**CASE REPORT**

*Travis Rayne Pickering,[1] Ph.D.*

# Carnivore Voiding: A Taphonomic Process with the Potential for the Deposition of Forensic Evidence

**REFERENCE:** Pickering TR. Carnivore voiding: a taphonomic process with the potential for the deposition of forensic evidence. J Forensic Sci 2001;46(2):406–411.

**ABSTRACT:** Carnivore defecation and regurgitation are taphonomic processes that create discrete concentrations of bone pieces and soft tissue fragments of animals that have been consumed. Experiments in which baboon carcasses were fed to leopards and spotted hyenas demonstrate that primate metapodials and phalanges are well represented as readily identifiable specimens in such scat concentrations. Most often phalanges are recovered from scat as whole, articulated digit units (composed of the proximal through distal phalanges) still covered with ligaments, intact skin and finger/toe nails. Considering the very basic similarities between baboon and human physiques, the potential applications of these findings to human forensic cases are significant. Fingers and toes possess features, including fingerprints and, sometimes, distinctive finger and toe rings, useful in the identification of human bodies.

**KEYWORDS:** forensic science, taphonomy, carnivores, baboons, humans, metapodials, phalanges, fingerprints

There is a preponderance of early hominid digit elements (i.e., metapodials and phalanges) compared with other postcranial bones recovered from Plio-Pleistocene deposits in the Swartkrans Cave site (Gauteng, South Africa). A series of experiments in which baboon (*Papio cynocephalus*) carcasses were fed to captive leopards (*Panthera pardus*) and spotted hyenas (*Crocuta crocuta*) were conducted in an effort to explain this pattern of observed skeletal part representation. The results of these experiments were instrumental in developing a hypothesis that states the skeletal part pattern resulted mostly from deposition of hominid postcrania in the feces and regurgitations of large carnivores (1). Baboon digit elements are much better represented proportionally than other postcrania in bone samples derived from carnivore scat than they are in samples consisting of bone pieces not ingested during carnivore feeding.

There is a broad similarity between the physiques of baboons and modern humans. There is comparability in the configuration of the torso, in the morphology of the manus and pes and in the morphology and breadth/length ratios of limb bones (2). Thus, in addition to the paleoanthropological significance (1) of the findings reported here, the observed patterns are potentially useful for application in modern forensic situations in which human cadavers have been ravaged and consumed by large- and medium-sized carnivores.

This paper describes the composition of a baboon bone assemblage created by carnivore voiding. Furthermore, it compares patterns of skeletal part representation in this type of assemblage to those features in an assemblage composed of baboon bones fed on, but not ingested by carnivores. The condition of the baboon remains recovered from carnivore feces and regurgitations are considered. Finally, the implications these findings have for the potential recovery of important forensic evidence in the deaths of humans that have been fed on by carnivores are discussed.

## Materials and Methods

Ten "problem" baboons were culled with a large caliber rifle on the Bergpaan Soutwerke, near the town of Vivo in northeastern South Africa. The culled sample consists of two subadult females, two adult females, one subadult male, one adult male and four old adult males. The keepers of the carnivores that the baboon carcasses were fed to, requested that the baboons' gastrointestinal tracts be removed before introduction to the carnivores. The guts were removed via a vertical incision in the abdomen, leaving the respiratory and cardiovascular systems in place. Baboon carcass weights ranged from 14.2 to 32.6 kg (mean, 22.0 kg) before evisceration, and ranged from 11.2 to 26.6 kg (mean, 17.44 kg) after being eviscerated.

The baboon carcasses were frozen for transport to the Moholoholo Wildlife Rehabilitation Centre (near Hoedspruit, South Africa) and African Game Services (near Broederstroom, South Africa). Six baboon carcasses were thawed at Moholoholo and presented one at a time to a captive male leopard (three years old, 75 kg). Four carcasses were thawed at African Game Services. Two of these carcasses were presented one at a time to a captive leopard, and two were presented one at a time to a captive spotted hyena. The baboon carcasses were fed concurrently, so there were no other types of food remains mixed with collected primate material.

Presentation of a carcass is referred to as a "feeding episode." Feeding episodes began after the carnivore involved had not eaten for 48 h. The carnivore was placed in a small holding cage while the baboon carcass was put into a larger, attached outdoor enclo-

[1] Department of Anthropology, Tulane University, New Orleans, LA and Department of Archaeology, University of the Witwatersrand, Johannesburg, South Africa.

Received 15 Oct. 1999; accepted 11 April 2000.

sure. The carnivore was introduced into the larger enclosure and allowed to feed on the baboon carcass for as long as it desired. Carnivore feeding took place intermittently and lasted anywhere from 12 to 72 h. Cessation of carnivore interest in a baboon carcass signaled the termination of a feeding episode; at that point the carnivore was induced back into the smaller, holding cage.

All baboon remains, including soft tissues and bones, were then collected from the large enclosure. The combined sample of bones recovered after all ten feeding episodes is referred to collectively as the "refuse assemblage."

In addition, all carnivore feces and regurgitations resulting from the feeding episodes were collected. Feces and regurgitations were disaggregated manually with dental picks and tweezers. Bones and soft tissues were separated, and the bone sub-samples were combined and referred to collectively as the "scat assemblage."

The scat assemblage was expanded with primate bones extracted from five carnivore scat piles collected in western Tanzania by myself and Dr. Janette Wallis. The primate bones recovered from these scats come from blue monkeys (*Cercopithecus mitis*) and/or redtail monkeys (*C. ascanius*) and baboons (*P. cynocephalus*). The likely origin of the scats is wild leopards, based on the size and shape of the feces (3,4).

## Results

### *Carcass Consumption*

Although there was slight variation in the sequence and thoroughness that the carnivores consumed the baboon carcasses, a generalized pattern of consumption was as follows. Feeding began inside the thorax, with the carnivore entering the baboon chest through the incision cut to remove the guts. The heart and lungs were eaten, along with the first through third ribs, clavicles and sternebrae. The sternal ends of lower ribs were also eaten. Feeding continued on the trunk, imparting damage to vertebrae, ribs, scapulae and pelves. In some cases some of these elements were consumed in their entirety. Muscles overlying limbs were eaten and joints often destroyed in the process. Hands and feet were consumed in some cases, with feeding starting invariably at the fingers and proceeding proximally towards the wrists and ankles. Articulated digits were often removed from the hand or foot at the articulation of the metapodial and proximal phalanx. These digits were swallowed whole, without chewing (5,6). Similarly, complete carpal and tarsal masses were often swallowed whole (7). Skull elements were not eaten, but the carnivores often dragged the baboon carcasses by the heads, inflicting puncture marks on the crania and mandibles.

### *Skeletal Part and Soft Tissue Representation*

Tables 1 and 2 summarize skeletal part representation data for both the refuse and scat assemblages, in terms of number of identified specimens (NISP) and minimum number of elements (MNE) per skeletal part category such as cranium or humerus. The MNE is arrived at by determining the minimum number of elements in a given skeletal part category necessary to account for the observed specimens (8). For example, if there are two heads of right humeri and the distal epiphysis of a left humerus, the resulting MNE for the humerus is three.

A clear pattern is apparent when the datasets are compared. Based on the MNE, the scat assemblage displays a much greater proportional representation of digit elements compared to all other postcrania combined than the refuse assemblage. Digit elements comprise 55.2% ($n$ = 313) of the total postcranial MNE in the scat assemblage, and only 33.98% ($n$ = 193) of the total posctranial MNE in the refuse assemblage.

In a hypothetical assemblage of ten complete baboon carcasses, digit elements compose 36.84% ($n$ = 760) of the total postcranial MNE. The refuse assemblage is similar to this hypothetical assemblage in proportional representation of digit elements, based on Chi-square analysis ($\chi^2 = 1.5765$, 1 d.f., $0.5 > P > 0.2$). On the other hand, the scat assemblage is significantly different from both the hypothetical assemblage ($\chi^2 = 62.085$, 1 d.f., $P < 0.001$) and the refuse assemblage ($\chi^2 = 51.728$, 1 d.f., $P < 0.001$) in proportional representation of digit elements. In summary, the refuse assemblage retains a similar proportion of digit elements as that expected in an assemblage of complete skeletons, while the scat assemblage diverges from the complete skeleton assemblage proportions in possessing a higher relative representation of digit elements.

In addition to preserving abundant digit elements, several hundred fragments of baboon hand and foot skin were recovered from the carnivore scats (9). Many pieces are fairly large (at least ~25 × ~15 mm in dimension), and preserve intact pad and fingertip whorls. One hundred fifty-one finger/toe nails were also extracted, most still articulated to distal phalanges.

### *Bone Surface Modifications*

Bone specimens that have passed through the digestive tracts of carnivores typically display damage such as corrosion, etching and smoothing caused by the action of gastric acids (1,5,10–21). Interestingly, although 79.29% ($n$ = 628) of the postcranial specimens recovered in the scat assemblage display these types of modifications, 164 recovered postcranial pieces display *no* damage from digestive acids. *All* these undamaged pieces are either metapodial or phalanx specimens, and all but 26 of the undamaged pieces were recovered from regurgitations rather than from feces. In addition, 62 of the 99 modified phalanges in the scat assemblages display only very moderate corrosion of bone surfaces; the remaining 37 phalanges are heavily corroded. *All* the damaged specimens passed entirely through carnivore digestive tracts, being recovered from feces rather than from regurgitations.

## Discussion and Conclusions

The results of this study demonstrate that carnivore defecation and regurgitation are important taphonomic processes that create samples of bone fragments and indigestible soft tissues. Primate digit elements are well represented in these samples as readily identifiable specimens. The identifiable condition of digested metapodials and phalanges is in contrast to other skeletal elements, which are more completely destroyed and/or rendered unidentifiable by carnivore mastication and digestion.

At least a few factors seem to be responsible for this observed difference between digit elements and other bones. First, unlike other postcranial elements, phalanges often entered the digestive tracts of the carnivores as whole, articulated digits (i.e., from the proximal to distal phalanx). The scat assemblage preserves a total of 46 articulated digits. Most of these articulated digits are still skin-covered and retain overlying finger and toe nails (Fig. 1).

Articulated fingers and toes are small, comparable in size, or more often, smaller than the size of bites taken from other parts of the baboon carcasses by carnivores. Because of this, there was no need to break the digits down into smaller units to be swallowed. In addition, primate phalanges and metapodials contain only minimal

TABLE 1—*Refuse assemblage skeletal part representation (NISP/MNE).*

| | Baboon Carcass Number | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Element | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
| CRAN | 1/1 | 1/1 | 1/1 | 1/1 | 1/1 | 1/1 | 1/1 | 1/1 | 1/1 | 1/1 | 10/10 |
| 1/2MAN | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 20/20 |
| ATLAS | 1/1 | 1/1 | 0 | 1/1 | 0 | 1/1 | 1/1 | 0 | 1/1 | 0 | 6/6 |
| AXIS | 1/1 | 1/1 | 0 | 1/1 | 0 | 1/1 | 0 | 0 | 1/1 | 0 | 5/5 |
| CERV | 0 | 3/2 | 1/1 | 0 | 0 | 0 | 0 | 0 | 4/4 | 0 | 8/7 |
| THOR | 1/1 | 0 | 0 | 4/3 | 0 | 10/10 | 6/4 | 3/2 | 13/8 | 2/2 | 39/30 |
| LUM | 1/1 | 0 | 2/2 | 3/3 | 0 | 9/6 | 1/1 | 0 | 4/4 | 4/3 | 24/20 |
| VERT | 0 | 3/1 | 0 | 4/1 | 0 | 0 | 3/1 | 0 | 5/2 | 1/1 | 16/6 |
| SAC | 0 | 0 | 0 | 1/1 | 0 | 1/1 | 1/1 | 1/1 | 1/1 | 0 | 5/5 |
| CAUD | 0 | 0 | 4/4 | 0 | 0 | 0 | 5/5 | 0 | 0 | 3/3 | 12/12 |
| RIB | 1/1 | 0 | 5/3 | 12/8 | 6/5 | 21/20 | 13/9 | 9/9 | 17/14 | 5/3 | 89/72 |
| CLAV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STERN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SCAP | 1/1 | 0 | 3/2 | 1/1 | 0 | 1/1 | 2/1 | 2/2 | 2/2 | 2/2 | 14/12 |
| HUM | 2/2 | 2/2 | 2/2 | 1/1 | 2/2 | 3/2 | 2/2 | 2/2 | 2/2 | 1/1 | 19/18 |
| RAD | 0 | 1/1 | 2/2 | 2/1 | 2/2 | 2/2 | 1/1 | 2/2 | 2/2 | 0 | 14/13 |
| ULN | 1/1 | 0 | 2/2 | 1/1 | 2/2 | 2/2 | 1/1 | 2/2 | 2/2 | 1/1 | 14/14 |
| CARP | 0 | 0 | 0 | 0 | 0 | 18/18 | 0 | 9/9 | 0 | 0 | 27/27 |
| MTC | 0 | 0 | 0 | 0 | 0 | 10/10 | 0 | 9/9 | 0 | 0 | 19/19 |
| PHLX I | 0 | 0 | 0 | 10/10 | 0 | 15/15 | 9/9 | 9/9 | 0 | 6/6 | 49/49 |
| PHLX II | 0 | 0 | 0 | 8/8 | 0 | 12/12 | 8/8 | 7/7 | 2/2 | 6/6 | 43/43 |
| PHLX III | 0 | 0 | 10/10 | 0 | 0 | 15/15 | 10/10 | 5/5 | 3/3 | 7/7 | 50/50 |
| 1/2PEL | 0 | 0 | 0 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 0 | 12/12 |
| FEM | 1/1 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 3/2 | 20/19 |
| PAT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TIB | 1/1 | 2/2 | 0 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 2/2 | 19/19 |
| FIB | 0 | 1/1 | 2/2 | 2/2 | 2/1 | 1/1 | 2/2 | 2/2 | 2/2 | 3/2 | 17/15 |
| TAR | 0 | 0 | 0 | 14/14 | 0 | 7/7 | 14/14 | 0 | 14/14 | 14/14 | 63/63 |
| MTT | 0 | 0 | 0 | 10/10 | 0 | 5/5 | 6/6 | 0 | 7/7 | 4/4 | 32/32 |
| LBS | 1/- | 0 | 1/- | 3/- | 3/- | 1/- | 0 | 6/- | 5/- | 0 | 20/- |
| FRG | 0 | 6/- | 8/- | 6/- | 1/- | 11/- | 16/- | 3/- | 4/- | 8/- | 63/- |

NOTE: This table provides a summary of baboon bones *not* ingested during feeding experiments in which ten baboon carcasses were fed singly to individual leopards and spotted hyenas (1). Skeletal part representation is expressed as NISP (number of identified specimens) and MNE (minimum number of elements) for each skeletal part category; see discussion in text ("Results" section) for derivation of these bone counts.

Abbreviations: CRAN, cranium; 1/2MAN, hemimandible; CERV, cervical vertebra; THOR, thoracic vertebra; LUM, lumbar vertebra; VERT, indeterminate vertebra; SAC, sacrum; CAUD, caudal vertebra; CLAV, clavicle; STERN, sternebra; SCAP, scapula; HUM, humerus; RAD, radius; ULN, ulna; CARP, carpals; MTC, metacarpal; PHLX I, first phalanx (manual + pedal); PHLX II, second phalanx (manual + pedal); PHLX III, third phalanx (manual + pedal); 1/2PEL, os coxae; FEM, femur; PAT, patella; TIB, tibia; FIB, fibula; TAR, tarsals; MTT, metatarsal; LBS, unidentifiable long bone shaft fragment; FRG, unidentifiable bone fragment. Sesamoids are excluded from this table and all analyses.

amounts of marrow compared to other tubular bones of the skeleton. Thus, digit elements provide little incentive for extensive masticatory processing from a flavorful or nutritional point of view.

Because metapodials and phalanges were not heavily masticated before swallowing, they escaped the initial destruction that other larger and differently shaped bones were subjected to prior to ingestion by carnivores. This initial crunching-up of non-digit elements, combined with the subsequent corrosive effects of digestive acids, rendered pieces of these bones recovered from scat more difficult (or impossible) to identify than metapodials and phalanges.

Many digit elements escaped degradation by gastric acids, another factor that contributed to their good condition (i.e., easily identifiable state) once through a carnivore's digestive tract. The predominance of tough, ligamentous connective tissues in the fingers and toes, as well as keratinous nails partially sheathing distal phalanges, are likely factors that protected digit elements from the destructive effects of stomach acids. In addition, it is notable that the majority of undamaged digit elements (84.15%) were recovered in regurgitations rather than in feces. This implies that these undamaged specimens spent less time in carnivore digestive tracts and therefore less time in contact with corrosive gastric acids.

### *Potential Applicability to Human Forensic Cases*

Large- and medium-sized carnivores often interact with human cadavers during the perimortem and postmortem intervals (6,12,22–29), whether or not the carnivores were actually responsible for the deaths of the humans. These interactions can result in the modification, destruction and/or displacement of forensic evidence due to carcass ravaging and consumption. However, some of this displaced evidence can be recovered with systematic searches and collection of carnivore feces and regurgitations. The results of this study indicate that such an effort is justified, as carnivore scats preserve primate body parts that are very useful in establishing the identity of the victim. In particular, digit bones (metapodials and phalanges) are often recovered from scat in a readily identifiable and very intact condition.

Digit units are usually articulated and retain overlying skin, ligaments, and finger/toe nails. The finger and toe skin is generally in good condition, with no degradation of fingerprint whorls. The importance of fingerprints in assisting with body identification in human cases is evident.

Similarly, human digits can hold clues to a body's identity because some people wear distinctive finger and/or toe rings. Rings

TABLE 2—*Scat assemblage skeletal part representation (NISP/MNE).*

| | Scat Occurrence | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Element | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total |
| CRAN | 0 | 15/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15/1 |
| 1/2MAN | 0 | 2/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2/1 |
| ATLAS | 0 | 0 | 0 | 0 | 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 1/1 | 0 | 0 | 0 | 2/2 |
| AXIS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 1/1 |
| CERV | 0 | 1/1 | 0 | 0 | 0 | 2/1 | 0 | 3/1 | 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 7/4 |
| THOR | 4/2 | 4/4 | 7/4 | 3/2 | 3/2 | 2/2 | 3/2 | 3/3 | 0 | 0 | 0 | 0 | 0 | 2/1 | 0 | 31/22 |
| LUM | 5/2 | 6/2 | 4/2 | 0 | 2/2 | 3/1 | 5/2 | 0 | 1/1 | 0 | 0 | 0 | 1/1 | 0 | 0 | 27/13 |
| VERT | 14/2 | 5/1 | 10/3 | 4/2 | 20/4 | 11/3 | 3/1 | 14/3 | 13/2 | 6/2 | 0 | 0 | 3/1 | 1/1 | 0 | 104/25 |
| SAC | 1/1 | 1/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2/2 |
| CAUD | 0 | 8/6 | 3/3 | 0 | 2/2 | 1/1 | 0 | 1/1 | 1/1 | 4/3 | 0 | 0 | 0 | 0 | 1/1 | 21/18 |
| RIB | 13/4 | 6/3 | 15/2 | 3/1 | 6/2 | 5/2 | 5/1 | 12/4 | 2/2 | 7/4 | 3/1 | 0 | 5/1 | 0 | 0 | 82/27 |
| CLAV | 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1/1 | 0 | 0 | 2/2 |
| STERN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SCAP | 2/1 | 1/1 | 0 | 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 1/1 | 0 | 0 | 0 | 1/1 | 6/5 |
| HUM | 1/1 | 2/2 | 0 | 0 | 2/2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2/1 | 0 | 0 | 7/6 |
| RAD | 1/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2/1 | 0 | 0 | 3/2 |
| ULN | 0 | 2/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2/1 |
| CARP | 6/6 | 0 | 4/4 | 7/7 | 20/18 | 0 | 16/16 | 3/3 | 19/18 | 8/8 | 3/3 | 0 | 0 | 0 | 1/1 | 87/84 |
| MTC | 0 | 0 | 0 | 1/1 | 10/6 | 0 | 8/5 | 0 | 11/9 | 4/2 | 0 | 0 | 1/1 | 0 | 2/2 | 37/26 |
| PHLX I | 6/4 | 11/9 | 2/1 | 3/2 | 17/14 | 1/1 | 10/6 | 11/9 | 12/10 | 9/7 | 1/1 | 0 | 8/8 | 0 | 1/1 | 92/73 |
| PHLX II | 5/4 | 10/10 | 8/7 | 3/3 | 14/14 | 1/1 | 8/8 | 6/6 | 8/8 | 8/8 | 3/3 | 0 | 7/7 | 4/4 | 1/1 | 86/84 |
| PHLX III | 5/5 | 12/12 | 12/12 | 4/4 | 15/15 | 2/2 | 9/9 | 10/10 | 9/9 | 5/5 | 3/3 | 0 | 6/6 | 3/3 | 1/1 | 96/96 |
| 1/2PEL | 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1/1 |
| FEM | 0 | 2/2 | 1/1 | 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1/1 | 0 | 0 | 5/5 |
| PAT | 0 | 0 | 0 | 0 | 1/1 | 1/1 | 0 | 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 0 | 3/3 |
| TIB | 0 | 0 | 0 | 0 | 2/2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2/2 |
| FIB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TAR | 0 | 1/1 | 5/5 | 0 | 9/9 | 1/1 | 0 | 12/12 | 0 | 0 | 1/1 | 0 | 0 | 0 | 0 | 29/29 |
| MTT | 0 | 0 | 0 | 0 | 1/1 | 12/5 | 0 | 11/8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24/14 |
| MTP | 10/6 | 4/2 | 4/3 | 0 | 8/5 | 0 | 0 | 1/1 | 0 | 6/3 | 0 | 0 | 0 | 0 | 0 | 33/20 |
| LBS | 45/- | 22/- | 9/- | 21/- | 13/- | 0 | 18/- | 26/- | 3/- | 46/- | 0 | 0 | 6/- | 2/- | 0 | 211/- |
| FRG | 83/- | 104/- | 79/- | 59/- | 124/- | 34/- | 77/- | 102/- | 33/- | 21/- | 14/- | 0 | 12/- | 36/- | 22/- | 800/- |

NOTE: This table provides a summary of baboon bone specimens recovered from the regurgitations and feces of leopards and spotted hyenas (1). Scat occurrences 1–10 are associated with Carcasses 1–10 (see Table 1), while occurrences 11–15 were recovered from the scat of wild, free-ranging carnivores and have no analyzed, associated refuse remains. Skeletal part representation is expressed as NISP (number of identified specimens) and MNE (minimum number of elements) for each skeletal part category; see discussion in text ("Results" section) for derivation of these bone counts. See legend to Table 1 for abbreviations. Sesamoids are excluded from this table and all analyses.

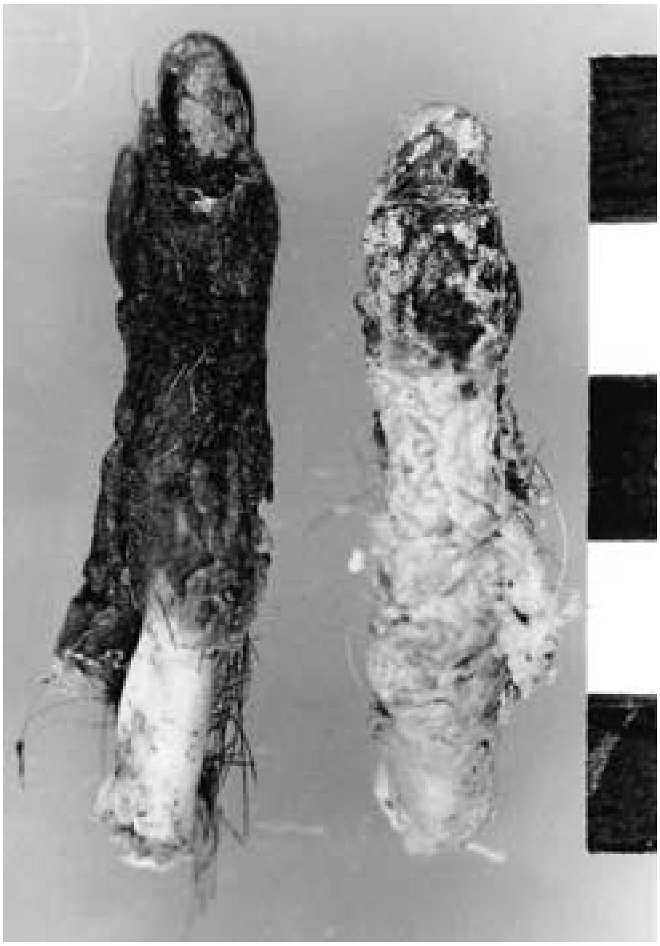

FIG. 1—*Skin covered baboon digits recovered from leopard feces.*

are necessarily worn around one of the phalanges. Thus, these types of jewelry would most likely be swallowed along with articulated digits during carnivore consumption, as digit units are sheared off the manus or pes at the articulation of the metapodial and proximal phalanx.

An important follow-up study to this work should include subjecting skin-covered human digits to carnivore digestive acids in order to assess the similarities and differences in the response of friction ridge skin between baboons (plantigrade quadrupeds) and humans (plantigrade, but usually shoe-covered, bipeds) (Dr. D. Klatzow, personal communication 1999). This has not yet been possible due to difficulties in obtaining "unfixed" human cadaver specimens. However, anecdotal reports suggest there may be comparability between the taxa. For example, Murad (26) illustrates a skin-covered human digit in bear (*Ursus americanus*) feces.

Although the experiments described here utilized large African carnivores, the findings have potential applications in human cases from other areas of the world. This is because there appears to be some regularity in carnivore preference for consumption of prey digit elements, regardless of the predator/scavenger species and prey species involved. Various researchers report an abundance of metapodials and phalanges recovered in the scats of such varied carnivores as North American wolves (*Canis lupus*) (5,6,30) and bears (26) to striped hyenas (*Hyaena hyaena*) from Israel (16).

However, it does seem that the most useful application of these results would be in cases involving humans in Sub-Saharan Africa. There are many well-documented cases of traditional African peoples such as hunter-gatherers (31) and agropastoralists (32,33) falling prey to leopards, lions and hyenas. Few of these types of people carry identity documents, although some may be fingerprinted by local authorities and/or wear distinctive jewelry potentially identifiable by family members and friends.

Although many African populations are composed of individuals smaller in body size than people from Western societies, even these small-bodied individuals are larger than modern baboons (compare average body weights of Bushman males and females (34) to average body weights of baboon males and females (35)). However, these African people *are* comparable in body size to common chimpanzees (*Pan troglodytes*) and much smaller in body size than lowland gorillas (*Gorilla gorilla*) (36). There are many documented cases of leopard and lion predation on chimpanzees and gorillas (9,36–40). Additionally, observations in a few cases of carnivore consumption of chimpanzees and gorillas (36,37) suggest that the pattern of preferential consumption and preservation of digit elements in carnivore waste also holds true for these human-sized and larger-bodied primates.

*Acknowledgments*

Research conducted in Tanzania was supported by the LSB Leakey Foundation and Sigma Xi, and in South Africa by the National Science Foundation, the Wenner-Gren Foundation for Anthropological Research and the University of Wisconsin Natural History Museums Council. I thank my co-investigator at Ugalla, Dr. Janette Wallis, and Dr. David Klatzow for much assistance and advice. Thanks to Dr. Jim Moore for the invitation to work at Ugalla. Thanks to all the people that assisted with the baboon feeding experiments in one way or another: Mr. Theuns Broekman, Mr. M. Duvenage, Mr. Robbie Emmerich, Mr. Ricardo Ghiazza, Dr. Simon Hall, Mr. Lex Hes, and Mr. Brian Jones. I appreciate the support of Profs. Nick Toth and Kathy Schick. As always special thanks to my family, Bob, Evelyn and Lance Pickering, and to my wife Anneliese for much support and perseverance.

## References

1. Pickering TR. Taphonomy of the Swartkrans hominid postcrania and its bearing on issues of meat-eating and fire management. In: Stanford CB, Bunn HT, editors. Meat-eating and human evolution. Oxford: Oxford University Press. In press.
2. Swindler DR, Wood CD. An atlas of primate gross anatomy: baboon, chimpanzee, and man. Malabar (FL): Robert E. Krieger Publishing Company, 1982.
3. Stuart C, Stuart T. Tracks and signs of southern and East African wildlife. Halfway House (South Africa): Southern Book Publishers, 1994.
4. Walker C. Signs of the wild: a field guide to the spoor and signs of the mammals of southern Africa. 5th ed. Cape Town: Struik Publishers, 1996.
5. Klippel WE, Synder LM, Parmalee PW. Taphonomy and archaeologically recovered mammal bone from southeast Missouri. J Ethnobiology 1987;7:155–69.
6. Willey P, Synder L. Canid modification of human remains: implications for time-since-death estimations. J Forensic Sci 1989;34:894–901.
7. Marean CW. Measuring the post-depositional destruction of bone in archaeological assemblages. J Archaeol Sci 1991;18:677–94.
8. Lyman RL. Vertebrate taphonomy. Cambridge: Cambridge University Press, 1994.
9. Tsukahara T. Lions eat chimpanzees: the first evidence of predation by lions on wild chimpanzees. Am J Primatol 1993;29:1–11.
10. Andrews P, Evans EMN. Small mammal bone accumulations produced by mammalian carnivores. Paleobiology 1983;9:289–307.
11. Bearder SK. Feeding habits of spotted hyaenas in a woodland habitat. East African Wildlife J 1977;15:263–80.

12. Brain CK. The hunters or the hunted? An introduction to African cave taphonomy. Chicago: University of Chicago Press, 1981.
13. Davis SJ. A preliminary report of the fauna from Hatoula: a Natufian Khiamian (PPNA) site near Latroun, Israel. In: Lechevallier M, Ronen, A, editors. Le site Natoufien-Khiamien de Hatoula. Paris: Association Paleorient, 1985;71–98.
14. d'Errico F, Villa P. Holes and grooves: the contribution of microscopy and taphonomy to the problem of art origins. J Hum Evol 1997;33:1–31.
15. Fernández-Jalvo Y, Andrews P. Small mammal taphonomy of Gran Dolina, Atapuerca (Burgos), Spain. J Archaeol Sci 1992;19:407–28.
16. Horwitz LK. The origin of partially digested bones recovered from archaeological contexts in Israel. Paleorient 1990;16:97–106.
17. Horwitz LK, Goldberg P. A study of Pleistocene and Holocene coprolites. J Archaeol Sci 1989;15:471–81.
18. Kruuk H. The spotted hyena: a study of predation and social behavior. Chicago: University of Chicago Press, 1972.
19. Schmitt DN, Juell KE. Toward the identification of coyote scatological faunal accumulations in archaeological contexts. J Archaeological Sci 1994;21:249–62.
20. Sutcliffe AJ. Spotted hyaena: crusher, gnawer, digestor and collector of bones. Nature 1970;227:1110–13.
21. Rensberger JM, Krantz HB. Effects of predator digestion on the microsurface of teeth and bone. Scanning Microsc 1988;2:1541–51.
22. Haglund WD, Reay DT, Swindler DR. Tooth mark artifacts and survival of bones in animal scavenged human skeletons. J Forensic Sci 1988;33:985–97.
23. Haglund WD, Reay DT, Swindler DR. Canid scavenging/disarticulation sequence of human remains in the Pacific Northwest. J Forensic Sci 1989;34:587–606.
24. Haglund WD. Dogs and coyotes: postmortem involvement with human remains. In: Haglund WD, Sorg MH, editors. Forensic taphonomy: the postmortem fate of human remains. Boca Raton (FL): CRC Press, 1997;367–81.
25. Morden JL. Hominid taphonomy: density, fluvial transport, and carnivore consumption of human remains with application to three Plio/Pleistocene hominid sites [dissertation]. New Brunswick (NJ): Rutgers, The State University of New Jersey, 1991.
26. Murad TA. The utilization of faunal evidence in the recovery of human remains. In: Haglund WD, Sorg MH, editors. Forensic taphonomy: the postmortem fate of human remains. Boca Raton (FL): CRC Press, 1997;395–404.
27. Horwitz LK, Smith P. The effects of striped hyaena activity on human remains. J Archaeol Sci 1988;15:471–81.
28. Milner GR, Smith VG. Carnivore alteration of human bone from a late prehistoric site in Illinois. Am J Phys Anthropol 1989;79:43–9.
29. Rossi ML, Shahrom AW, Chapman RC. Postmortem injury by indoor pets. Am J Forensic Med Pathol 1994;15:105–9.
30. Binford LR. Bones: ancient men and modern myths. New York: Academic Press, 1981.
31. Thomas EM. Reflections: the old way. The New Yorker 1990 Oct 15:78–110.
32. Treves A, Naughton-Treves L. Risk and opportunity for humans coexisting with large carnivores. J Hum Evol 1999;36:275–82.
33. Tunnell GG. Comment on Rose and Marshall: meat eating, hominid sociality and home bases revisited. Current Anthropology 1996;37: 327–8.
34. Truswell AS, Hansen JDL. Medical research among the !Kung. In: Lee RB, DeVore I, editors. Kalahari hunter-gatherers: studies of the !Kung San and their neighbors. Cambridge: Harvard University Press, 1976:166–94.
35. Alden PC, Estes RD, Schlitter D, McBride B. National Audubon Society field guide to African wildlife. New York: Alfred A. Knopf, 1995.
36. Fay JM, Carroll R, Kerbis Peterhans JC, Harris D. Leopard attack on and consumption of gorillas in the Central African Republic. J Hum Evol 1995;29:93–9.
37. Boesch C. The effects of leopard predation on grouping patterns in forest chimpanzees. Behaviour 1991;117:220–41.
38. Tobias PV. The work of the gorilla research unit in Uganda. S Afr Sci 1961;57:297–8.
39. Dart RA. The Kisoro pattern of mountain gorilla preservation. Current Anthropology 1961;2:510–1.
40. Rahm R. Observations during chimpanzee captures in the Congo. In: Starck D, Schneider R, editors. Neue ergebnisse der primatologie. Stuttgart: Gustav Fischer Verlag, 1967.

Additional information and reprint requests:
Travis Pickering
Department of Anthropology
Tulane University
Anthropology Building
1021 Audubon Street
New Orleans, LA 70118