

THE STUDY OF SKELETAL PART PROFILES: AN AMBIGUOUS TAPHONOMIC TOOL FOR ZOOARCHAEOLOGY

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ABSTRACT.- *Recent studies on bone accumulations and bone modifications by humans and carnivores have made the use of skeletal part profiles of limited value for zooarchaeological purposes. Equifinality (different processes with the same end products) is very common, and renders this type of analysis ambiguous if used as a referential framework. Some alternative methods (studies of bone surface modifications) seem to be more adequate for taphonomic analyses.*

RESUMEN.- *Estudios recientes sobre acumulaciones y modificaciones óseas por seres humanos y carnívoros han transformado el análisis de perfiles de representación esquelética en una aproximación de limitado valor para la Zooarqueología. La equifinalidad (diferentes procesos generando idénticos resultados) es muy común y convierte este tipo de estudio en un marco referencial muy ambiguo. Métodos más modernos, como el estudio de las modificaciones de la superficie ósea, parecen ser más adecuados para la investigación tafonómica.*

KEY WORDS: *Human behavior, Carnivore behavior, Equifinality, Bone accumulation, Skeletal part frequency.*

PALABRAS CLAVE: *Comportamiento humano, Comportamiento carnívoro, Equifinalidad, Acumulación ósea, Frecuencia de partes esqueléticas.*

1. INTRODUCTION

Skeletal part frequencies and taxonomic identification have long been faunal analysts' principal work. Although other types of analyses—such as bone breakage patterns and bone surface modifications (tooth marks, cut marks...)—were incorporated to the study of archaeological sites, zooarchaeologists have mainly been concerned with the development of quantifying methods for the various anatomical parts and individuals represented at fossil bone assemblages (Binford 1978, 1981, 1988; Bunn 1982; Bunn & Kroll 1986, 1988; Grayson 1984; Stiner 1991). Identification of the damage undergone by these parts by perimortem and post-mortem processes (butchery, dismembering, marrow extraction, burning, carnivore gnawing, trampling, weathering, root marks...) has constantly been used as a secondary analytical procedure, with the aim of reinforcing inferences drawn from the other primary types of analyses.

The discussion about hominid behavior at archaeological sites—irrespective of their geographical location and chronology—based on skeletal part fre-

quencies, has always been subjected to controversy. For instance, Binford's (1981, 1984) and Binford & Ho's (1985) interpretations on hominid participation in site formation at Choukoutien, Olduvai or at Klasies River Mouth have been contested by Bunn & Kroll's (1986) and Klein's (1982a, 1982b) alternative explanations, respectively. A clear example of this situation is observed in the discussion of hominid behavior at Plio-Pleistocene sites. The debate, focused mainly on the skeletal part representation, led some researchers to suggest that hominids were marginal scavengers (Binford 1981, 1984, 1985, 1988; Shipman 1986), whereas others pictured them as successful hunter/scavengers (aiming at flesh rather than at marrow, when processing carcasses) (Bunn 1981, 1982, 1983; Bunn & Kroll 1986; Isaac 1983, 1984). More recently, and based on the same skeletal part profiles, some researchers believe that hominids were transporting high-yielding meat sections from carcasses (Potts 1988; Bunn & Ezzo 1993), whereas others argue that they were simply selecting high-yielding marrow bones that were already defleshed (Blumenschine 1991, 1995; Blumenschine & Marean 1993).

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Identification of bone damage along this debate was used as a secondary argument by most of the researchers involved in the discussion. Binford (1981, 1985, 1988) used the evidence of tooth marks on fossil bones from sites to support the hypothesis that carnivores were the main consumers of carcasses; Bunn (1981, 1982, 1983, 1991) used the percentages and anatomical distribution of cut marks also found on some of these bones to claim that hominids were processing fleshed carcasses; Blumenschine (1988) and Potts (1982, 1988) used—in different ways—both types of marks to reconstruct the sequence of intervention of both agents (hominids and carnivores) in site formation. Blumenschine (1995) further used them to justify the hypothesis that hominids were scavenging carcasses from felid kills, from which they removed the scraps of flesh and exploited their marrow contents.

However, the secondary use of bone damage as a taphonomic indicator is responsible for the lack, during a long period in such debates, of the development of the analytical procedures in which the study of bone surface modifications could really be diagnostic of hominid and carnivore interaction (Blumenschine 1988). Concerning this issue, Blumenschine leads a group of researchers that, due to the lack of resolution of the traditional focus, have turned their attention to bone modifications, using them as a primary source of information to infer hominid intervention in carcass processing and site formation. In this sense, several studies and experiments have been carried out to create a referential framework to be used as a guideline for the methods of analysis and interpretations that are being elaborated and applied to the Plio-Pleistocene archaeological record (Blumenschine 1988, 1995; Blumenschine & Marean, 1993; Marean *et al.*, 1992; Selvaggio, 1994; Capaldo 1995, Domínguez-Rodrigo 1997a, 1997b).

The controversial interpretations of hominid behavior using analyses of skeletal part profiles, are they a proof of their limited value and, subsequently, of their excessive use in zooarchaeological studies or is this simply a smoke screen of surmountable criticism?

In this work, I will try to show how skeletal part analyses are ambiguous for taphonomic purposes. In the first part of the paper, I will argue that theoretical backgrounds elaborated to interpret archaeological assemblages are based on a limited array of preconceptions and referential frameworks, that turn out to be more heterogeneous than previously thought. In the second part, I will stress that most Paleolithic sites are palimpsests and, therefore, they are not interpretable from referential backgrounds (single-patterned models) that do not properly take into account such a consideration. Dual-patterned experiments with carni-

vores show how distorted original human-made bone accumulations may be after carnivore ravaging. As a conclusion, I offer a few examples and predictions about skeletal part profiles in bone assemblages that have undergone several processes of modification by more than one agent (low resolution and low integrity [Binford 1981]). Based on this theoretical and experimental frameworks, I suggest that studies on skeletal representation are of little value for zooarchaeological research, and that more attention should be paid to alternative taphonomic techniques.

2. ON THE UTILITY OF SKELETAL PART REPRESENTATION ANALYSES IN ZOOARCHAEOLOGICAL INTERPRETATIONS

2.1. Modern Humans as a reference for hominids

Skeletal part profiles are used under the assumption that there are diagnostic patterns in the way that modern humans and other agents transport and accumulate bone remains. In order to create a referential framework that can be applied to the archaeological record, some actualistic ethnoarchaeological studies on differential transport of carcasses by human groups have been carried out (Binford 1978, 1981; Bunn *et al.* 1988, 1991; O'Connell *et al.* 1988, 1990, 1992). Some of these studies have constituted—and still do in many academic circles—the basis for many taphonomists' analytical and interpretive procedures, based on White's (1952) and Perkins & Daly's (1968) claim that humans prioritarily transport limbs from carcasses (the so-called "Schlepp effect"). Thus, the application of these references to archaeological bone assemblages makes long bones usually to be seen as the result of transport processes, whereas axial bones are assumed to be preferentially represented at kill sites (Binford 1981; Bunn 1982, 1991; Bunn & Kroll 1986; Bunn *et al.* 1988, 1991).

However, important pitfalls can be observed in such referential frameworks. A lot of factors determine the transport of carcasses by humans and their posterior accumulation on a specific spot. One of them is the cost of transport, conditioned by the distance between the carcass and the base camp, the number of individuals that participate in the transport, the time of the day and the size of the animal (Metcalfe 1989; O'Connell *et al.* 1980, 1990). Another factor that must be taken into account is the initial strategy on the preparation of the animals to be transported. Some human groups disarticulate carcasses where they obtain them and prepare them for trans-

port, by discarding some bones on the spot (O'Connell *et al.* 1992), whereas others do not. Other circumstances that will condition the way that carcasses are accumulated are the cultural variations among different ethnic groups and their preferences for anatomical sections (O'Connell *et al.* 1990, 1992) and the web of social interactions which will condition the way that carcasses are shared: within the group (same nuclear family, among several families...) or outside the group (Marshall 1994). Some of these behaviors will not show a clear archaeological evidence (Gargett & Hayden 1991; Bartram *et al.* 1991; Marshall 1994). We should also consider humans as agents prone to distort their own bone accumulations, when they clean some areas of debris and garbage (O'Connell *et al.* 1991).

However, even considering such a bunch of factors that conditions carcass transport and bone accumulation, one of the main objections that can be made about the use of skeletal part profiles for zooarchaeological purposes is that there is no "unique human pattern" of bone accumulation. Differences emerge when considering several lines of evidence from various human groups. The way that the Nunamiut transport carcasses (Binford 1978, 1981) is not the same as those exhibited, for instance, by the Hadza (O'Connell *et al.* 1990) or other populations. If we take the Hadza as an example, we can notice that there is a wide variation in the parts that they select from carcasses at kill sites to be transported to base camps. Studies on the carcass transport by the Hadza show that the Whitean proposition –also developed in the Perkins & Daly model–, that hunters preferentially transport appendicular rather than axial bones from kill sites, is wrong (O'Connell *et al.* 1990). When dealing with wildebeest and hartebeest carcasses, the Hadza seem to preferentially transport vertebrae, pelvis and ribs from kill sites to base camps, followed by the head, scapulae and limbs. For impala, the transport pattern is similar. For elands, the Hadza preferably transport vertebrae and pelvis followed (by this order) by head, ribs and limbs. Curiously enough, for buffalo (in spite of its similar size to the eland) limb bones are most likely to be removed and axial bones are the least likely. Zebras display a high proportion of axial elements transported, the same as warthogs (O'Connell *et al.* 1990).

Very often, the Hadza foraging groups prepare carcasses prior to their transport, which is made by stripping meat from all the long bones, which are then cracked so as to eat the marrow they contain and afterwards, abandoned in the kill site or nearby (O'Connell *et al.* 1992). Transport, thus, is mainly made on axial and cranial elements (O'Connell *et al.* 1992). On other occasions, with some species, the Hadza just separate the lower legs from carcasses and

metapodials and phalanges are either abandoned or consumed in or near the kill site, while the rest of limbs are transported to base camps (O'Connell *et al.* 1992). That is, in some instances, meat from limbs is transported once it has been stripped from long bones, which are abandoned at kill sites –also referred to as "snack sites" (Bunn *et al.* 1991) –, and other times limb bones are also transported. In these cases, lower leg bones –usually considered diagnostically transported– are abandoned at kill sites.

Overall, O'Connell *et al.*'s (1990, 1991, 1992) studies show not only that the appendicular preference by humans has been exaggerated by ethnoarchaeological models –contra Binford (1978, 1981) and Bunn *et al.* (1988, 1991)–, but also that carcass transport is highly patterned among Hadza, and that it varies among different carcass sizes and even in the same size group, among different species. Thus, if one same human group shows variation in the patterns of carcass transport, it is not surprising that such a difference becomes more important when comparing several human groups (Dominguez-Rodrigo & Marti 1996). The most relevant consequence of these studies is that they show that there is not a particular "human pattern" of bone transport and accumulation.

2.2. Humans as carnivores

Another assumption implicit in the analyses of skeletal part profiles is that humans act like carnivores –that is, aiming at the highest-yielding fleshed parts– transporting those elements with larger amounts of usable meat (White 1952; Perkins & Daly 1968). Blumenschine (1986) modeled a consumption sequence based on the rank order of consumption of each anatomical section, as observed among modern savanna predators. From it, he also elaborated an inverse consumption sequence, in which he tried to model the skeletal parts most likely to be found at a den to which bones had been transported and accumulated. However, even though important discordances were observed when matching these theoretical frameworks with real data from carnivore dens and lairs (Lyman 1994), carnivores seem to behave in a regular way, prioritarily exploiting those anatomical parts with higher yields (Blumenschine 1986). The assumption that humans would do the same led Binford (1978) to argue that strategies in the use of food resources by humans were also determined by the differential anatomical distribution of such resources. Thus, he measured the amounts of meat, marrow and grease associated with each of the skeletal elements of two domestic sheeps and one caribou. With these measurements, he elaborated indices on the utility (GUI) that each carcass part could have for humans. Then, in order to gain a better insight into transport

processes, bearing in mind that some parts with low GUI may also be transported because they remain attached to other skeletal units with high GUI, he elaborated a modified general utility index (MGUI) to incorporate categorical utility values to the dynamic process of transport (Binford 1978, 1981).

The way that Binford derived these utility model was promptly followed by other researchers, that began to create utility indices for other taxa (Will 1985; Borrero 1990; Lyman *et al.* 1992). However, all these models were made assuming that people decide how to butcher and transport carcasses influenced by the associated availability of meat, marrow and grease. Blumenschine (1986, 1988, 1991, 1995) has insisted on the fact that hominids might have had a different order of access to carcasses from that observed in modern humans and their food choice may have been constrained by the differential availability of such resources. He urged to elaborate a separate GUI for flesh (Blumenschine & Caro 1986) and for marrow (Blumenschine & Madrigal 1993), which could be more useful to understanding hominid decisions and their involvement with carcass processing.

However, the application of GUIs in general to the archaeological record should still be done cautiously, because such indices have usually been elaborated from one or a few individuals and, therefore, do not take into account variations observed in animals according to their sex, age, and nutritional status (some of the species analyzed are subjected to significant seasonal changes). Moreover, we lack a proper referential framework on GUI for all the species that archaeologists unearth at sites. Thus, the application of GUI documented in other species, even though they are not dissimilar in size, may be misleading. The analyses of GUI on various species show how significant variation is (Metcalf & Jones 1988; Borrero 1990; Lyman 1992), even among taxa structurally similar, belonging to the same size category –for instance, see the differences between Bison (Brink & Dawe 1989; Emerson 1990) and Muskox (Will 1985), bearing in mind GUI and MGUI.

Variation is also documented in GUIs elaborated for particular food sources. Blumenschine & Caro (1986) generated a GUI for flesh from a sample mainly made up of Thompson's and Grant's gazelles, one adult impala and one adult wildebeest. They observed "evident age, sex and taxonomic differences in the proportionate contribution of flesh to the whole weight of each carcass unit" (o.c.: 278). They also documented that "adult male wildebeest have proportionately less flesh on their hindlimbs than do males of other species, but relatively more on the forelimbs" (o.c.: 280). Therefore, the GUI for flesh yield in African ungulates is only applicable to species similar to those studied by these researchers. "Taxonomic differ-

ences in the distribution of flesh are apparent in comparison of adult male gazelle and impala with adult male wildebeest... The concentration of appendicular flesh in the hindlimb of gazelle and impala can perhaps be related to the great amount of springing and leaping seen in these species compared to wildebeest, which have a more equitable distribution of limb flesh fore and aft" (o.c.: 282). Blumenschine & Caro (1986) are right when cautioning about the applicability of Binford's (1978) flesh yield data to archaeological faunas, as they observed how variation was manifested among species and even in the same species, depending on the age and sex of the individual considered.

This variation is not only observed in the anatomical distribution of flesh. Blumenschine & Madrigal (1993) also elaborated a GUI for marrow in 27 east African ungulates (including bovids, equids and suids) and documented that the gross energetic yield and skeletal distribution of marrow in them varied according to age, species and faunal group (e.g. bovids versus equids).

Therefore, we should be aware of this range of possibilities when applying GUIs to archaeological faunas.

However, in spite of all these methodological drawbacks, another important objection that can be made to the traditional position is the assumption that humans behave like any other carnivore when processing carcasses. Predators preferentially consume carcasses from their most high-yielding parts to the lowest-yielding ones (Blumenschine 1986). We will see that humans do not necessarily do so.

2.3. Humans as butchers

The same that there seems to be a "common sense" consumption sequence among carnivores, is there a similar consumption sequence for humans? This has been one of the main issues that ethnoarchaeological studies have not usually dealt with. Maybe it is because zooarchaeologists commonly assume that what is transported (irrespective of its order of consumption) is what really matters for taphonomic purposes. Should this be true, would we then expect such variation among human transport decisions?

Carnivores process carcasses without disarticulating them. The frequent dismembering made on them by gregarious carnivores is to reduce the degree of intra-group competition and it is usually manifested in limbs being separated from the rest of the carcass, but all long bones remain joined. Humans, on the contrary, fully disarticulate carcasses before consuming them.

The pattern of disarticulation is also highly variable among different ethnic groups –even on the

same type of carcass— and according to the species. As Gifford (1977) documents, the traditional butchery patterns among the Maasai, Kalenjin and Akamba peoples of Kenya are different from one another. Limbs are dismembered in different order. In some cases, the whole limb is dismembered from carcasses, and in others they are disarticulated first, before removing the upper sections from the axial skeleton.

As an example of further variation within a same ethnic group and with the same type of carcass, I had the chance to observe on several occasions the dismembering pattern made by Maasai people living in Peninj, west of Lake Natron (Tanzania), on goats. It is different from the one that Gifford documents for the Maasai of Kenya. First, after skinning, they sever metapodials from limbs. Then, depending on the occasion, one of the front legs (humerus plus radio-ulna) is removed complete, followed by the rib cage of the same side. Afterwards, the same process is observed for the other side (front leg and rib cage). Then, they remove the head and, finally, the hindlimbs (femur and tibia) from the pelvis and spine that remain together.

The consumption sequence observed is: some viscerae (e.g. kidneys) are first eaten raw. The rest is consumed after preparation. Then, they process metapodials. The rest of the goat is consumed by the group at the same time.

Such pattern of dismembering and consumption differs from the one that I observed among the Maasai of South-Eastern Kenya. After evisceration, they remove limbs, without disarticulating them, and then the axial skeleton. The kidneys are also eaten raw, but no initial consumption of metapodials was observed.

Among the Hadza people, it has been observed—as mentioned above—that the preparation of carcasses for transport may convey the consumption of some viscerae and marrow from long bones (O'Connell *et al.* 1992). This initial consumption will condition the variety of bones that will be transported to base camps.

Bearing in mind that humans share food, there is no clear consumption sequence once the carcass has been prepared either for transport of, once in the camp, for consumption—although there seems to be a “sharing sequence” (Marshall 1994). Nevertheless, there appears to be a clear contrast with carnivores. Whereas they initially aim at high-yielding anatomical parts, humans often consume lower-yielding parts at first, during what could be called the “snack phase” of carcass processing.

Once again, variation in the decisions made by humans, concerning what products are initially consumed (viscerae/flesh/marrow) means that the use made of skeletal part frequencies can no longer deal

with simple or unique human models as reference for interpreting archaeological faunas.

3. SITES AS THE RESULT OF MULTIPLE-PATTERNED PROCESSES

Another of the main objections that could be advanced against the analyses of skeletal part representation is the fact that most of the referential frameworks elaborated so far have been made on the differential transport of anatomical parts by humans from kill sites to base camps, and not from what is left after the consumption of carcasses. Bone assemblages at sites are the result of dynamic processes of selection and destruction, which results in a distortion of the initial bone accumulations made by humans. Faunal assemblages at sites are the result of humans taking decisions at kill sites, transporting determined bones, modifying and destroying part of these bones at camps due to consumption, abandonment and intervention of other agencies: physical (e.g. water flows) and/or biological (e.g. carnivore post-ravaging). Thus, it is not methodologically correct to use as reference data drawn from the initial stage of this process to be compared with the end product thereof.

Comparison should be made in equal terms. This means that since we recognize that sites are palimpsests—and, therefore, the result of the intervention of several agencies—single-patterned models (carnivore dens, human transport of carcasses...) are no longer appropriate as reference to interpret archaeological bone assemblages. The recognition of this fact led some researchers to suggest that such reference should be obtained from multiple-patterned models (Blumenschine 1988, 1995; Blumenschine & Marean 1993; Marean *et al.* 1992; Selvaggio 1994; Capaldo 1995).

Given the fact that hominids and carnivores (in particular, hyenas) intervened in the formation of Plio-Pleistocene sites, due to the presence of both cut marks and tooth marks on archaeological faunal assemblages (Bunn 1981, 1982, 1983; Potts & Shipman 1981), the experiments carried out to test the effect of carnivore post-ravaging on bone accumulations made by humans led to the following conclusions (Marean *et al.* 1992; Blumenschine & Marean 1993; Capaldo 1995):

1. Axial bones (ribs, vertebrae and pelves) and certain long bone epiphyses are preferentially depleted, followed by the small compact limb bones. This creates an artificial profile, dominated by limb and cranial elements.
2. With respect to limb bones, the epiphyseal fragments are more likely to be depleted than the mid-shaft specimens.

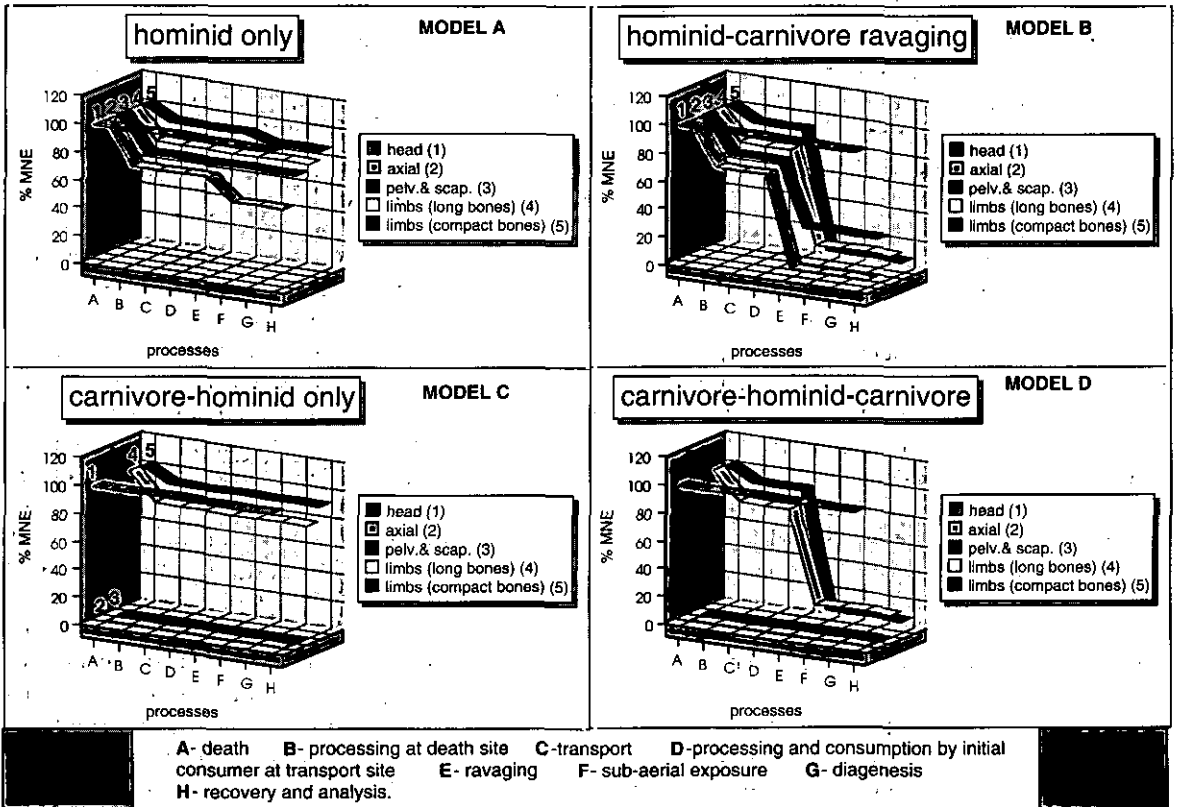


Figure 1.- Differential bone deletion in each stage of carcass modification; from acquisition to deposition, sedimentation, and recovery. Notice the strong bias introduced by carnivore ravaging. Data and information for this figure can be found in the works of Blumenshine (1988, 1991, 1995), Capaldo (1995), Marean *et alii* (1992), Domínguez-Rodrigo (1996, and personal observación).

Previous studies on bone density demonstrated that the anatomical sections of the skeleton composed of cancellous tissue were prone to be destroyed or taken away from their original site of accumulation by several processes: water flows, weathering, carnivore depletion, etc... It is because they are less dense than other bone sections and usually constitute significant deposits of grease (Lyman 1994).

This adds a further dimension to the discussion of the utility of the skeletal part profiles for zooarchaeological analyses, because in sites where some of these processes have been operating, especially carnivore ravaging, the distortion of the anatomical representation patterns of carcasses transported to sites by hominids is such that we are not able to discern the original patterns of bone accumulation made by humans. Were hominids selectively transporting certain skeletal units (e.g. limbs) or complete carcasses? Zooarchaeological explanations of both types of behaviors can be widely different, as they can be used to support different types of strategies of carcass exploitation by humans.

The distortion that carnivore post-ravaging may cause in human-made bone accumulations is really remarkable. This is only one of the processes to which bone accumulations are subjected prior to their

analysis by taphonomists. If we take into account some other agents that may also intervene in the final configuration of fossil skeletal part profiles, we will notice that the degree of distortion can be further increased. As an example, we can hypothesize about final skeletal elements in bone assemblages that have undergone the effect of several deletion processes (figure 1). In such a modeling I will consider several processes involved in carcass modification and final bone preservation in the fossil record. Carcass transformation begins at the moment of the animal's death. Considering the effects of processing at acquisition site, transport, processing and consumption at transport site, carnivore ravaging, sub-aerial post-nutritive exposure, diagenesis and, finally, recovery and analysis, the final result is a substantially biased bone assemblage. I have divided these theoretical backgrounds into two modalities: dual-patterned models in which humans are primary agents of carcass processing and triple-patterned models in which humans occupy an intermediate position between felids and hyenids in carcass consumption. In the first option, I have considered a model of human modification of carcasses that excludes the action of carnivores (model A) and a model in which the action of humans is followed by the intervention of carnivores (model B).

In the second set of models, I have assumed that carnivores (in this case, lions) preceded the intervention of hominids and other scavengers, namely hyenids, modified bones in the last stage of carcass processing. I have included a model without ravaging by scavengers after hominid manipulation of bones (model C) and another one with bone ravaging included (model D). In all these models I have used data on middle-sized carcasses. In their elaboration, I have made the following assumptions:

1. Bone discard at kill or acquisition sites is not excessive, contrary to what can be observed in some modern hunter-gatherer groups. In those models in which hominids intervene after lions, we assume they would have transported the edible parts. Therefore, axials, scapulae or pelves would have remained at kill sites.
2. In the "sub-aerial post-nutritive exposure" only minor hydraulic disturbance and moderate to high weathering of bones is assumed. The former would influence on bone fragments according to their size and shape, and the latter would affect more on the preservation of cancellous bone specimens (limb bone epiphyses and axial bone).
3. In the "diagenesis" phase, only slight vertical movements of materials is assumed. Smaller specimens would have been more prone to move in the stratum than the larger ones. Bearing in mind that small shaft fragments would have been more numerous than small fragments from epiphyses, they would have been more likely to undergo this process.
4. In the "recovery & analysis" it was differentiated between global recovery of bones and bone discard made by archaeologists, who are responsible for a great loss of faunal remains (especially from shafts, frequently considered as "unidentifiable") from sites.

In all the models, it can be observed that an initial bone discard of most of the different anatomical sections (head, limbs, axial elements, pelves and scapulae) occur at the acquisition site. It has been repeatedly observed among different ethnic hunter-gatherer groups, like the Hadza or the San, that they frequently process or discard metapodial bones, some portions of rib slabs, the head and other marrow limb bones, as a result of carcass defleshing at the kill site. The aim of this initial butchery at the acquisition site is meant to reduce the weight of the load to be carried back to the camp (Bunn *et al.* 1988; O'Connell *et al.* 1990, 1992; Bartram 1993). Marrow bones exposed during defleshing are often abandoned at the kill site after having been cracked open and their marrow contents eaten (Bartram 1993). Therefore, most of the flesh of the carcass is transported to camps, after having being stripped from bones. A quantifying analysis of part abundances from the bones preserved at sites would wrongly indicate selective transport of determined anatomical sections instead (Bartram 1993).

Variation of human behavior concerning the initial butchery carried out at the kill site is also very notorious. Even in the same human group, strategies may vary depending on several circumstances. For instance, Bartram (1993) documents how the same type of animal (gemsbok) can be differently treated by the Kua. In some cases, the carcass is transported complete to the camp site, on other occasions, most of the bones can be discarded at the butchery site. Regularly, scapulae are discarded at kill sites, whereas pelves are more often transported. However, in other ethnic groups, like the Nunamiut, pelves are often abandoned at kill sites (Binford 1981). Vertebrae may also be abandoned, but they are also transported very often (O'Connell 1990, 1992). One third of the rib cage as well as half of all the long marrow elements can be abandoned at butchery sites (Bunn *et al.* 1988; Bartram 1993). The analysis of skeletal part abundance at camp sites among the Kua is not positively correlated to any food utility index, because their strategy of stripping the flesh from bones and its subsequent drying to reduce transport costs bias the products transported, as inferred from the bones accumulated at camps. However, for the sake of the models proposed, and just as I mentioned earlier, in this case I will assume a moderate to low proportion of bone discard at the acquisition site.

The second process of bone deletion and skeletal part bias in bone assemblages that have not been ravaged by carnivores occurs in the sub-aerial post-nutritive exposure (model A) in which some bones, namely cancellous and greasy bones like vertebrae and ribs undergo the effects of weathering and water flows, that even if moderate, may delete more fragments (and elements) of these types of bones than of other denser elements. Finally, during the phase of recovery and analysis, one of the greatest loss that may occur is attributed to the action of archaeologists themselves that regularly discard non-identifiable specimens. Among these specimens the most frequent ones belong to the limb shafts. This entails the loss of information of the original MNE present at the site (Bunn & Kroll 1986; Blumenschine & Marean 1993). However, as we have documented in the previous section, the major process of distortion of original skeletal part abundance originally accumulated by humans at transport sites (assuming a moderate to low bone discard at the acquisition site) is due to the ravaging by bone-crunching carnivores (model B). Pelves, scapulae, axial bones and compact elements, as well as most limb bone epiphyses are mostly deleted (Capaldo 1995). We can observe the contrast between model A and model B, once ravaging has taken place. The original number of elements represented at sites is significantly low. This suggests that in bone accumulations where carnivore ravaging is documented,

skeletal part profiles may be highly biased and are not reliable indicators of the transport and processing behaviors of humans (Capaldo 1995).

Even in the case of passive scavenging from felid kills, the behavior of humans can be distorted in a similar way. At a lion kill, for instance, the bones more likely to be transported by humans are the marrow-yielding ones and the head, containing the tongue and the brain. Head and long limb bones would be then transported to consumption sites (Blumenschine 1986, 1991; Dominguez-Rodrigo 1994). If no ravaging occurs after consumption at transport site, the total MNE might be represented without bias (model C). If ravaging is documented, most compact bones as well as the epiphyseal fragments would disappear and the total MNE might be somewhat biased, especially if an important percentage of shaft specimens are lost (model D). In both cases, the skeletal part profiles obtained may be barely distinguishable from bone assemblages accumulated by an initial transport of mostly complete carcasses.

4. CONCLUSIONS AND FUTURE PERSPECTIVES: EXPERIMENTAL MULTIPLE-PATTERN MODELS AND BONE SURFACE MODIFICATION AS AN ALTERNATIVE TAPHONOMIC APPROACH

We have seen how skeletal part profiles are biased when carnivore ravaging of bones takes place at sites. In this sense, it is impossible to differentiate primary access (model B) from secondary access (model D) to carcasses by hominids. Recently, a change of focus by some researchers on the study of bone assemblages is propitiating the appearance of new technological and interpretative procedures that seem to be more resolute than the traditional use of skeletal part profiles. The assumption that sites were palimpsests and, therefore, the result of dynamic processes in which more than one actor have participated, led Blumenschine (1988) to study the timing of hominid and carnivore participation at sites. He made several experiments on the frequencies and distribu-

tion of tooth marks according to bone section in a set of assemblages created first by humans and in another set of assemblages in which hyenas were the primary actors. When comparing the results obtained with the distribution of tooth marks and cut marks at Plio-Pleistocene sites, Blumenschine could determine—for the first time without ambiguous and untested speculations—the order of both agents at Olduvai sites.

The utility of this novel approach fueled other studies on bone modification as a useful source of taphonomic information. Since then, several experiments have been carried out on the differential depletion of bones by hyenas (Marean *et al.* 1992; Capaldo 1995), on their distinctive tooth marking frequencies and distribution according to their access to carcasses (Blumenschine & Selvaggio 1991; Capaldo 1995), on the percentages and distribution of cut marks according to the order of intervention of humans to carcass processing, analysing their distribution on bone section (Selvaggio 1994) and the relationship of bone section to bone type (Dominguez-Rodrigo 1997a,b). Studies on bone breakage patterns have also been made analysing particular traces related to carnivores and humans, such as tooth marks, percussion marks (Blumenschine & Selvaggio 1988) and bone notches (Capaldo & Blumenschine 1994).

These experiments are modeling site formation from dual-patterned conceptions: hominids and hyenas (alternating their order of access to carcasses). More recently, in order to test hypotheses of hominids scavenging from felid kills (Blumenschine 1991, 1995), new experiments, dealing with three-patterned models are being created (Selvaggio 1994; Dominguez-Rodrigo 1997a, 1997b). All the information that we are obtaining from these type of studies is potentially more useful than the traditional approaches to the study of archaeological sites (Blumenschine 1995). However, so far their application has been restricted to Plio-Pleistocene sites in Africa. There is a complete field of study open to this new taphonomic approach: the Pleistocene archaeological record of Eurasia.

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