1.6	N	3.1	0.9	
21	18985	1902	CO	M	3.2	3.1	1.8	N	3.0	0.9	
22	145970	?	WY	?	3.2	3.1	1.8	N	2.8	0.9	
Canis latrans mearnsi											
23	10913	1902	Mexico	M	2.9	2.8	1.6	N	2.7	0.8	
24	10912	1902	Mexico	M	2.8	2.5	1.6	N	2.7	0.8	
25	10914	1902	Mexico	F	3.1	3.0	1.6	N	2.8	0.8	
26	52860	1942	AZ	M	3.3	3.2	1.7	Y	2.9	0.9	
27	53755	1942	CA	F	3.2	3.1	1.7	N	2.7	0.8	
28	13247	1903	CA	M	3.2	3.1	1.8	N	3.2	0.9	
Canis latrans microdon											
29	8875	1892	TX	F	3.0	3.0	1.8	N	2.8	0.8	
Canis latrans ochropus											
30	13250	1903	CA	M	3.5	3.4	2.0	N	3.0	1	
31	81498	?	CA	M	3.3	3.2	1.9				Mandible glued together poorly
32	81495	1906	CA	?	3.2	3.1	1.7	N	2.7	0.8	
Canis latrans texenis											
33	83481	1955	TX	?	2.7	2.6	1.5	N	2.5	0.8	
34	57504	?	TX	?	3.1	3.0	1.8	N	2.7	0.9	
35	53053	1942	TX	?	3.2	3.1	1.8	N	3.0	0.9	
Canis latrans thamnos											
36	167044	1999	IL	M	3.4	3.3	1.9	N	2.8	1.1	
37	172552	1994	IL	M	3.0	2.8	1.7	N	2.8	1.0	
38	18858	1895	Canada	?	3.7	3.2	2.2	N	3.3	1.2	
39	126805	1984	IL	F	3.6	3.4	2.0	N	3.9	1.1	
40	167068	1999	IL	M	3.4	3.1	2.1	N	3.1	1.1	
41	167043	?	IL	M	3.4	3.2	1.8	N		0.8	LL canine tip fx
42	129292	1973	IL	M	3.6	3.0	2.0	Y	3.2	0.9	
43	154637	1993	IL	F	3.1	2.9	1.8	N	2.5	1.0	
44	23946	1924	IL	M			1.9	N	3.0	1.0	UR canine missing
45	175313	2001	IL	F	3.3	3.0	1.9	N	2.6	1.0	
46	167069	1999	IL	F	3.3	3.0	2.0	N	2.7	1.0	
47	13163	1903	MN	?	3.6	3.4	2.0	Y	2.7	1.0	
48	129293	1970	WI	F	3.0	2.7	1.9	Y	2.8	1.1	
49	43961	1935	MI	F	3.3		1.9	N	2.7	0.9	UR canine tip fx
50	160105	1993	MN	F	2.6	2.5	1.7	N	1.9	1.0	Juvenile: 1° teeth, 2° erupting
51	19682	1908	WI	F			1.5	Y	2.5	0.8	UL canine fx
52	150782	1943	WI	F	3.0	2.8	1.8	N	2.8	1.0	
53	29513	1928	IN	M	3.2	3.0	1.9	N	2.8	1.0	
54	154646	1987	WI	M	3.4	3.1	1.9	N	3.1	0.9	

All measurements are in centimeters.
FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 9 *Gray Wolf* (Canis lupus).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Canis lupus baileyi											
1	7619	?	Mexico	F	4.4	4.1	2.6	N	4.2	1.4	
2	7618	?	Mexico	?	4.5	4.0	2.6	N	3.7	1.3	
Canis lupus hudsonicus											
3	72960	1951	Canada	?	5.2	4.7	2.9	Y	4.4	1.3	
Canis lupus irremotus											
4	7657	1901	Canada	F	4.4	4.0	2.4	N	4.0	1.4	
5	19018	?	Canada	?	4.7	4.4	2.6	Y	4.2	1.4	
6	18988	?	Canada	?	4.7	4.4	2.5	N	4.0	1.3	
7	20190	1902	Canada	?	4.9	4.3	2.9				No mandible
8	20192	?	Canada	?	4.9	4.6	2.8				Mandible glued together improperly
9	18987	?	Canada	?	4.3	4.1	2.4	N	3.6	1.2	
10	20189	1902	Canada	?	4.5		2.6	N		1.3	Both max and LL canine tips fx
11	20191	1900	Canada	?	4.5	4.2	2.4				No mandible
Canis lupus ligoni											
12	43964	1935	AK	?	5.3	5.1	3.0	N		1.5	LL canine tip fx
Canis lupus lycaon											
13	54015	1944	Canada	F	4.5	4.1	2.5	Y		1.4	Max also separated; UL canine tip fx
14	129295	1976	Canada	M	4.7	4.2	2.7	Y	3.7	1.1	

TABLE 9 *Continued.*

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
15	129294	1974	Canada	M	4.8		2.8	Y	3.8	1.3	UL canine extruded from socket
16	21207	1911	MI	F	4.4	4.0	2.6	Y	3.6	1.3	
17	147640	1990	MN	M	4.9	4.5	2.8	N	4.2	1.5	
18	153798	1993	MN	F	4.4	3.9	2.4	N	3.7	1.4	UR canine tip fx
19	160109	1995	MN	F	4.1	3.7	2.5	Y		1.3	LL canine tip fx
20	147638	1990	MN	M	4.4	4.1	2.5	N	3.6	1.2	
21	147639	1990	MN	F	4.8	4.5	2.7	Y	4.1	1.4	
22	147636	1990	MN	M	5.3	4.9	2.9	N	4.2	1.4	
23	147637	1990	MN	F	4.8	4.3	2.9	N	4.1	1.5	
24	160108	1995	MN	M	5.2	4.9	2.9	N	4.5	1.5	
25	160107	1996	MN	F	4.4	4.0	2.6	N	3.8	1.4	
26	140894	1990	MN	M	4.9	4.5	2.8	N	3.9	1.3	
27	147641	1990	MN	F	4.7	4.3	2.7	N	4.0	1.5	
28	153802	1994	MN	F				N	3.6	1.3	Max left side damaged
29	165352	1997	MN	M	4.8	4.2	2.9	N	4.1	1.5	UR canine tip fx
30	172392	1999	MN	M	4.9	4.5	2.8	Y	4.2	1.3	
31	153799	?	MN	M	4.8	4.4	2.8	N	4.1	1.9	
32	153800	1994	MN	M	4.8	4.3	2.8	N	4.0	1.5	
33	160106	?	MN	M	5.2		2.8	N	4.1	1.4	Both max canine tips fx
34	160110	?	MN	M	4.8	4.3	2.9	N	4.0	1.4	
35	51772	1941	WI	M			2.7	N		1.5	Max separated; UL and LL canine fx off
36	51773	1941	WI	F	4.6	3.9	2.7	N	3.7	1.4	
37	21208	?	WI	?	4.8	4.2	2.8	N	4.0	1.3	
Canis lupus nubilus											
38	92252	1940	SD	?	4.3	3.8	2.4	Y	3.9	1.3	
39	154638	1895	WY	?	4.6	4.3	2.7	Y	3.9	1.5	
Canis lupus pambasileus											
40	138772	1986	AK	M	5.2	4.8	2.9	N	4.4	1.4	
41	138776	1987	AK	F	4.7	4.2	2.7	N	4.0	1.1	53 lb. juvenile
42	138759	1988	AK	F	4.8	4.4	2.5	N	4.1	1.5	
43	138773	1986	AK	M	5.3	5.0	2.9	N	4.1	1.6	
44	138794	1988	AK	M	5.2	5.0	2.8	N	4.4	1.6	
45	19019	?	AK	?	4.9	4.5	2.8				No mandible
46	138775	1986	AK	M	4.4	4.0	2.3	N	4.0	1.4	Juvenile: secondary canines erupting
47	138793	1988	AK	M	5.2	4.8	2.9	N	4.4	1.4	
48	14027	1904	AK	?	4.4	4.2	2.4	N	3.8	1.3	
49	138774	?	AK	F	4.9	4.7	2.7	N	4.2	1.3	
Canis lupus tundrarum											
50	72962	1951	AK	F	5.3	5.0	2.7	N	4.2	1.4	
51	72961	1949	AK	M			2.7	N			Fx UL; LR fx & abscess with bone loss
Canis lupus youngi											
52	21750	1917	NM	F	4.5	4.1	2.7	Y	4.0	1.3	
53	21751	1917	NM	M	4.9	4.5	2.9	N		1.4	LL canine fx tip

All measurements are in centimeters.
FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 10 *Wolverine* (Gulo gulo).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Gulo gulo luscus											
1	14021	1904?	Canada	?	3.6	3.0	2.1	N	2.5	1.0	
2	14020	1904	Canada	?	4.0	4.3	2.1	Y	3.2	1.0	
3	74056	1952 1953	Canada	M	4.0	3.2	2.0	N	2.7	0.7	
4	57196	1951	Canada	F	4.1	3.3	2.1	Y	2.9	0.9	
5	53936	1944	Alaska	?	4.2	3.3	2.3	N	3.0	0.9	
6	14025	?	Alaska	?			2.1	N	2.8	0.9	UR canine pushed up in socket
7	14026	1904	Alaska	?	4.3	3.5	2.3	Y	2.7	1.0	
8	14024	1904	Alaska	?	4.1	3.3	2.1	N	3.1	0.9	
9	9884	1902	Alaska	?	4.1	3.3	2.2	Y	3.0	0.8	
10	129315	1996	Alaska	M	4.0	3.1	2.0	Y	2.8	0.9	
11	129316	1974	Alaska	M	4.1	3.2	2.2	Y	3.0	0.9	
12	129317	1976	Alaska	F	3.6	2.8	1.9	Y	2.6	0.7	
13	79409	1952	Alaska	M	4.1	3.1	2.3	Y		0.9	Fx LL canine
14	138755	1965	Alaska	F			1.9	Y	2.8	0.9	Max canines missing
15	138766	1982	Alaska	F	3.4	2.7	1.9	N		0.8	LL canine missing
16	138762	1966	Alaska	M			2.1	Y	2.8	0.9	UR canine missing
17	138761	1967	Alaska	F			1.9	Y	2.9	0.8	UR canine missing

TABLE 10 *Continued.*

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
18	138760	1967	Alaska	F			2.0	Y		0.8	UR, UL, and LR canines missing
19	138757	1965	Alaska	M			1.9	Y	2.9	0.8	UR canine missing
20	138768	?	Alaska	?			1.8	Y	2.5	0.7	Both max canines missing
21	138763	1989	Alaska	F	3.7	3.0	2.0	Y			1/2 of mandible missing
22	138765	?	Alaska	?	4.0	3.3	2.0	N		0.8	LL canine missing
23	138769	?	Alaska	?			2.3	Y	3.0	0.9	Both max canines missing
24	138764	1988	Alaska	?	3.6	3.0	2.0	Y		0.9	LL canine missing
25	138759	1966	Alaska	M			2.1	Y	2.9	0.9	UL canine missing
26	138756	1966 1967	Alaska	M			1.9	Y		0.9	UL, LL and LR canines missing
27	138771	?	Alaska	?			2.5	Y	3.2	1.0	Both max canines missing
28	138770	?	Alaska	?			2.2	Y		0.9	All canines missing
29	138758	1965	Alaska	F			1.9	Y		0.9	Max canines missing, mand canines fx
30	138767	?	Alaska	?			1.9	Y	2.7	0.8	Both max canines missing
31	151027	1989	Alaska	M			2.4	N		1.0	All canines fx

All measurements are in centimeters.
FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 11 *Black Bear* (Ursus americanus).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Ursus americanus altifrontalis											
1	7054	1898	WA	?				N	2.9	1.7	Juvenile: 1° teeth, 2° erupt.; R max damaged
2	68179	1950	AZ	F	5.5	4.8	3.3	N	4.6	1.7	Juvenile
Ursus americanus amblyceps											
3	68178	1950	AZ	M	5.8	5.1	3.2	Y	4.7	1.5	Juvenile
4	68177	1950	AZ	M	5.2	4.8	3.1	Y	4.1	1.3	Juvenile
5	72895	1951	AZ	M	6.1	5.2	3.2	N		1.4	LR canine tip fx
6	72894	1951	AZ	F	5.4	4.6	3.2	N	4.4	1.5	
Ursus americanus americanus											
7	154193	1992	MN	F	4.9	4.5	2.9	Y	4.2	1.6	Juvenile
8	65740	1947	NM	M	6.2	5.1	3.6	N	5.1	1.7	
9	104615	1919	IN	?			3.5				UR canine missing; no mandible
10	106356	1972	WI	F	5.2	4.8	2.6	N		1.1	LL canine tip fx
11	16027	?	MI	?	5.4	4.9	2.9	N		1.2	LR canine tip fx
12	165353	?	MN	M	3.7	3.3	2.2	N	3.0	1.7	Juvenile: mixed dentition
13	141990	?	WI	M			2.0	Y		1.1	Juvenile: mixed dentition; both max canines fx
14	65739	1932	Canada	M	6.1		3.5	N	4.9	1.5	UR canine tip fx
15	51641	1941	ME	M	5.0	4.5	2.7	N	4.2	1.2	
Ursus americanus carlottae											
16	19011	1903	Canada	?	5.3	5.0	2.6	N	4.6	1.5	
Ursus americanus emmonsii											
17	21798	1918	AK	M	5.6	5.1	3.2	N		1.6	LL canine fx
18	21802	1918	AK	?	3.8	3.2	2.1	Y	3.0	1.1	Juvenile: secondary canines erupting
19	21801	1918	AK	?	3.5	3.6	2.3	Y	2.8	1.2	Juvenile: secondary canines erupting
20	18146	1909	AK	?	5.2	4.8	2.8	N	4.3	1.5	
Ursus americanus floridanus											
21	18864	1906	FL	?	5.2	4.5	3.1	N	4.4	1.6	
Ursus americanus eremicus											
22	18151	1904	Mexico	?			3.6				Both max canines missing; no mandible
23	18152	1904	Mexico	?			4.0				Both max canines missing; no mandible
Ursus americanus machetes											
24	89904	1901	Mexico	?	6.7		3.7	N		1.8	UL and LR canine tip fx
25	89906	1912	Mexico	?	5.0	4.4	2.9	Y	3.8	1.3	
26	22362	1907	Mexico	?	5.6	4.5	3.3	Y	3.8	1.7	Juvenile: max secondary canines erupting
27	89905	1907	Mexico	?		5.4	3.4	N	5.0	1.6	Distal side of UR canine fx off
Ursus americanus perniger											
28	44062	1935	AK	M	6.4	6.0	3.5	Y	5.2	1.7	
29	41509	1914	AK	?	5.5	5.0	3.2	N	4.6	1.9	
30	41508	1914	AK	?	5.7	5.1	3.1	N	4.4	1.3	
31	89897	?	AK	?	4.6	4.4	2.5	N	4.1	1.3	
32	41510	1914	AK	?	5.0	4.2	2.9	N	4.1	1.3	
Ursus americanus: Zoo											
33	44725	1936	IL Zoo	M	5.7	4.9	3.4	N	4.8	1.9	
34	57282	1957	IL Zoo	F	4.8	4.3	2.8	N	4.2	1.3	
35	57290	1957	IL Zoo	M	6.3		3.7	N	5.1	1.7	UL canine tip fx

All measurements are in centimeters.
FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 12 *Grizzly Bear* (Ursus arctos).

	FMNH#	Date Collected	Location	Sex	Maxillary MCW	Maxillary Tip	Maxillary MBH	Mandible Separated	Mandibular Tip	Mandibular MBH	Comments
Ursus arctos alascensis											
1	50044	1939	AK	?	7.9	6.7	4.5	N	6.6	2.1	
2	50046	1939	AK	?	8.3	6.9	4.5	N	6.8	2.0	
3	50045	1939	AK	?	7.3	6.5	4.0	Y	6.1	1.9	Juvenile, but all secondary teeth
4	98126	1954	AK	F	6.4	5.4	3.5	N	5.0	1.5	
5	98127	1955	AK	F			3.5	Y	5.1	1.6	UR canine missing
6	98129	1957	AK	F	6.5		3.8	N	5.3	1.6	UL canine tip fx off
7	41506	1914	AK	?	8.0		4.5	Y	6.6	2.2	UL canine tip fx off
8	41505	1914	AK	?	8.7		4.8	N	6.6	2.3	UL canine tip fx off
9	41507	1914	AK	?	6.5		3.7	N	5.2	1.9	UL canine tip fx off
Ursus arctos gyas											
10	27265	1927	Alaska	F	8.4	7.4	4.7	Y		2.2	Both L canines fx tips
11	27266	1927	Alaska	F		5.3	4.0	Y	3.9	1.9	Juvenile: max canines only tips erupted
12	27267	1927	Alaska	M	5.8	5.0	3.4	N	4.4	1.7	Juvenile: secondary canines half erupted
13	63802	1947	Alaska	M	10.8	9.6	6.1	N	9.1	3.3	
14	63803	1947	Alaska	F	8.3	7.0	4.7	N	7.1	2.5	
15	63804	1947	Alaska	F	5.8	4.7	3.4	Y			Juvenile: 2° half erup; unable to fit mand halves
16	89910	?	Alaska	?	9.4			N			Both max tips fx; jaw wired shut
17	98125	1954	Alaska	M			4.6	N	6.9	2.2	UR canine fx off
18	98124	1954	Alaska	F	7.3	6.0	4.1	N	5.9	2.0	
19	98130	1960	Alaska	M			4.3	N	5.9	1.9	Juvenile: 2° half erupted; UR canine missing
20	98128	1956	Alaska	F	8.9	7.4	5.6	N		2.8	Both mand canine tips fx
Ursus arctos horribilis											
21	44851	1932	Canada	?	7.4		4.2	N	6.2	1.9	UR canine tip fx
22	65738	1937	Canada	M	7.2		4.3	N		1.9	UR UL and LL canine tips fx
23	21859	1919	Canada	M	7.1	6.1	3.9	N	5.6	1.9	
24	21860	1920	Canada	F	6.3	5.3	3.5	Y	5.3	1.7	Juvenile: secondary teeth
25	9864	1901	Mexico	?	7.2	5.8	4.0	N	6.0	2.0	
26	16025	1901	Mexico	?	7.1	6.3	3.7	N		2.2	LL canine tip fx
27	16026	1901	Mexico	?	6.4	5.3	3.6	N	5.6	1.8	
28	98919	1960	Mexico	M	7.4	6.3	3.8	N		1.9	Both mand canine tips fx
Ursus arctos middendorffi (Kodiak Bear)											
29	7626	?	AK	?	7.1		4.4	N	6.0	2.2	UL canine 1/2; pulp chamber not visible
30	49882	1940	AK/Zoo	F	8.0	6.2	4.9	N	5.8	2.1	
31	60630	1976	AK/Zoo	F			5.8	N	8.1	3.2	UR canine fx off
Ursus arctos sitkensis											
32	46167	1937	Alaska	F	6.3	5.7	3.8	N	5.0	1.6	
33	27484	1927	Alaska	?	7.5	6.9	4.2	N	6.1	1.9	
Ursus arctos stikeenensis											
34	49056	1938	Canada	?	8.4	7.1	4.4	N	6.9	2.3	
35	65737	1934	Canada	F	7.3	6.3	4.2	N	6.1	1.9	

All measurements are in centimeters.

FMNH#, field museum of natural history number; MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height; M, male; F, female; N, no; Y, yes.

TABLE 13 *Cat family measurement ranges.*

	Max MCW (cm)	Max Tip (cm)	Max MBH (cm)	Mand Tip (cm)	Mand MBH
Cat (25)	1.1 2.4	0.9 2.2	0.7 1.6	0.8 1.8	0.4 0.7
Bobcat (39)	2.3 3.8	1.9 3.1	1.1 2.1	1.2 2.4	0.5 0.9
Lynx (34)	2.2 3.7	1.8 3.0	1.3 2.3	2.0 2.5	0.5 1.0
Mt Lion (39)	3.3 5.8	2.5 4.5	2.1 3.3	2.3 4.0	1.0 1.5

The numbers in parentheses indicate how many of each species were meas ured.

MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height.

TABLE 14 *Dog family measurement ranges.*

	Max MCW (cm)	Max Tip (cm)	Max MBH (cm)	Mand Tip (cm)	Mand MBH (cm)
Gray Fox (52)	1.5 2.2	1.5 2.2	0.9 1.3	1.3 2.0	0.4 0.7
Red Fox (54)	2.0 2.8	1.5 2.7	1.1 1.6	1.4 2.5	0.4 1.0
Dog (35)	2.1 5.3	2.0 4.8	1.3 3.3	1.8 4.9	0.6 1.7
Coyote (54)	2.6 3.7	2.5 3.6	1.5 2.2	1.9 3.9	0.7 1.2
Gray Wolf (53)	4.1 5.3	3.7 5.1	2.3 3.0	3.6 4.5	1.1 1.9

The numbers in parentheses indicate how many of each species were meas ured.

MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height.

TABLE 15 *Wolverines and bears measurement ranges.*

	Max MCW (cm)	Max Tip (cm)	Max MBH (cm)	Mand Tip (cm)	Mand MBH (cm)
Wolverine (31)	3.4 4.3	2.7 4.3	1.8 2.5	2.5 3.2	0.7 1.0
Black Bear (35)	3.5 6.7	3.2 6.0	2.0 4.0	2.8 5.2	1.1 1.9
Grizzly Bear (35)	5.8 10.8	4.7 9.6	3.4 6.1	3.9 9.1	1.5 3.3

The numbers in parentheses indicate how many of each species were meas ured.

MCW, maximum canine width; Tip, canine cusp tip; MBH, mesial bone height.

TABLE 16 *Intercanine width ranges.*

	Maxilla (cm)	Mandible (cm)
Domestic Cat (25)	0.7 2.2	0.4 1.8
Bobcat (39)	1.1 3.1	0.5 2.4
Lynx (34)	1.3 3.0	0.5 2.5
Mountain Lion (39)	2.1 4.5	1.0 4.0
Gray Fox (52)	0.9 2.2	0.4 2.0
Red Fox (54)	1.1 2.7	0.4 2.5
Domestic Dog (35)	1.3 4.8	0.6 4.9
Coyote (54)	1.5 3.6	0.7 3.9
Gray Wolf (53)	2.3 5.1	1.1 4.5
Wolverine (31)	1.8 4.3	0.7 3.2
Black Bear (35)	2.0 6.4	1.1 5.2
Grizzly Bear (35)	3.4 9.6	1.5 9.1

The numbers in parentheses indicate how many of each species were measured.

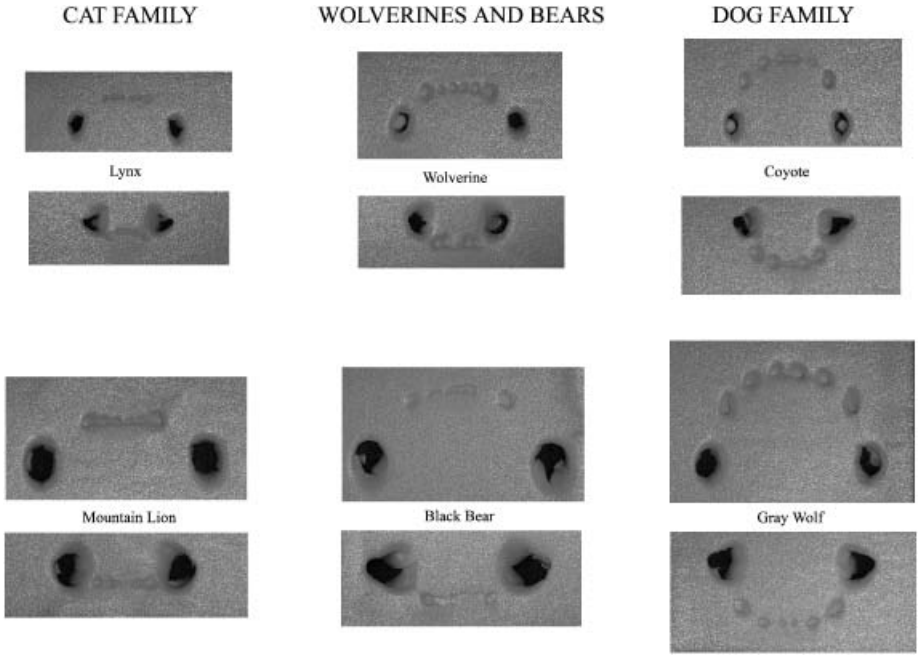


FIG. 9 *Same scaled exemplars showing family group differences and similarities.*

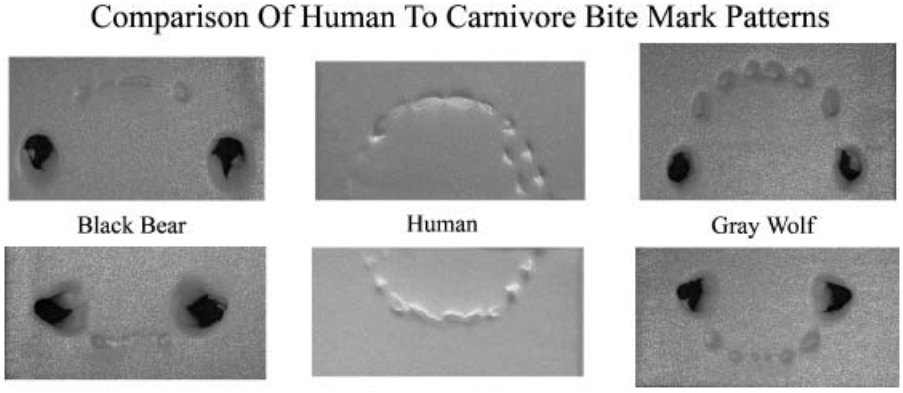


FIG. 10 *Same scaled exemplars allowing a comparison of the bite patterns. Note that the carnivores have six incisors and two very large canines per arch. Humans have only four incisors and much smaller canines, comparatively speaking.*

Acknowledgments

We gratefully acknowledge the Field Museum of Natural History in Chicago, Illinois, for making available their collection of mammalian skulls. We also thank them for the use of their copy stand and caliper that were utilized in our photographic and metric studies.

The authors would like to also thank Bill Stanley and Minh-Tho "Michi" Schulenberg from the Field Museum of Natural History, for their generous assistance with access to the Mammalian Collection. We are grateful to Mary Cimrmancic, D.D.S., for her helpful comments and editing skills.

No official disclaimers.

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Additional information and reprint requests:
Denise C. Murmann, D.D.S.
5540 South Pulaski Road
Chicago, IL 60629
E-mail: dcmurmann@juno.com