Journal of Archaeological Science 59 (2015) 35–53

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

# A new methodological approach to the taphonomic study of paleontological and archaeological faunal assemblages: a preliminary case study from Olduvai Gorge (Tanzania)

Manuel Domínguez-Rodrigo [a, b, *], José Yravedra [b], Elia Organista [b], Agness Gidna [c], Jean-Baptiste Fourvel [d], Enrique Baquedano [e]

[a] IDEA (Instituto de Evolución en África), Museo de los Orígenes, Plaza de San Andrés 2, 28005 Madrid, Spain
[b] Department of Prehistory, Complutense University, Prof. Aranguren s/n, 28040 Madrid, Spain
[c] Paleontology Unit, National Museum of Tanzania, Shaaban Robert Street, P.O. Box 511, Dar es Salaam, Tanzania
[d] UMR 5608 CNRS, GDR3591 TaphEnA, Université de Toulouse-Jean Jaurès, 5 allées Antonio-Machado, F-31058 Toulouse Cedex 1, France
[e] Museo Arqueológico Regional, Plaza de las Bernardas s/n, 28801 Alcalá de Henares, Madrid, Spain

ARTICLE INFO

*Article history:*
Received 2 February 2015
Received in revised form
8 April 2015
Accepted 11 April 2015
Available online 21 April 2015

*Keywords:*
Bone damage patterns
Tooth marks
Taphonomy
Olduvai
BK
FLK N
Correspondence analysis

## ABSTRACT

Here we present a new analytical method that classifies bone damage patterns objectively and mathematically via a morphotypic definition (taphotype) of each long limb element and a bootstrapped correspondence analysis. This enables statistically-based classification and interpretations. The accuracy of these interpretations depends on the accuracy of the analogical frameworks applied. The new method shows that bone damage patterns differ according to carcass type and size. They also differ depending on environmental conditions (captive and wild carnivores). The method is also useful to detect the type of carnivores involved in the modification of epiphyseal portions. This opens the door to interpretations of hominin–carnivore interactions and the resulting strategies of carcass acquisition strategies by hominins. The application of the method to a sample of epiphyseal portions from two archaeological sites from Olduvai Gorge (BK and FLK N) shows its potential resolution. BK has been previously interpreted as a hominin–carnivore assemblage, whereas FLK N has been interpreted as a felid-accumulated assemblage. The new method confirms these interpretations.

## 1. Introduction

A large array of neotaphonomic studies describe how carnivores modify bones. However, despite the wealth of information, there is still confusion as to how each type of carnivore displays specific bone modification patterns. This is mostly due to the following factors: a) researchers tally bone damage using different methods, b) even when using similar methodological approaches (e.g., damage on proximal femoral epiphysis), the method is ambiguous as to what the damage type is (e.g. tissue deletion versus tooth marking) or where exactly it is located (e.g., articular surface or trochanter), c) the damage documented by different authors involves samples that are not comparable; they are composed of a different set of elements (e.g., some include more stylopods whereas others include more autopods) and different carcass sizes (damage reported for small carcasses is not necessarily the same as that reported for larger carcasses), d) authors conduct research on captive and wild carnivores (which result in very different bone damage patterns caused by the same taxa) (Gidna et al., 2013), e) last, but not least, researchers use different statistical methods to test the validity of their hypotheses when using their datasets.

This makes inter-assemblage (inter-research) comparison extremely difficult. We have frequently stressed that analogical frameworks are only epistemologically valid if they really test the premises of the questions that led to their formulation. Bunge (1981) criticized that most analogical reasoning was either undefined or too narrowly defined under isomorphic (and sometimes homomorphic) applications of the concept. He developed a qualitative concept of analogy embedded within the concept that most analogical reasoning in science occurs in dynamic systemic structures. These systems depend on the tight interaction of three

---

* Corresponding author. Department of Prehistory, Complutense University, Prof. Aranguren s/n, 28040 Madrid, Spain.
*E-mail address:* m.dominguez.rodrigo@gmail.com (M. Domínguez-Rodrigo).

http://dx.doi.org/10.1016/j.jas.2015.04.007
0305-4403/

components: composition (substance), structure and environment. Composition refers to the collection of components in any of two given systems. Structure refers to the relationship of those components within each system. Environment impacts the structure by determining how the system components interact. This third element is of utmost importance because it shows that when comparing two systems (as analogical reasoning does), even if both systems have similar composition their structure may be different on account of the environmental differences between them. The variable degrees of structural, substantial and environmental analogies involved in most of the experimental work carried out with carnivores makes their application of limited validity when used in specific contexts (e.g., African Pleistocene carnivore behavior).

Domínguez-Rodrigo et al. (2012) insisted that inter-carnivore comparison was only valid if it followed Bunge's analogical principles; that is, by using experiments that share the same substance and structure (e.g., same types of bones from the same type of carcasses) and the same experimental environment (e.g., in the wild). One could be even more cautious and criticize comparisons among different wild carnivores that are adapted today to different biomes (e.g., lions and wolves) (Domínguez-Rodrigo et al., 2012). The best environmental analogical framework contains all the carnivore types that will be neotaphonomically compared. Gidna et al. (2013) showed important differences in the way that wild and captive lions modified equid carcasses. The latter caused more intensive damage to bones, which was documented both in the number of tooth-marked elements as well as in the number of tooth marks per tooth-marked element. These differences were more drastically observed when comparing wild and captive leopards (Gidna et al., 2015). Bone furrowing, breaking and even deletion on similarly-sized carcasses was much more intensive in the experiments made with a captive leopard.

Pobiner (2007) carried put experiments with captive and wild lions. Domínguez-Rodrigo (2012) argued that Pobiner's data should be treated cautiously to understand wild lion bone modification patterns because: a) samples from the wild were small and lacking observational control, b) had low degree of environmental analogy, since the samples from the wild were obtained in a private ranch where trophic dynamics (involving inter- and intra-taxon competition) were very different from more natural settings (e.g., national parks) with much more reduced anthropogenic impact and, c) the data from captive lions did not reproduce bone damage patterns documented in experimental work carried out with wild lions (Domínguez-Rodrigo, 1999; Domínguez-Rodrigo et al., 2007; Gidna et al., 2014).

Domínguez-Rodrigo et al. (2012) used conspicuous bone damage (furrowing versus simple tooth marking) on long bone ends of equid carcasses as an indicator of carnivore type and compared assemblages modified by wild lions, wild hyenas and wild wolves. Lions showed small variability in the resulting bone damage patterns compared to wolves, whose bone damaging skills varied according to the number of times they accessed carcasses (Yravedra et al., 2011). Although the degree of environmental analogy was higher than other studies that combined information from wild and captive carnivores, it was nevertheless lower than desired since it combined wild carnivores from different biomes.

More recently, Parkinson (2013) carried out research with captive felids. Much of her research reproduces some (but not all) of the bone damage patterns identified in wild felids. For instance, she reports more damage on most elements, more specifically so on radii and even on metapodials, than has been documented in wild lions (Domínguez-Rodrigo, 1999; Gidna et al., 2014). This pattern of more intensive damage can be in part attributed to the captive conditions of the felids used, which made the degree of environmental analogy low. Parkinson's (2013) GIS approach documents very nicely the intensity of bone modification on each element. Hers is a good method to visually compare damage patterns from different carnivores (Parkinson et al., 2015).

Gidna et al. (2014), following a more traditional analytical method, quantified damage patterns on long bones caused by wild lions using samples from natural ecosystems. Gidna et al. (2014) replicated previous work (Domínguez-Rodrigo, 1999) of felid bone damage patterns, showing that most damage inflicted by lions can be documented on stylopods (per element type) and long bone ends (per element section). Metapodials were mostly intact and radii were the least modified meat-bearing long bones.

Domínguez-Rodrigo and Pickering (2010) argued that XXI century taphonomy should be multivariate to use all the potential information contained in the multiple sources of evidence from various analytical approaches to the study of bone assemblages. For this purpose, information on bone damage patterns should be systematically classified in a way that could be statistically useful and methodologically standardized, so that different researchers could have the same analytical language. It is with this purpose that we introduce here an analytical approach based on taphotypes or damage documented per long bone quadrat. This approach, which allows standardization and statistical quantification, has been applied to bone assemblages modified by lions in the wild (Gidna et al., 2014) and a bone assemblage modified by lions in captivity (Gidna et al., 2013). As a comparative complement, an assemblage of bones modified by captive jaguars was also analyzed. Arguing for a felid-only bone modification pattern can be as misleading as previous attempts to define a carnivore-only bone damaging pattern. It is our purpose to present here not a pattern of felid modification of bones, but to show diagnostic bone modification patterns created by lions and jaguars separately. The following step will be to do the same with other carnivore types so that inter-taxonomic taphonomic comparisons can be carried out.

## 2. Method and sample

A classification of forms in which bones are progressively modified will be presented here. This classification system is innovative because it will enable the quantification of the resulting types. The approach is inspired by the descriptions of bone destruction patterns (morphotypes) of Fourvel (2012), following previous approaches to taphonomic morphological change (e.g., Fosse, 1994). Wauthoz et al. (2003) defined “taphotype” as variability due to taphonomic agents. Taphotypes have been applied in studies of morphological variability caused by biostratinomic and diagenetic processes (e.g., Fatka and Brocke, 2008). Here, following the same definition, taphotypes will be defined on ungulate long bones modified by carnivores. Comparisons among different carnivore types will be based on modification of equid bones. By using the same anatomical elements and the same carcass type, this comparison will control for the substantial and structural parts of the analogy. Differences thus reported can be interpreted in terms of variable environmental reasons and/or specific taxonomic qualities.

### 2.1. Research questions

In this study we intend to answer the following questions:

1. Do bone modification patterns made by the same carnivores (in this case, by the same prides of lions) vary depending on bovid and equid carcasses, due to the different muscle anatomy of these ungulates? Do they vary depending on carcass size (e.g., wildebeest versus buffalo)?