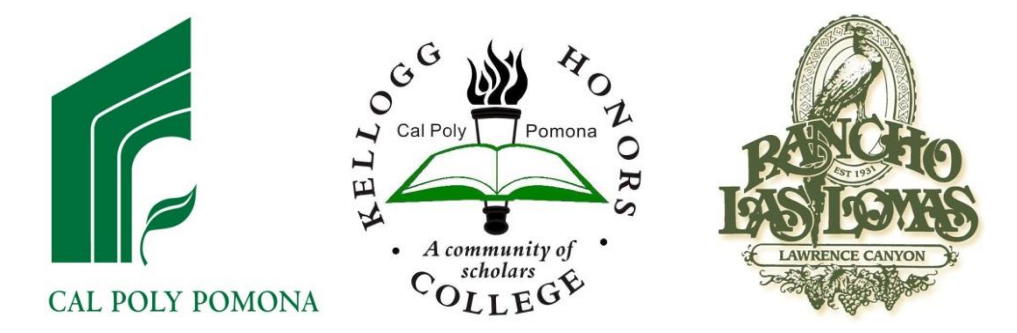


Post-Feeding Tooth Mark Data from Fleshed and Defleshed Bones Presented to Captive Bengal Tigers, *Panthera tigris tigris*

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Abstract

The large cat, or felid, is an elusive predator in an archaeological context. Archaeologists study faunal assemblages bearing signs of predator involvement to better understand the differences in tooth mark data between various predator taxa. Previous studies have analyzed tooth mark dimensions made by multiple carnivore species on defleshed bone [3]. Because large cats are generally flesh eaters and not bone crackers or chewers like the canids, they have been known to leave few modifications indicative of their involvement at a site [1]. Thus, using only defleshed bones could yield atypical results. As such, this study looks only at the tooth mark modifications made to bone by the Bengal tiger, *Panthera tigris tigris*, and compares the tooth mark frequencies and dimensions present between fleshed and defleshed bovid long bones. Our results show the frequency of bite marks, specifically furrows and scores, to be greater on the epiphyseal and metaphyseal regions of defleshed bones in comparison to fleshed bones. The fleshed bones, however, presented with a slight increase in diaphyseal marking. Overall, there were 1.5 times as many tooth marks on defleshed bone than there were on fleshed bone. Score and furrow dimensions were also greater on defleshed bone. This suggests that the lack of meat present on defleshed bones could influence a felid's feeding methods, encouraging atypical behavior and yielding results contrary to the archaeological record.

Background

Often the archaeological record presents faunal assemblages bearing specific bone modifications related to the feeding habits of various carnivores. Because evidence of the carnivore responsible for the bone modification is rarely found in context, inferences must be drawn concerning the archaeologically "invisible" predator [2]. Through experimental archaeology with modern captive carnivore populations, archaeologists have been able to devise methods for determining the specific size and taxon of the predator responsible for the bone damage, or even lack thereof, in a faunal assemblage [3].

Knowing the specific carnivore responsible for the feeding modifications present on faunal remains adds to the overall understanding of how that particular predator consumes its prey. For example, large felids, like the Bengal tiger, consume parts of their prey whole, typically removing the hands, feet and axial skeleton from the original site of deposition. This feeding behavior produces both a refuse assemblage as well as a scat assemblage, thereby separating specific skeletal elements from the primary context [1,5].

Currently, *Panthera tigris tigris* tooth mark dimensions have been analyzed on defleshed bones [3]; however, large felids are not typically scavengers by nature, thus tooth mark patterning on defleshed bone may yield results different from fleshed prey. Additionally, previous studies have fed smaller prey animal bones to large felids and it was observed that the epiphyses and metaphyses were destroyed. Our study employs the use of large prey animal (>120 kg) long bones and compares tooth mark frequencies and dimensions on fleshed and defleshed bones to determine if data for fleshed bone will differ from established data for defleshed bone [3,4].

Methods

Tooth mark samples were obtained through feeding experiments conducted with the Rancho Las Lomas Zoological Gardens' captive population of Bengal tigers. Two male tigers of known ages were chosen for the feeding experiment to represent large felid predators greater than 50 kg [3]. Prior to the experiment both male tigers were weighed and general profile data was recorded (Table 1). The feeding experiment lasted for a duration of four days. Each day the tigers were presented a set of bones altering between defleshed bovid femurs and fleshed bovid foreshanks, or tibiae (Fig. 1). Normal diets were adjusted accordingly for fleshed bones to accommodate the addition of meat to the tigers' daily food intake. It should be noted that the animal keepers were the only individuals to interact directly with the tigers in this study and that the feeding experiment did not differ from pre-existing feeding routines and procedures.

Both felids were observed for their general feeding behavior and level of interest in the bones. The tigers were allowed access to the bones for 24 hours, after which point the samples were collected, labeled according to which tiger fed upon them, and bagged for later processing. The bones were boiled in a water and detergent solution and cleaned with wooden tools and soft brushes to expose tooth mark modifications.

The cleaned bones (Fig. 2) were examined for tooth pits, scores, furrows, and punctures with a 5x magnification lens. The location and frequency of marks was noted (Table 2). Margins of tooth marks were outlined in pencil to increase contrast in photographed images [6]. Marks were photographed in macro function with a Nikon Coolpix P90 digital camera with a 24x lens. Picasa™ 3 photo editing software was used to adjust picture contrast prior to uploading images to ImageJ for analysis (Fig. 3). ImageJ open source software was used to calculate tooth mark dimensions on a best fit ellipse.

Results

Table 1

General profile information for the two Bengal tigers involved in the feeding experiment.

Family	Species	Common name	Zoo name	Age (yrs)	Sex	Mass (kg)
Felidae	<i>Panthera tigris tigris</i>	Bengal tiger	"Tonka"	8.75	M*	211.82
Felidae	<i>Panthera tigris tigris</i>	Bengal tiger	"Zombo"	8.75	M*	201.36

*Indicates an animal that has been surgically sterilized

Figure 1

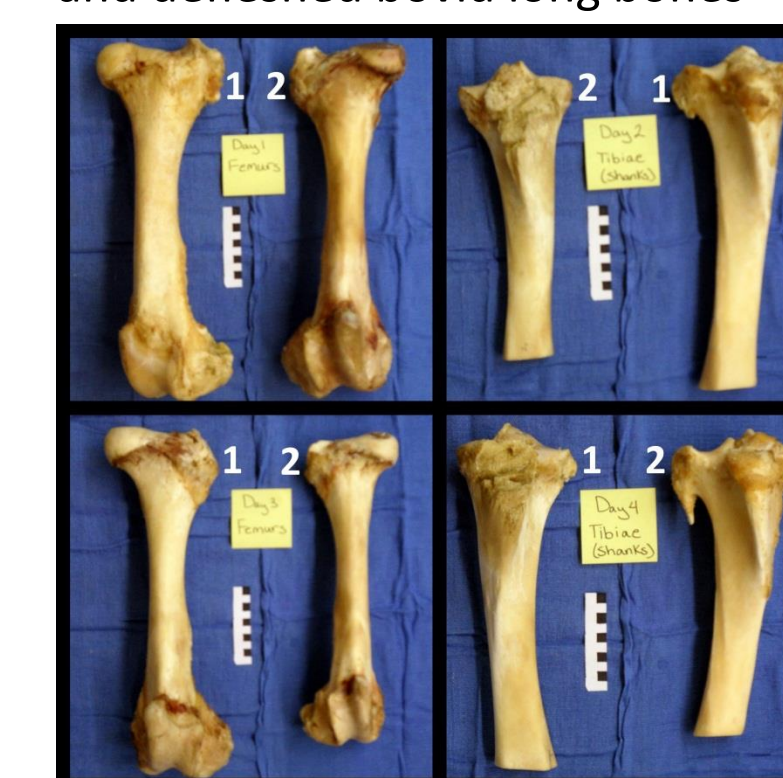
Pre-feeding fleshed and defleshed bovid long bones.



(1) Indicates a bone fed on by Bengal tiger "Tonka"
(2) Indicates a bone fed on by Bengal tiger "Zombo"

Figure 2

Cleaned, post-feeding "fleshed" and defleshed bovid long bones



(1) Indicates a bone fed on by Bengal tiger "Tonka"
(2) Indicates a bone fed on by Bengal tiger "Zombo"

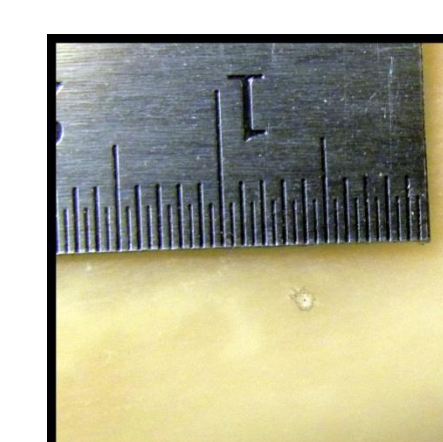


Figure 3

Example of a tooth pit on the diaphysis of a femur. (Traced in pencil to increase contrast)*

*Tooth pits are defined as circular marks on the surface of bone that reflect the shape of the tooth crown or cusp. Scores are marks whose length out measures their width by 2-3 times. Punctures are similar to pits but differ in that the entire thickness of the cortical bone is damaged. Finally, furrows are defined as large, broad gouges where the cortical bone has been stripped away and only cancellous bone remains.

Table 2

Dimension data for tooth pits, scores, furrows, and punctures by fleshed and defleshed bone portion.

Species	N	Major Axis (in mm)				Minor Axis (in mm)			
		Mean	s.d.	min	max	Mean	s.d.	min	max
Femur-Bengal Tiger "Tonka"									
Epiphyses									
• Pits	5	2.558	0.539	1.771	3.243	1.852	0.259	1.574	2.200
• Scores	13	12.443	2.778	7.918	17.964	2.860	0.865	1.389	4.170
• Furrows	3	72.362	11.890	61.746	85.210	60.570	8.099	52.520	68.717
• Punctures	4	4.878	1.434	3.772	6.942	3.111	0.356	2.613	3.377
Diaphyses									
• Pits	2	2.006	0.738	1.484	2.528	0.959	0.010	0.951	0.966
• Scores	4	14.670	5.408	7.741	20.944	1.88	0.545	1.240	2.420
Metaphyses									
• Pits	3	1.710	0.377	1.457	2.144	0.924	0.208	0.697	1.106
Femur-Bengal Tiger "Zombo"									
Epiphyses									
• Pits	3	2.582	0.392	2.338	3.034	2.096	0.221	1.928	2.347
• Scores	3	68.802	10.381	60.285	80.365	48.356	9.622	39.534	58.617
• Punctures	1	5.276	N/A	N/A	N/A	5.075	N/A	N/A	N/A
Diaphyses									
• Pits	9	1.577	0.676	1.041	3.315	1.098	0.176	0.907	1.428
• Scores	8	4.121	1.253	3.200	7.079	0.746	0.173	0.499	1.075

Species	N	Major Axis (in mm)				Minor Axis (in mm)			
		Mean	s.d.	min	max	Mean	s.d.	min	max
"Fleshed"									
Tibiae-Bengal Tiger "Tonka"									
Epiphyses									
• Pits	1	3.051	N/A	N/A	N/A	2.459	N/A	N/A	N/A
• Scores	3	6.184	0.671	5.412	6.628	2.018	0.363	1.646	2.371
• Furrows	4	47.921	18.203	21.626	63.619	30.129	13.807	11.196	42.504
Diaphyses									
• Pits	5	1.413	0.156	1.142	1.525	1.095	0.140	0.908	1.266
• Scores	5	6.888	2.488	3.076	10.039	1.308	0.423	0.929	2.036
• Furrows	1	46.878	N/A	N/A	N/A	27.983	N/A	N/A	N/A
Metaphyses									
• Furrows	1	52.92	N/A	N/A	N/A	21.68	N/A	N/A	N/A
Tibiae-Bengal Tiger "Zombo"									
Epiphyses									
• Pits	1	1.732	N/A	N/A	N/A	1.431	N/A	N/A	N/A
• Scores	2	61.277	4.369	58.188	64.266	37.514	12.176	28.904	46.124
Diaphyses									
• Pits	7	1.508	0.318	1.105	1.901	1.063	0.293	0.734	1.399
• Scores	5	11.099	3.565	6.885	14.803	1.029	0.333	0.633	1.548
• Furrows	1	35.173	N/A	N/A	N/A	16.973	N/A	N/A	N/A
Metaphyses									
• Furrows	2	32.756	0.759	32.218	33.291	32.755	0.759	15.145	25.96

Discussion

The results of this feeding experiment indicate that there are notable differences in feeding behavior between large felids presented defleshed bones and those presented fleshed bones. The tigers were observed to have a high level of interest in the defleshed bones. Treating the defleshed bones as novel objects, the tigers spent approximately an hour chewing and gnawing on the proximal and distal ends. Neither felid was observed chewing for an extensive period of time on the diaphyses and this is corroborated by the lack of diaphyseal tooth marks on the defleshed bones. In contrast, the tigers treated the meat on the fleshed bones as the novel object and spent approximately an hour cleaning the muscle and connective tissue off of the surface of the bones, thus losing interest in the tibiae once the meat was relatively gone. Because of this feeding behavior associated with fleshed prey, there were slightly more diaphyseal marks indicating attempts at removing meat from the surface of a bone; however there were few marks associated with proximal and distal end chewing. Overall, there were 1.5 times as many tooth marks on the defleshed bones as there were on the fleshed bones. Furthermore, dimension data differed greatly in the observed furrows and scores on epiphyseal and metaphyseal regions. Prior studies lacked large animal (>120 kg) bones for feeding experiments and noted that no data could be collected from the epiphyses and metaphyses due to those regions being virtually destroyed by the tiger [3]. Our study presents data from these regions and the differences between fleshed and defleshed bone was better noted. Our dimension data for pits was comparable to that collected from previous studies; however our scores were somewhat larger possibly due to size and sex of the tigers used in this experiment compared with those in other studies [3].

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