Methodological Biases in Zooarchaeology and the Interpretation of Human Activity from the Faunal Record

Rebecca Torgerson
University of Wisconsin-Milwaukee

Abstract

Zooarchaeology is a growing multidisciplinary field, which can answer questions about the relationship of humans and other animals and its effects on the environment. There are significant advantages to studying faunal data over other types of assemblages. First, bones allow for a culture-free taxonomy where there is little question of use. Second, faunal data from the past can be matched to species that still exist in the modern day. The latter especially, allows for the use of middle range theory or the ability to create a controlled experiment with living systems based on general principles. The biases in the methods of zooarchaeology can affect interpretation of human activity, therefore taphonomy, recovery, identification, and choice of quantification methods should be taken into account. Each of these methods should be standardized and tailored to a specific research question. Also I believe with the help of ethnoarchaeology we can increase awareness and even reduce some of the biases in zooarchaeology.

Keywords: Zooarchaeology, ethnoarchaeology, methods

Human beings have interacted with other animals for millions of years as evidenced in the archaeological record. Animals have been an important part of daily life in the past and continue to be indispensable today. Some of the daily uses of animals included nutrition, companion pets, and domesticated animals as labor. Parts of animals such as the hide, hair, and elements can be useful in everyday life to create clothing, tools, shelter, ornaments, and traps. By-products of animals can be used for fertilizer, fuel, building material, oils, and glue (Reitz and Wing 2008). To gain a better understanding of the interactions between humans and other animals and their relationship with the environment, archaeologists study animal remains from archaeological sites, which is referred to as zooarchaeology (Peres 2010).

The focus of this paper is to examine the ways in which zooarchaeologists analyze the faunal record to produce interpretations about exploitation practices. First, I will justify using animal bones to suggest human activity and exploitation. Second, I will discuss some of the environmental and cultural issues that can affect our data, as well as biases that archaeologists themselves can cause, such as use of recovery and identification techniques. Last, I would like to provide a critique of specific quantifying
methods used in faunal analysis, while providing examples of how using these methods may produce different interpretations based on the same assemblage. The quantification methods I will include are the most common in zooarchaeology; they consist of NISP, MNI, and bone weight. The methods within zooarchaeology can allow for several types of biases in interpretation, both controllable and uncontrollable to the archaeologist. These variable interpretations may be stabilized by the strict standardization of taphonomic studies, recovery, identification, use of multiple quantification methods for comparison and the increase in use of ethnoarchaeology to objectively observe living systems.

*Why Do Zooarchaeologists Study Faunal Material?*

To begin discussion of the methods of zooarchaeology, it is beneficial to answer the question of why archaeologists study faunal material. There are two advantages of using animal bone to gain insights about the past, which are that bones are not man-made and faunal species used in the distant past are frequently still present in modern day (Binford 1978). The initial advantage of using animal remains to suggest human activity is that man did not create bones; therefore we can create a culture-free taxonomy of bones. In other words, there are no cultural influences that would affect the taxonomy because human beings did not create the animal bone themselves. This fact allows one to conclude with certainty that any variability in frequency or anatomical parts must be due to the dynamics of their use (Binford 1978). The human role in the placement of faunal assemblages is to partition, segment, and differentially distribute animal bone. There is little question that these activities reflect human use.

The second advantage of faunal analysis is the presence today of many of the same species exploited in the past. Processes of exploitation are also still available for observation. According to Binford (1978), archaeologists can calculate food utility of various anatomical parts by studying their representativeness in modern species. We can directly observe the link between behavior and archaeological by-product. This allows for a meaningful point of reference and also a chance for controlled experimental research, which in turn gave rise to Binford’s middle range theory. Faunal material is beneficial to the archaeologist due to the ability to conduct experiments that determine factors such as food value, where with artifacts such as stone tools, it would much more difficult to know their exact value and use (Binford 1978).

Even though these advantages existed, a frustrated Binford still longed to give meaning and find causal relationships between assemblages and human usage in a theoretical fashion. In light of his frustrations he created middle range theory, which supported the understanding of relationships in terms of general principles. To conduct middle range research was to study living systems in the contemporary world. The documentation of living systems allows for systematic control of both the dynamics and the static derivatives that are observed (Binford 1981). In other words, one can observe the actions of a person as well as the artifact or animal bone in a controlled
fashion. Important to middle range research in the contemporary world is that it allows for the development of criteria for signature patterns, which will be more visible to the archaeologist when he or she is looking at an actual assemblage (Binford 1981). Ethnoarchaeology is extremely successful with faunal data due to the large number of species still accessible in the modern world. In this paper, I will argue that it is important for zooarchaeology to use middle range research to its advantage because it allows for observation, control of variables, testability, and an affinity to minimize biases in the archaeological record.

Taphonomy

“Taphonomy is the study of the transition, in all details, of organics from the biosphere into the lithosphere or the geological record” (Lyman 1994:1). Taphonomy is the analysis of how, in our case, animal bones become embedded into the archaeological record including all the environmental and cultural processes that affect the burial. It is important to study taphonomic processes because recovered assemblages do not include all material that was originally deposited. Comprehension of these laws allows one to indirectly observe what was lost and prevent possible biases in interpretation (Peres 2010).

Natural and Environmental Biases

There are both intrinsic and extrinsic characteristics that affect the process of decay of bone (Henderson 1987). Differential preservation is highly variable between faunal assemblages depending on how the animal died, osteological characteristics, and the local environment (Lyman 1994). Intrinsic characteristics of the bone itself influence how well the bone will preserve, which includes bone density, maturity, shape, age, and size of the animal. These factors can allow for either an increased or decreased probability of survival (Peres 2010). Bone density patterns are consistent within species of similar morphology, which makes it testable and more predictable (Lam and Pearson 2005). This predictability has attracted many zooarchaeologists to document bone density in numerous taxa in an attempt to standardize the methods to be used as a measurement for destruction of bones. Examples of bones with a high density are cranial and foot elements, which have a better chance of survival. These elements are considered low utility, meaning they have a lack of meat and marrow. A large amount of low utility bone may cause a zooarchaeologist to interpret an assemblage as used by a group who scavenges and is not capable of obtaining high utility elements. Elements with a high utility contain more meat and marrow and therefore are more desirable to a hunter. Research on this topic shows that scavenging is most likely not the case, but that low utility bones have a higher density or ability to survive. Archaeologists also have difficulty identifying shaft bones, which causes uncertainty in the data set (Lam and Pearson 2005).

Bone density can also affect age profiles. Adult teeth and bones are more likely
to survive due to higher densities, which may skew the age profile and one’s interpretations (Lam and Pearson 2005). Utilization of younger animals may be more prevalent than the profile suggests. Bone density may also affect species representation in an assemblage. For example, small and thin bones of fish with low density may disappear from a site. Another important intrinsic factor that affects preservation of bone is its internal chemistry. Organic areas of bone are automatically subject to hydrolysis of protein to peptides. Even though this process is slow, it causes destruction and break down into amino acids. Inorganic material of bone also breaks down by severing the bond between proteins and minerals, which cause decay by both internal and external elements (Henderson 1987).

Not only are bones affected by intrinsic factors, but extrinsic aspects cause differential preservation as well, such as exposure to certain types of soil and weathering. The fluctuation of soil from wet to dry is incredibly destructive to all osseous material (Lyman 1979). Extremes of soil pH cause accelerated destruction and deterioration of bone material. Weathering such as temperature change and erosion may cause bones to deteriorate if exposed. Buried bones have a lesser chance of being affected by weathering, which could mean that bones disposed of in a trash pit or buried by a dog may have a better chance of survival. Possible effects of weathering on bones can include open cracks, large splinters, fibrous texture, rounded edges, color change, and exfoliation of outer surface (Lyman 1994). If animal bone is buried, it may suffer from root etching. Root etching occurs when the bone is deposited near dense plant roots. The acid associated with the growth and decay of the plant is etched on the bone. According to Binford, bones with root etching look like they have a “decorative macaroni type motif” (1981: 49). Lyman (1994) describes the pattern as dendritic. Before knowledge of root etching was available, the dendritic markings were interpreted as an ancient art style (Binford 1981). This acutely biased interpretation is a clear cut example of why it is important to standardize taphonomic processes. All archaeologists should not only be thoroughly trained in taphonomic studies, but also continue educating themselves to current discoveries in the subject to increase the probability of reliable interpretations.

Extrinsic agents in the natural environment also disrupt or change the preservation processes. Insects and microscopic organisms are two small agents one would not generally think of as capable of modifying large bones, but as Lyman (1994) notes they do cause damage. Insects such as, termites, moth larvae, and beetles can create grooves and scratches in bone that could be interpreted as human markings if taphonomic knowledge is not available to the zooarchaeologist. Another surprising culprit in bone destruction is herbivores, particularly ungulates, which gnaw on bones and antlers. The result of side to side graze- like chewing may be mistaken as use of human tools (Lyman 1994).

A more commonly studied agent of bone modification is dogs or wolves. First,
studies show that most carnivores disarticulate other animals in a consistent sequence from head to front leg to rear leg, which effects how the bone is spatially deposited. Canines show four specific types of tooth markings on bones as well, which allow them to be distinguished from human modified cut or butcher marks (Binford 1981). These four types of tooth marks include punctures, pits, scores, and furrows. Puncturing, pitting, and furrowing are very typical of dogs and wolves and are made by digging teeth directly into the bone or the scratching of carnassial teeth respectively. Scoring can be confused with human cut marks because the dragging of teeth along the bone resembles stone tool cut marks. Scoring differs in that it follows the contour of the bone, while cut marks do not. Dogs and wolves break bones in a distinct way by chewing on soft spongy parts first, while also removing splinters to lick out marrow (Binford 1981). This strategy is not seen in humans. The extensive study of canines is significant to zooarchaeology because they live and scavenge near human groups. Yet future research should be directed at other carnivores, such as cats or bears. These animals may also have tooth mark or disarticulation patterns different from dogs and may carry essential information for our interpretations of diet and human modification of animal bone. To study further the way animals change bone, we should examine live animals on a long-term basis and observe specific behaviors. An example of the observation of live animals was done by Jeske and Kuznar (2001), who observed how dogs dug certain pits, which may have previously been thought to be dug by humans at archaeological sites. The evidence of systematic dog pit digging could influence our interpretations just as examining tooth marks by dogs can change our ideas about what human modification is.

Cultural Transforms

Humans affect the way animal material is deposited in different ways than do natural transforms. These are known as Cultural Transforms (Schiffer 1976). If one’s interpretations are based on subsistence and diet, the first aspect that affects deposit is what people choose to eat. People choose what to eat based on belief systems, social organization, food preferences, and taboos. These define both animals they choose and do not choose (Peres 2010). After food choices are made, the hunter decides which parts of the animal have a high utility and are to be brought back to the residential area, especially if the animal is large and not possible to be brought back in full. Skeletal elements with the largest amount of usable meat will most likely be chosen, which include proximal limb bones (Emerson 1993). Distal limb bones and other elements with a low amount of usable meat will be left at the kill site (Lyman 1994). Although this signature seems to be correct, Lam and Pearson (2005) have said that cranial and foot elements are more likely to be found due to their high density even though they carry a low utility as far as meat and marrow are concerned. Does this mean that individuals are not bringing back high utility parts, since the high value items are actually not found as often as the low are? This may also be due to the failure of
Lastly when talking about cultural transforms, food processing and disposal have significant effects on how bone becomes deposited. Human modification of bone is systematic and easily discriminated from other animal or environmental processes that act upon the element. Humans tend to dismember animals in consistent fashions, which Binford (1981) describes in great detail. For example, all groups separate the head and the neck between the occipital condyle and the atlas vertebra. Butchering marks are relatively similar in the same manner across groups. To qualify as a human-made butcher mark there must be repetition between specimens at the same locations and an anatomical reason for a particular mark. These marks were observed by Binford (1981) in systematically the same anatomical hotspots. Some of these hotspots include the distal femur, metatarsals, and thoracic vertebrae. One issue with Binford’s conclusions on dismemberment and butcher marks was that his research questions while working with the Nunamiut of Alaska were not focused specifically on these topics. Therefore, he may not have collected all relevant detail on the matter. On the other hand, differential butchering between species may causes biases, where discarding choices may be unequal in nature (Gilbert and Singer 1982).

The last step before deposit depends on the disposal practices of the group. The discard of trash at the location of activity results in a primary refuse (Meadow 1980: 66). These types of deposits will allow archaeologists to find articulated and articulatable elements. Loss of bones in this case takes place when activity is located away from the residential area, such as a kill site. Removal of trash from its original area into a dumping location also causes variability in interpretation. It is more difficult to determine specific activities because bones and other trash become mixed (Meadow 1980).

Controllable Biases of the Archaeologist

Not only are there environmental and cultural biases, there are biases that the archaeologists themselves can create. Biases by archaeologists are able to be mitigated by careful recovery methods and skillful identification. Decisions made by the archaeologist on recovery procedures directly affect quality, quantity, and type of samples obtained (Peres 2010). If one wants to obtain a representative sample, a small mesh size should be used when screening, particularly 1 millimeter mesh sieve. Some archaeologists may believe this method to be time consuming and expensive, but without it one could miss out on bones from fish, reptiles, and insects. The archaeologist should consider aligning their research question with both the size and quality of the sample and the context of where the specimen was found, such as in a house or a pit (Meadow 1980). Treatment of specimens is another concern of the archaeologist. Each bone should be uncovered in situ and as slowly as possible to prevent damage. A poorly organized excavation team may be just as detrimental to a bone and an interpretation as erosion or canine activity.
Different skill levels and techniques in identification of bone can be responsible for variable interpretations from a particular assemblage. Identification can be made on many levels from taxon, age, gender, side, and specific element. The lack of universal rules for identification of each of these categories can cause differential interpretation of the same assemblages between different archaeologists (Lyman 1979). To remedy the situation Lyman has created seven detailed levels of identifiably, which he says will make identifications between archaeologists comparable (Lyman 1979). Other suggestions for lack of comparability in identification are to use the binomial nomenclature, which provides rules for classification used by zoologists. Archaeologists should also use a representative comparative collection along with guides and keys of animals and their bones (Driver 2011). In order to standardize the methods of identification it is important to utilize zoological methods, as we have with the classification system. Also comparative collections, guides, and keys can be updated and made more standardized allowing each zooarchaeologist to be using the same tools.

Quantification Methods

Quantification formulas are mathematical operations intended to reduce the assemblage into categories that express abundance of species or a higher taxon, which is comparable to other species counted in this way (Gilbert and Singer 1982). Popular methods in zooarchaeology include, number of identified specimens (NISP), minimum number of individuals (MNI), and bone weight. Relative frequencies in taxa can provide specific data on which and to what extent certain species were being exploited. These data can also be used to compare diets between different groups or identify specific activity sites (Reitz and Wing 2008).

NISP is considered the sample size and a count of how many bones there are in a data set based on species or another form of higher taxon (Gilbert and Singer 1982). For example, if there is a high count of deer and mammal bones compared to bird, one can suggest that the group’s diet consisted heavily of deer. MNI is similar in that the archaeologist analyzes the bones of the deer separately and based on their own anatomical knowledge. Deer bones would be categorized as individuals by side (left or right), age, and gender (Binford 1978). Weight is a less commonly used method where the relative weight of the bone is used to determine frequency. The higher the weight of the taxon, the more likely it is to be a food of choice. There are complications with these methods, such as differential preservation and differing amounts and weight of bone between taxon.

Based on my research, NISP seems to be one of the simplest, yet highly criticized quantification methods. Consisting of a count based on taxon, it is also considered the sample size; therefore it remains easy to calculate. Another attractive feature of NISP is that calculation is possible with a relatively small sample size compared to that needed by MNI; specifically it requires 1/30th of the sample size that
MNI needs to be accurate (Grayson 1979). Criticisms of NISP are extensive, including most notably, the possibility of counting the same animal several times (Grayson 1979; Gilbert and Singer 1982; Reitz and Wing 2008). Further criticisms consist of, not accounting for the fact that each species have a different skeletal structure, dispositional bias, butchering patterns, collection techniques, and fragmentation (Gilbert and Singer 1982). For example, when comparing groups such as mammal and fish, NISP will most likely be higher for fish because they have a large quantity of bones that are relatively thin and easily fragment when compared to mammal bone (Reitz and Wing 2008).

MNI accounts for the most abundant criticism of NISP, which is counting the same individual more than once, where instead specific individuals are identified and counted. MNI may also allow for more inferences to be made (Grayson 1984). MNI does have drawbacks, such as the need of a larger sample size to separate individuals. Also since it is necessary for the archaeologist to use one identifiable element to compare in identifying individuals it may be that MNI is simply measuring tool popularity, bone density, or commonness of discard (Gilbert and Singer 1982). The aggregation and sorting of bone into groups by the archaeologist will cause MNI to vary (Grayson 1984). Lastly, there is an uneven distribution of body parts at a given site as bone density and utility are differential (Marshall and Pilgram 1993). Overall, MNI is more difficult to calculate, but both methods summarize recovery frequencies, not actual site activity (Gilbert and Singer 1982).

Bone weight consists of weighing the bones for each taxon to assume probable meat weight (Reitz and Wing 2008). This can be done due to the predictable relationship between the weight of an animal skeleton and the quantity of meat it may have had (Barrett 1993). There seems to be disagreement on how useful meat weight actually is. For example, Grayson (1984) says this version of bone weight is invalid because the predictability is only applicable to individual animals and not to an entire taxon. Gilbert and Singer (1982) said that it is difficult to attribute bone weight to muscle and tissue mass because bone is fragmented and chemically altered. There is also variation in sizes of animals which may cause differences in weight (Grayson 1982). For example, a large quantity of fish bones may weigh less than one large mammal. Should we interpret this as a larger contribution of fish or mammal to diet? Still others like James H. Barrett (1993) defend the weight method, which he says that taphonomic factors affect all quantification methods and animals of both different and the same taxa have different, but predictable proportions of bone weight to body weight. More complicated versions of weighing bone have been created by Binford (1978), such as the MUI or meat utility index, which measures decision making practices based on context and utility. This involves measuring gross weight of the specific element as well as dry bone weight and dividing these by the gross total weight of the animal.
A Case study: NISP vs. MNI of bone survival and Aka dogs

An ethnoarchaeological study by Jean Hudson (1993) indicates the variable relationship between MNI and NISP and the tendency for interpretations to be skewed if one over the other is used. Hudson has studied the influence of scavenging activity of the African Aka dogs on the survivability of bone. Her project consisted of documenting the hunting, butchering, meat redistribution, cooking, consumption, and discard during daily life, while also excavating camps that were abandoned since the Aka relocated frequently. The following results show the effects that dogs can have on the reliability of two widely used quantification methods in zooarchaeology. The calculation of MNI was shown to underrepresent abundance in each of the 16 taxonomic groups. Specifically, 48% of the original faunal record was lost, which 77 of the 149 individual animals were represented (Hudson 1993: 305). There was an underrepresentation of squirrel, which may have been due to the action of dogs on very small fauna. NISP showed a slightly different picture, where 898 identifiable fragments were produced of the original 149 (Hudson 1993:307). NISP covaried with body size, which caused the two largest taxa to be overrepresented, while small taxa were extremely underrepresented. Tortoise was overrepresented due to the highly fragmented carapace (Hudson 1993). When interpreting this data one can see that the calculation of NISP alone will allow the researcher to overestimate the abundance of larger taxa in the diet and underestimate the smaller. The archaeologist may also see turtle as a likely important factor in diet or other form of exploitation due to high counts of carapace. If MNI is calculated, we see a greater loss in the faunal record due to identification procedures and a lack of small fauna. In the same study based on another camp, it was noted that a small sample size caused these two methods to be increasingly variable when compared.

The Aka data suggest MNI and NISP still work well in ranking the significance of taxa, even though dogs do cause a large amount of damage and loss, because both quantification methods exhibited a statistically significant degree of correlation with actual numbers of individuals documented by Hudson (1993) in her ethnographic studies. Results of the study portray the significance of using more than one quantification method to improve interpretations and also that sample size is an important contributor to our final results. Larger samples and possibly an increased duration of ethnoarchaeological studies will allow an increasingly clear view of temporal variability and in turn more accurate conclusions. To further improve the accuracy of future interpretations of faunal assemblages, especially when we know small fauna will be underrepresented as demonstrated by the Aka case study, fine mesh sampling and floatation should be utilized (Hudson 1993).

Conclusion

Zooarchaeology is a broad and multidisciplinary field, which can answer extensive questions about the relationship of humans and other animals and its effects
on the environment. One of the most significant contributions is the use of animal bone to suggest human exploitation and diet, which can be done by studying living species using middle range theory or ethnoarchaeology. The methods and their biases in zooarchaeology have significant effects on one's interpretation; therefore taphonomy, recovery, identification, and quantification methods should be taken into account and standardized.

In conclusion, it is most significant to tailor one’s method choices to a specific research question as well as to the specific assemblage. As we have seen, a highly fragmented assemblage may result in variable interpretations based on method. Recovery and identification methods should also be taken into consideration based on one’s research question, especially if diet is a main concern, small mesh sizes and careful identification should be used to allow all possible fauna into the data set. It would be beneficial for archaeologists to be knowledgeable in taphonomic processes, especially the processes specific to the site or assemblage. Continued research can be done to further standardize taphonomic research, as for example in observations of live animals, such as Binford’s (1981) wolf teeth marks and Kuznar and Jeske’s (2001) dog holes.

Lastly, ethnoarchaeological studies can help to bring awareness to and potentially minimize biases by shedding light on important signatures or patterns within the archaeological record. Ethnographic information is essential for interpreting faunal material. These observations yield important data pertaining to the ways people butcher and transport carcasses, tool use, preparation and cooking practices, and how refuse is discarded (Reitz and Wing 2008). Middle range approaches are both objective and testable, allowing one to see how methods, such as NISP and MNI work under various circumstances and conditions as seen in Hudson’s (1993) study on canine interaction with bone. Ethnoarchaeology can also assist in understanding the complexities of specific animals and their habitats by looking at live populations. Zooarchaeologists can use living systems to look at mortality and age profiles, taphonomic factors, ecosystems, and meat values, which can be applied to species of the past. Continued study of taphonomic factors related to other fauna as well as canine will help to advance our knowledge base of animal and environmental interactions and improve accuracy of our interpretations. Controlled studies are also useful in providing “cautionary tales,” which help in avoiding the making of groundless assumptions (Hudson 1993).

Future research may include the usage of additional methods, such as meat utility indices. For example, the modified general utility index (MGUI), which measures food utility of various skeletal elements, can be used to answer questions about carcass transport (Binford 1978). It is important to note that ethnoarchaeology can also assist in answering social research questions. A topic of particular importance is food sharing. Food sharing along kin lines and to satisfy social obligations is mostly a
universal human trait (Reitz and Wing 2008). Since these food transfers definitely modify the distribution of faunal remains, a better grasp of the sharing signature would be increasingly helpful in improving the accuracy of interpretation. In sum, ethnoarchaeology or middle range theory can contribute significantly to the understanding of signatures and patterns in the faunal record pertaining to a wide array of both natural and social topics.

Author Biography: Rebecca Torgerson is a graduate student of Anthropology at the University of Wisconsin-Milwaukee. She is interested in zooarchaeology, foraging societies, food sharing, and museum studies. She intends to pursue a career in museums, specifically in the areas of collections and curation after graduating with her master’s degree and museum studies certificate.

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