The Statistics of Archaeological Deformation Processes
An archaeozoological experiment

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Abstract: The quantification of faunal bone assemblages from archaeological sites has a long tradition. Nevertheless, in most cases those studies are somewhat "passive", as if the bones have always been in those conditions, waiting for the archaeologist. There are many taphonomic studies to solve these problems, but in most occasions, taphonomic results seem totally unrelated to archaeological research, as if the natural factors were studied independently from social factors.

In this paper we present a case study where the natural formation process of bone assemblages is experimented. Contrary to the usual view, when wild animals (scavengers) are the causal agent of the assemblage, the archaeologically observable consequence is not an accumulation of bones, but a considerable spread of them. As a result, bones enter into the archaeological record as individual items, without an understandable spatial pattern.

We have studied 30 animal carcases scavenged by foxes in Tierra del Fuego (Argentina). A general statistical analysis of those examples is presented in order to describe an important "archaeological de-formation process". The goal of the study is to discuss how to analyse de-formation process of the archaeological record, and how they affect the quantification of faunal remains in archaeological sites.

Key words: Zooarchaeology, Spatial Archaeology, Formation Process, Correspondence Analysis, Disturbance, Post-Depositional alteration

The Deformation of Archaeozoological Assemblages

Archaeologists traditionally have drawn their inferences about past behaviour from dense, spatially discrete aggregations of artefacts, bones, features, and debris. They have traditionally assumed that the main agent responsible for creating such aggregates was only human behaviour. Even though nowadays most archaeologists are aware of natural disturbance process and the complexities of archaeological formation, archaeological contexts are still usually viewed as a deposit or aggregate of items, which are part of single depositional events. We usually speak of human behaviour being fossilised in archaeological accumulations or deposits, as if the materials of social action through time were only accumulative.

In the case of faunal processing, the "supposed" main observable consequences of social action are bone accumulations. The underlying idea seems to be that the bones of the creatures under consideration have survived since deposition to a more-or-less similar extent, and that the relative abundance of species is representative of that originally deposited. However, the accumulation of animal bones in the archaeological record not always is the result of purposeful human activity. An aggregation of bones may not reflect past human social action, but rather post depositional processes. Loss, discard, reuse, decay, and archaeological recovery are numbered among the diverse formation processes that in a sense, mediate between the past behaviours of interest and their surviving traces (see among others Meadow 1976, Hassan 1987, Schiffer 1987). Most post-depositional processes make archaeozoological assemblages more amorphous, lower in elements density, more homogeneous in their internal density, less distinct in their boundaries, and more similar (or at least skewed) in composition. Those processes have the effect of disordering artefact patterning in the archaeological record, and increasing entropy. Furthermore, some post-depositional disturbance process may increase the degree of patterning of artefact disturbances, but towards natural arrangements (Ascher 1968, Carr 1984). Consequently, determining whether the various frequencies of items in an assemblage or deposit have resulted from undisturbed deposition, differential distribution, differential preservation is the problem (Brain 1980, Lyman 1987).

Archaeological assemblages should be regarded as aggregates of individual elements, which interact with various agents of modification in statistical fashion, with considerable potential for variation in the traces they ultimately may show. Cowgill (1970) proposed a preliminary solution: we have to recognize three basic populations (in the statistical sense):

(1) events in the past,
(2) material consequences created and deposited by those events, and
(3) artefacts that remain and are found by the archaeologist ("physical finds").

By stressing the discontinuities, Cowgill states for viewing formation process as agents of bias within a sampling framework. At the beginning, material items are organized in the archaeological record in a way coherent with the resource management strategies and social practices that generated them. Once the location of social action was left, those remains were subject to bio-geologic forces, which introduce a new material organization. This new patterning of social material remains is opposite to the original pattern, and consequently increases entropy (des-organization, chaos, and ambiguity), until the original patterning become unrecognisable. Each population is then a potentially biased sample drawn from the previous population that was itself a potentially biased sample. We may view these discontinuities as sampling biases in the sense that what we recover and observe does not proportionately represent each aspect of the antecedent behaviour.

From our dialectic point of view, changes and transformations in the original patterning of activity sets are not a simple accumulation process from low entropy sets (primary deposition) to higher entropy patterns (disturbed deposits), but a non-linear sum of quantitative changes, which beyond a threshold, produce a qualitative transformation. A depositional set may be thought of as a mathematical set, the organization of which is the end product of structural transformations operating upon a previously structured set. In this sense, the occurrence of specific formation process is determined by specific causative variables. That means, that depending of the degree of entropy, the transformed archaeological set is not necessary a random sample of the original population. That is, the difference between a depositional and an activity set is based on a deep qualitative discontinuity generated by the aggregate of minor quantitative modifications (Estevez 2000).

The main point is not the recovery of the "social action direct effect" by reversing the formation process of "depositional sets" (for definitions, see Carr 1984, Urbancyk 1986). Rather, the processes responsible for generating organizing, preserving, and presenting the archaeological record should be viewed simply as a dialectic formation processes. Attention should be drawn to the dynamic life history of archaeological remains and the processes of different temporal frequency on the ultimate position, content, and pattern of archaeological remains. This perspective provides a strong antidote to the facile "reconstruction of culture" by "correcting" for apparent disturbances or distortions.

Substraction as an Archaeological Formation Process

In most archaeological bone assemblages, for any given species the frequencies of different skeletal elements show at least some significant departures from the frequencies in which they would be represented in complete skeletons. Modifications in original skeletal frequencies may appear: as a result of human actions, as a result of subtraction by animal scavenging, or as a result of differential preservation and recovery (Klein 1980, Monahan 1998, Bartram & Marean 1999, Estevez 2000).

There is a long discussion whether the difference between primary deposition of animal bones and the recovered bones may bear directly on the distinction of hunting from scavenging at archaeological sites. Since the days of Efremov (1940), archaeologists are looking for regular relevant linkages –signature criteria- between static attributes of the archaeological record and their dynamic causes and associations. A signature criterion is a criterion that is constant and unique and that discriminates one modifying agent or set of agents from another. The idea of some authors is to create a dictionary of material consequences of human hunting and animal scavenging to be able to "predict" the structure of the assemblages produced by a specific action. These predictions should be tested experimentally, that is, by evaluating the predictions in light of modern assemblages known to have been formed by the process stipulated in the predictions (Gifford 1981, Binford 1981, Schiffer 1987, Dominguez-Rodrigo 1999). For instance, scavenged assemblages appear to be without some bones selected by size, weight and shape according to the particular size, mechanical capacity, and foraging range of the scavenger. Recognizable signatures therefore can be characterized by specific ranges of taphonomic loose, generally defined through upper size and weight limits (Marean & Bertino 1994, Stahl1996). For instance, an over-abundance of cranial and distal limb elements of middle-to-big sized game would be characteristic of butchery sites, whereas the over-abundance of proximal limbs would be a definitional feature of consumption sites (Binford 1981, Stahl 1999). That means that a characteristic "human" pattern of disarticulation would be the refuse of lower legs because they lack sufficient meat to make them desirable. The heavier and less nutritious portions of a carcass (the axial skeleton) tend to remain at animal death sites, while the lighter and more nutritious portions of a carcass (the appendicular skeleton or limbs) tend to be transported more extensively away from animal death sites.

But nothing is so easy. The actual combination of those variables related to causal processes that could have given rise to specific deposits is nearly infinite, and so one cannot expect to find many simple correspondences between a priori lists of evidences and the characteristics of specific deposits. Bone subtraction also appears under the form of differential preservation. Under a given destructive regime, the individual parts will survive in proportion to their robusticity. Survival may be correlated with the compactness of the bone, expressed as specific gravity (Brain 1980). Skeletal parts of high utility tend to be low in density, and then those bones are not resistant to damage (Lyman 1987, Rogers 2000): an assemblage dominated by parts of low utility is also likely to be dominated by parts that are dense and therefore resistant to scavenger gnawing. Such an assemblage could have been produced either by selective transport or by selective destruction of low-density parts

One can hardly argue that uniformitarian principles may be formulated concerning the social scope of human communities, given the profoundly varied, and specific exploitation strategies of resources by different societies (Hassan 1987, Castro et al. 1993, Marciniak 1999). There are many actions and processes, both social and natural having acted during and after a primary cause, and also primary causes act with different intensities and in different contexts, in such a way that effects may seem unrelated with causes.

The fact that we cannot predict the degree a bone assemblage has been scavenged, does not mean we cannot analyse an animal carcass as a by-product of a series of social actions and which has been altered by other processes (or the reproduction of the same actions at the same place). In most real cases, we should speak about multiple causes and complex causal relationships, rather than indeterminism or intrinsic randomness. In this paper we are interested in measuring the probability an archaeological assemblage of animal bones can be "deformed" by the action of scavenging. We think that the aggregate of quantitative modifications experimented by a carcass (in content and spatial distribution) can produce a significative qualitative change (a bone assemblage). Scavenging should be considered as a sequence of modifications which convert an animal carcass into a disintegrated set of bones. It is no more an animal, but it contains some distorted elements of what once was (palimpsest). Given the probabilistic nature of causal relationships, we cannot assert that, the survival parts of a skeleton will follow an entirely predictable pattern if the destructive influences are known (Brain 1980, p. 117). That means, that simple documentation of frequencies of disarticulated and articulated joints in an assemblage may not permit the inferential identification of social action before/after/ in absence of subtraction by scavenging.

We have designed a series of controlled observations in order to be able to calculate the probability relationship between the disturbance effect and the composition and spatial pattern of bone remains. That is, causal significance of scavenger activity for bone assemblages composition and spatial patterning corresponds to the difference that the presence or absence of scavenger activity makes on the features of bone assemblages. In terms of Stochastic Interaction, the probability of existence for scavenger activity and the features of bone assemblages are determined reciprocally. Therefore, changes in the probability of scavenger disturbance determine changes in the probability of spatial patterning of bones and changes in the probability of spatial patterning determine changes in the probability of scavenger activity. We want to test the hypothesis that an increasing skeletal disorganization in terms of taphonomic loose suggests a more complex archaeological formation history.

Tierra del Fuego. An Archaeozoological Case Study

We have studied 30 carcases of "guanaco" (Lama guanicoe, a comparable middle sized herbivore) scavenged by foxes in Tierra del Fuego (Argentina). During three years we have taken measurements from animal carcasses produced by a catastrophic natural death in 1995. We have yet published some preliminary results using traditional frequency approach (Mameli & Estevez 1999, Estevez & Mameli 2000).

In this study we have used the following controlled variables: presence/absence of bone elements in each carcass, the quantity of bitted bones in each carcass, and the Euclidean distances between bones in each carcass, according to the longitudinal axis of orientation (from head to tail).

The Statistics of "Deformation" Process: general patterns

Archaeological deposits (bone and artefact) are usually described and analysed using global attributes:

- the average density of attributes,
- the form of arrangement of artefacts within it –clustered, random, or systematically spaced- independent of density (Carr 1984).

In this paper, we have followed this approach. As a preliminary stage we have produced some qualitative statistics of the general pattern of scavenging, as observed in our data. Different carcasses were observed, and the evidences of scavenging on any kind of tissue were annotated.

Taphonomists have paid little attention to the statistical problem. They draw inferences from bone counts to develop general patterns of scavenging, transport and attrition, relying almost exclusively on measures of association between the frequencies of body parts (cf. Binford 1981, Davidson & Estevez 1986, Blumenshine 1988). Our preliminary analysis has been a frequency analysis of scavenging as observed in controlled situations. The goal is to record the relative frequency with which different body parts occur in modern carcasses lying on land surfaces, which permits the construction of a statistical model of disarticulation.

To our surprise, the observed statistical pattern of scavenger disturbance does not coincide exactly with the standard decay order of natural joint disarticulation of large ungulates (Hill 1979), probably because scavenging is not always related to disarticulation, but with edible tissues subtraction. Hill studies have shown that there tends to be a pattern in the sequence of natural skeletal disarticulation from forelimb-body disarticulation until cervical vertebrae breaking. Disarticulation of Mandible and Skull arrives only in fourth place, after forelimb-body, caudal vertebrae-sacrum and Scapula-proximal humerus. Disarticulation of carpals and tarsals is even later. In our case (see Figure 2), softer parts (anus, belly) where the first ones to be scavenged until its total consumption. Mandible and Skull of the animal is scavenged in full well before the rest of the carcass. In general, the less scavenged parts during the first year are limb bones, thorax, neck, lumbar and sternum. In the second year, those neglected parts are scavenged in greater proportion, probably because the skin of the animal preserved edible tissue in those parts. During the third year, many elements of the carcasses are hardly visible, and nearly all remaining parts are equally scavenged.

The very process of Scavenging is hardly visible in the archaeological record, because it affects softer tissues. The only indirect evidences we have are those bitted bones in the archaeological record. That is to say, from the total amount of bones in a carcass, only the quantity of bitted bones can be used as evidence of the intensity of scavenging (Mameli & Estévez, 1999, Estevez & Mameli 2000). The obvious question is then the relationship between scavenging and morphological damage discovered on the bone surface.

If we consider now the number of bones with traces of animal scavenging (bitten or gnawed bones)(Figure 3), the results of our controlled observations suggest that cranium is the only damaged skeletal part in the first year, which coincide with the fact of preliminary scavenging on less skin protected parts. During the second year, skulls are still being damaged, together with scapulae, pelvic bones and ribs. Long bones, although scavenged show very few evidences of surface modification, concentrated on epiphyses. In the third year, vertebrae are the most damaged bones.

There is also a strong temporal dynamics, which prevent a proper description of the scavenging process from archaeological remains. If we consider that archaeological record is very similar to our last year observations –when trapping has already begun-, then we see that most bones are bitten in a similar relative frequency, with the exception of zigopodia, sternum, ribs. But to affirm that those parts have been less scavenged than others would be a misleading conclusion, as the results for first and second year suggest.

To go beyond this frequency description we need multivariate techniques to disentangle the multiplicity of effects produced by different post-depositional processes. We have studied through Correspondence Analysis the presence/absence of observed evidences for scavenging.

A Bi-dimensional factorial solution accounts for a very low proportion of total variance (42%). That means that we cannot speak about a general pattern of variation which can explain observed variation among carcasses. 87 scavenging events have been observed, and it seems impossible to infer a regular pattern (see Figure 4). Where the anus or belly have been scavenged, other body parts have not evidences of being disturbed or modified as a result of scavenging. In the opposite, where limb bones or autopodia have been scavenged, there are no evidences of disturbance in the softer parts.

When we consider all observations made during the three years of the experiment, the only pattern which emerges is that of the influence of the softer parts scavenging, instead of disarticulation.. In figure 4, it is interesting to observe the differences and similarities between head parts (cranium, mandible, mouth, even neck) and limb bones (limbs and feet).

Differences between the theoretical pattern (Hill 1979) and the observed one in our case study is probably the result of the characteristic of grey foxes scavenging (little canids) and the anatomical features of guanaco, with very robust bones and a thick skin. We have observed that before disarticulation, little canids ravage soft tissues from the head of the animal (eyes, tongue, etc.) or the belly. Only when other disturbance process have acted, meat is easier to scavenge. This is why forelimb bones are mostly scavenged at later moments.

The Statistics of "Deformation" Process: Temporal Dynamics

In most taphonomic analysis of scavenged carcasses, temporal dynamics are only partially taken into account. We think that it is impossible to understand scavenging as a disturbance process, if we do not characterize it as a dialectical process, where a non-linear aggregation of quantitative changes, beyond a threshold, produce a qualitative transformation. That means that a single description of some events of scavenging is not enough for understanding the process. Scavenging is a dynamic process, introducing quantitative modifications which eventually produces a deep discontinuity.

Why carcasses with softer parts being scavenged have no evidences of modification in other body parts? Because scavenging is not a static event, but a continuing process. That means, what is not scavenged at first, will be ravaged later. We have controlled three temporal stages for each case, and we have documented a strong temporal component

An opposition between first year observations, and the rest characteristically dominate dimension 1, which accounts for 29% of total variance (see Figure 5). If we combine these results with those obtained in preceding chapter, we can arrive at the conclusion that softer parts are much scavenged during the first year that later in the process. It is interesting that we cannot separate the last two stages on the basis of softer parts scavenging.

Let we process the results differentiating the effects for each temporal stage.

Variability among carcass during the first year is very great (Figure 6a). A Bi-dimensional Multiple Correspondence Analysis only accounts for 36%. The main aspect of this variability is the relevance of low neck. That means, carcasses with evidence of scavenging at the level of the low neck (4 items), are significatively different from the others. In general, the same body part seems to be scavenged differently in different carcasses. During the second year (Figure 6b), the perceived regularity only accounts for 25% of total variance, but events are totally different. Softer parts have disappeared, and the carcasses become disarticulated. As a consequence, the same body part is processed in the same way in different carcasses. As the time goes, the effects of scavenging are more similar, and we can define some redundancy patterns. During the third year (Figure 6c), most body parts have disappeared, and foxes scavenge all remains they can find. The overall similarity increases, because the Multiple Correspondence Analysis accounts for 40 % of total variance.

It is highly significative that the important differences between forelimbs and hindlimbs, as between left and right during the first year of observations (Figure 6a), diminish during the second year (Figure 6b). That means that extremities seem to have been scavenged differently in different carcasses at the beginning of the process, tending towards an increasing similarity. We can explain all this temporal dynamics suggesting that the more scavenged the bones, the more disturbance, but also, the more similarity between body parts. The primary deposition has been totally altered, but similar bones are scavenged in similar ways, when carnivores have less edible choice, than when carcasses are complete.

We have also studied the influence of the intensity of scavenging. Figure 7 plots factor scores for individual carcasses against a measure of intensity (number of bones displaced or modified). In all cases, the most disturbed carcasses (cases where intensity values are the highest) are usually at the center of the distribution, what suggests the high similarity between them. Most cases of low intensity appear everywhere in the plot, suggesting the low degree of global similarity between the best preserved carcasses. This pattern is clearer at later stages than an the beginning of the scavenging process.

Consequently, we cannot conclude that the only effect of scavenging is to increase entropy. In fact, although disorder increases, the general similarity also increases. This final patterning of animal bones at butchery sites seem to be very different to the original pattern, which becomes unrecognisable. The more disturbances scavenging has produced in the past, the less possibilities of differential re-scavenging remains in the present. Consequently, as the process continues, scavenging concentrates in those bone which survive, appearing some hints of regular pattern at a later stage. In any case, this pattern does not go beyond 40% of total variance.

Temporal dynamics of scavenging are not characterised by a simple accumulative process from low entropy sets (death animals) to higher entropy patterns (scavenged carcasses), but it should be defined as a non-linear aggregate of quantitative changes, which beyond a threshold, produce a qualitative transformation (an archaeological deposit). We have not identified any regular pattern that could differentiate scavenging from other social actions, but a general pattern towards increasing qualitative deformation. This result is in strong opposition with usual approaches trying to identify natural disturbance processes using single identifiers.

The Statistics of "Deformation" Process: Spatial Dynamics

In our case study, we have discovered evidence for a relationship between the intensity of scavenging, the distance of transported elements and the relative frequency of lost material: although the intensity of scavenging diminish as the time goes, the spatial disturbance (distance) increases .

These graphs show the spatial distribution of skeletal parts of some carcasses analysed in our case study. Spatial coordinates have been measured in reference to local reference points (a theoretical line along the orientation axis of the carcass). Given that results are always expressed in the same scale, they can be compared, although points in the graphs cannot be interpreted as individual comparisons. Graph coordinates should be seen as non-normal transformations of original coordinates, preserving ordinal differences and similarities. In Figure 8, a 3 meters zoom window from the original location has been selected. It is important to realize that the 3 meters zoom window only includes a subset of bones from the third year. We have given emphasis on the examination of the original deposition area and how it is transformed through time, rather than a general exam of the total distribution (it can arrive until 30 meters).

We see that differences are not greater between the second and third year, than between the first and second. That means, scavenging during the second year is still produced on relatively dense carcasses. Dispersal seems to be a consequence of long scavenging and not a direct consequence of a single event animal action on carcasses.

We obtain a new test of the previous hypothesis: as the time goes, the density of locations diminishes and the spread of bones increases. That is, although scavenging is less intense after the first year, occasional disturbance produces much more spatial dispersal than original scavenging.

Our analysis pretends to examine if the number and nature of bones in one location have anything to do with characteristics in a neighbour location through the definition of a general model of spatial dependence. We usually assume that "everything is related to everything else, but near things are more related than distant things" (Tobler's law). This assumption is based on the Neighbourhood Principle, which relates the intensity of influences converging to a single location from the spatially neighbouring locations. This axiom is not always true, specially when we deal with natural disturbance processes.

What we are looking is whether the location of individual bones or skeletal parts is homogeneous or heterogeneous in the area defined by the natural disturbance process. The effects of scavenging as a disturbance process should be explained in terms of the "influence" an action performed at a location has over all locations in the proximity. A formation or de-formation process can generate some material effects (quantitative and/ or qualitative changes) around it, or it can prevent that effects of other processes leave evidences in the same vicinity. Some of the processes acting in the vicinity of the location increase the probability of some material (observable) effects and decrease the probability of others. The approach here relies on a prior hypothesis of spatial smoothness, which considers that two neighbouring observations are supposed to have been more likely originated from the same group than two observations lying far apart. (Barcelo & Pallares 1998).

This can be easily computed by estimating the spatial probability density function associated to each location. Given that locations are defined bi-dimensionally, we can calculate an interpolated surface representing the form of a probability density distribution for two continuous random variables, Cartesian co-ordinates x and y. The idea is to estimate this 2D dimensional density function, given a sample of known locations, by estimating the density in that area, the relative frequency of all observations falling in a given interval is counted. We use Kernel estimation techniques for this task (Baxter and Beardah 1997, Delicado 2000). These techniques are characterised by the use of a weight function (the kernel function) that permits give more mass to observed data near the point when the function is estimated.

A preliminary exam of point clouds graphs shows that as the time goes, the material effects of scavenging (spatial disturbance) increases, the density of bone locations diminishes and the probability of inferring the correct place for the original deposition of the carcass also diminish. We have translated this information using a kernel density approximation. The results for carcass number 1 appear in Figure 9.

Contours in Black corresponds to the probability distribution of first year observations, those in grey to the second and third year. That is, when animal bones begin to be integrated into what will become an archaeological record (after trapped in soil) we have a disturbed spatial distribution characterised by its lower density. Given that that distances among bones have increased, the probability of inferring the original placement of the carcass diminish: the increase of entropy (disorder) is the cause of an increase in the ambiguity of the archaeological record. The main effect of scavenging is then a negation of Tobler's Law: in an altered context, near skeletal parts are not more related than distant parts. In some cases distant skeletal parts can even be more related than near bones. The question is then if we can discover any traces of the original deposition even after post-depositional processes.

We have calculated a general spatial density model for all carcasses in the case study.

We use contour maps, to represent spatial densities. Probability maps should be considered a visual model of locational features, and not an explanation of spatial causality. Contour maps as those presented here are a graphical convention for showing changes in the probability of action as a function of disturbances generated by scavenging at neighbouring locations. Figure 10a shows a density map corresponding to undisturbed or only partially disturbed carcasses: all bones are in the "correct" place according to the anatomy of the dead animal, and according to the cause of death. As the time moves on, spatial disturbance increase, and the density of bones diminish. Fig.10c shows the global density of bone placement after three years of continuing scavenging. It remains a core area of more dense findings, corresponding to the precise location of the original action (animal death). It is at this level when we can affirm that the higher the density of findings, the higher the probability of the original action. We are not calculating the probability of scavenging, but evaluating the possibilities to infer the original action in the palimpsest generated by post-depositional processes. Results are clearer if we use a 3D representation of the same kernel filter.

Conclusions

Usually, archaeologists assume that prehistoric social practices, including procurement, butchering, storage, cooking and disposal will produce faunal assemblages distinct from those generated by natural processes (catastrophic death, for instance). However, animal bones found in archaeological conditions have usually been exposed to a long scavenging process, and characteristics of the original deposition are no more visible. We have shown that scavenging increases entropy, and we have also shown that the patterning at the end of the disturbance process may be explained in probabilistic terms.

In this paper we have argued that archaeological assemblages should be regarded as aggregates of individual elements, interacting with various agents of modification in statistical fashion, with considerable potential for variation. As a result, what we recover and observe does not proportionately represent each aspect of the prior behaviour. It is not yet possible to explain scavenging in terms of a regular subtraction process characterized by a logarithmic reduction of the amount of bones to be scavenged. Consequently it does not exist a simple rule able to separate the effects of scavenging from primary deposition. Each bone assemblage is a potentially biased sample drawn from an original population that was itself a potentially biased sample. We should view these discontinuities not only as sampling biases, but as a discontinuous, and non-linear process: *an increasing skeletal disorganization in terms of taphonomic substraction and spatial disturbance is related with complex site formation histories.*

Therefore, element-abundance data cannot be used in archaeology in a simple way to investigate social practices, like butchery, carcass-transport decisions, human nutritional needs, activity specialization, discard, rubbish formation, and so on, without considerations of the specific formation process. Interpreting the content and frequency of an archaeological assemblage must be grounded in an understanding of both the social and natural events that have influenced the presence/absence, alteration, and displacement (relative to it as a primary site of production, use or discard) of its individual components and of the assemblage as a whole.

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Figures

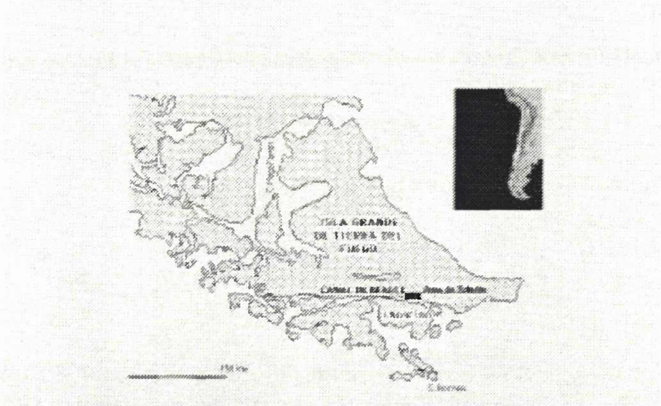

Figure 1. Study Area

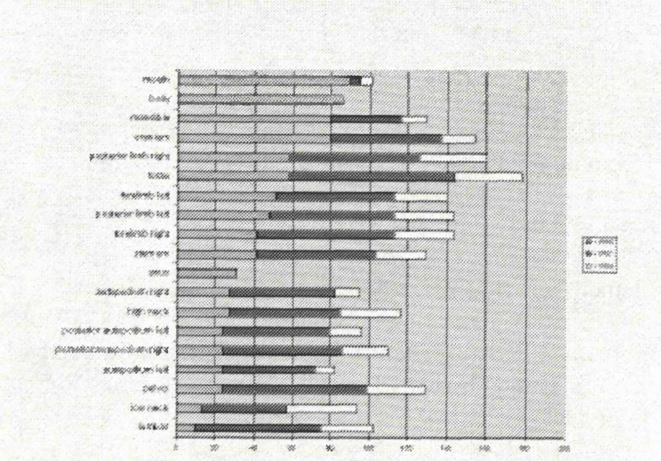

*Figure 2. Presence/absence Data. Preliminary Qualitative Statistics. Body parts representation * year*

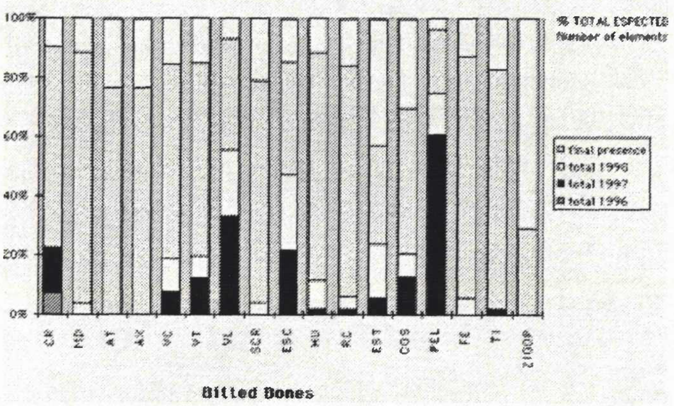

*Figure 3. Bitted Bones data. Preliminary Qualitative Statistics. Bitted bones representation * year*

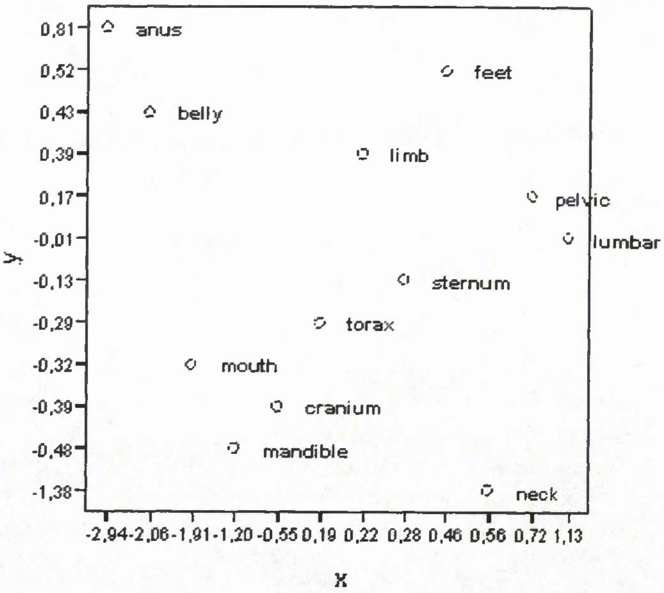

Figure 4. Presence/Absence Data. Correspondence Analysis of all carcasses during 3 years of observation. Variables Plot.

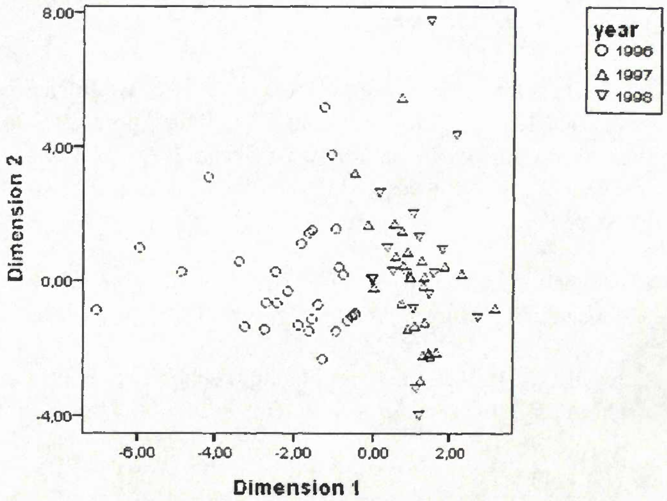

Figure 5. Presence/Absence Data. Correspondence Análisis of all carcasses during three years of observation. Individual Scores with temporal values stratification

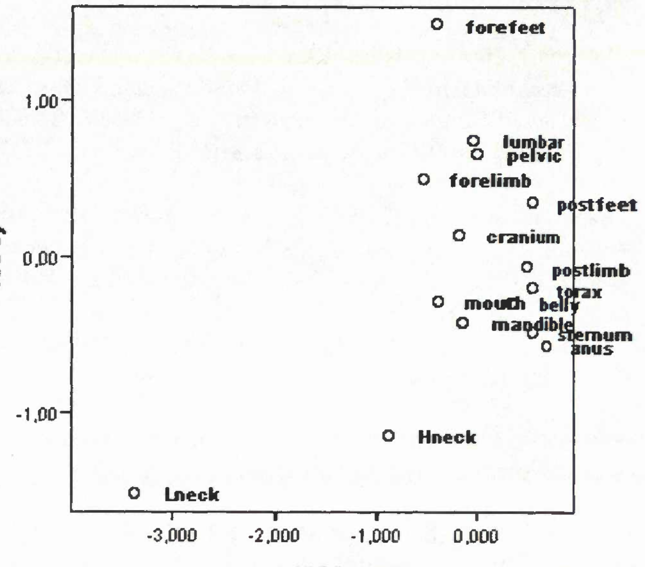

Figure 6a. Presence/Absence Data. Correspondence Analysis. First year of observations. Variable Plotting

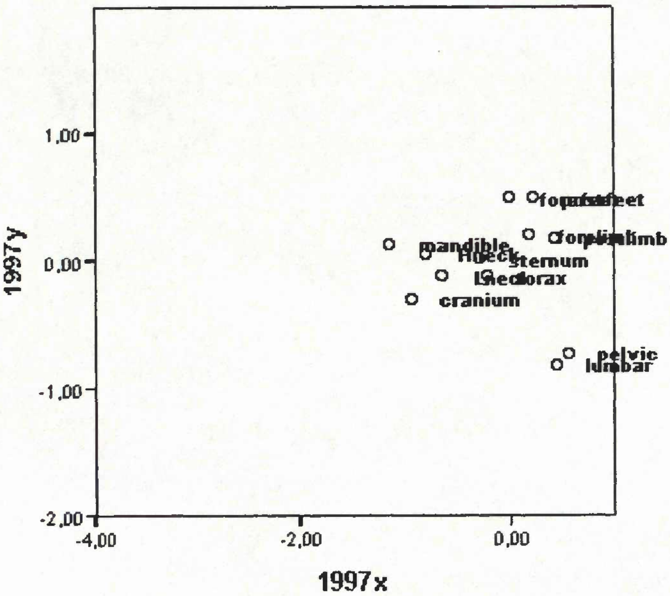

Figure 6b. Presence/Absence Data. Correspondence Análisis. Second year of observations. Variable Ploting

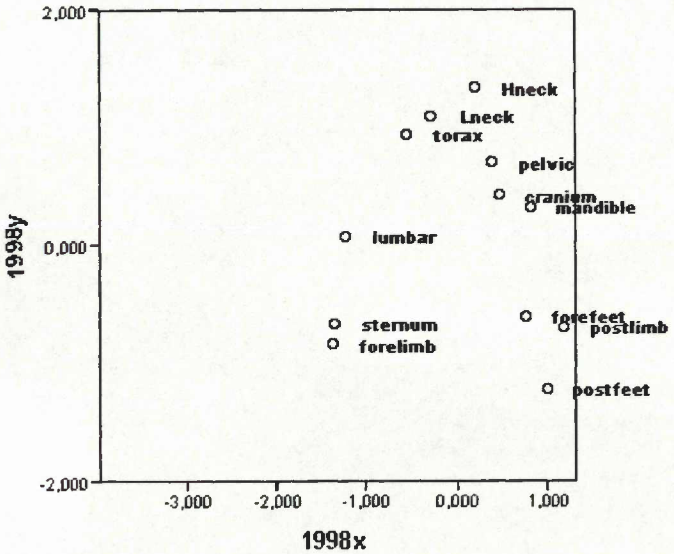

Figure 6c. Presence/Absence Data. Correspondence Analysis. Third year of observations. Variable Plotting

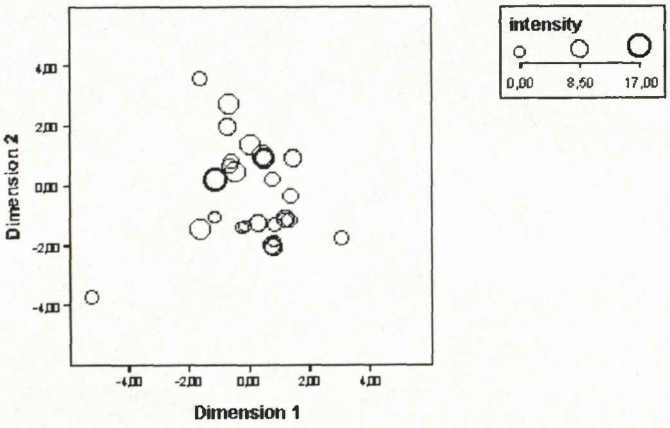

Figure 7a. Presence/Absence Data. Correspondence Analysis Individual Scores for each carcass during the first year of observations

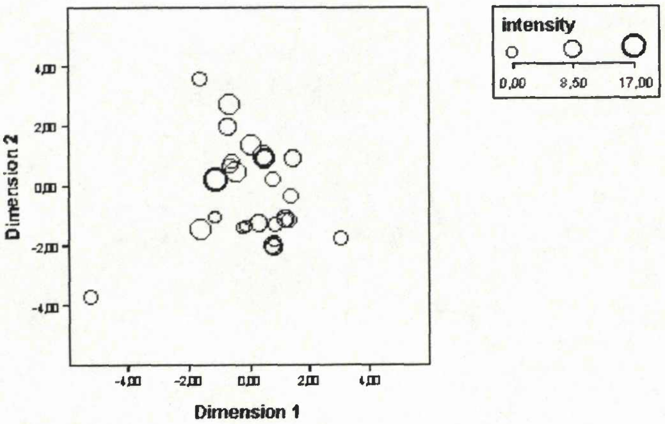

Figure 7b. Presence/Absence Data. Correspondence Analysis Individual Scores for each carcass during the second year of observations

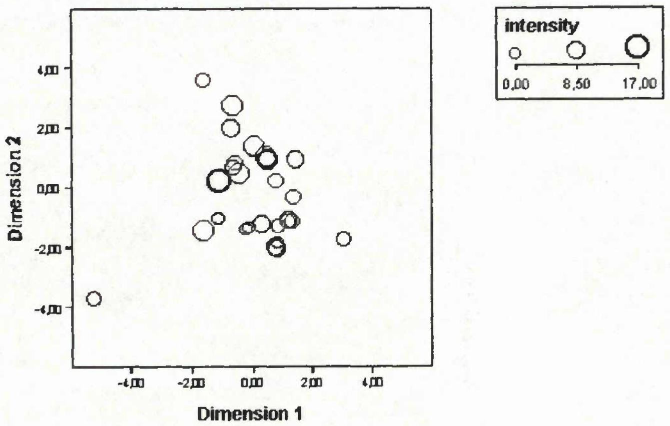

Figure 7c. Presence/Absence Data. Correspondence Analysis Individual Scores for each carcass during the third year of observations

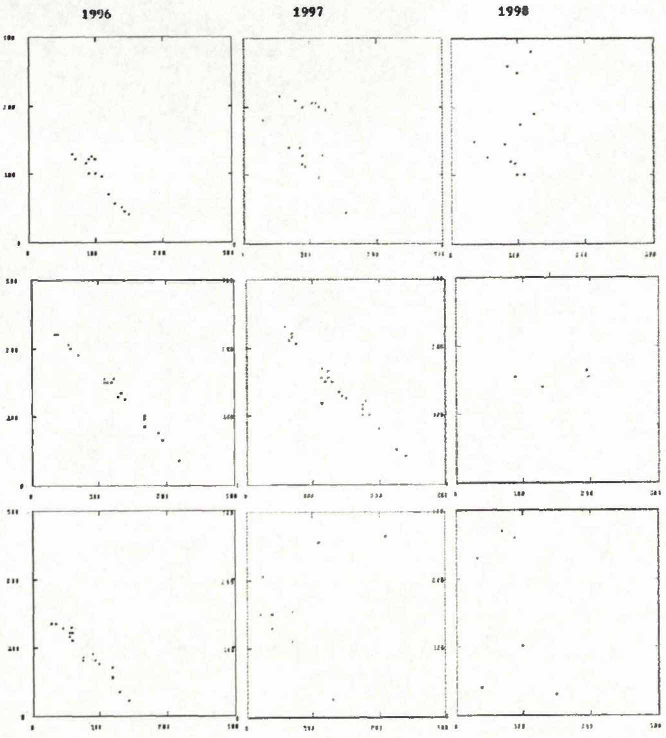

Figure 8. Spatial distribution of bones in three different carcasses

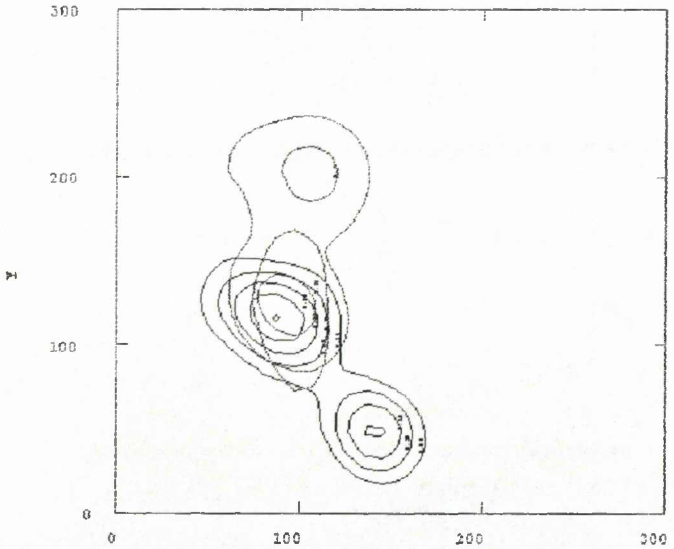

Figure 9. Kernel Function interpolation on point cloud for Carcass No. 1

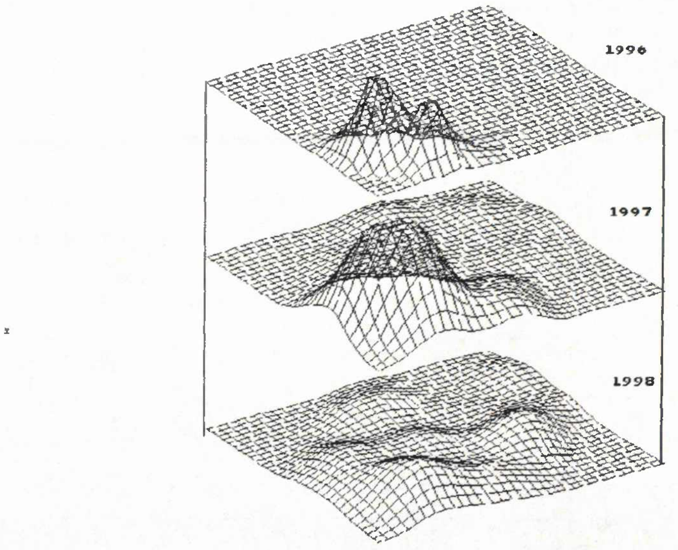

Figure 11. A 3D view of Figure 10

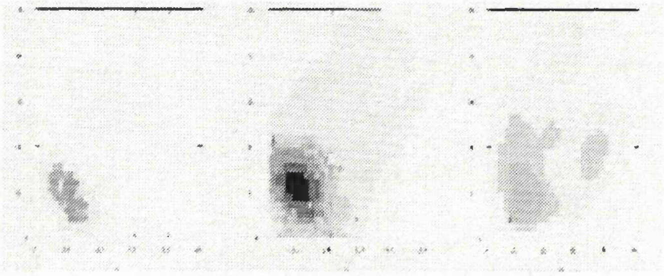

Figure 10. Kernel density maps for all carcasses in the sample