Juggling with Indices: A Review of the Evidence and Interpretations regarding Upper Palaeolithic Horse Skeletal Part Abundance

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Introduction

Theodore White (1952, 1953) was amongst the first to realize that skeletal part frequencies might tell us much about past hunting and butchery strategies, and that presence or absence of particular elements might be related to particular economic decisions. It was Binford (1978), however, who first introduced a methodological mechanism for the study of bone transport decisions that made use of uniformitarian principles. Binford (ibid.) calculated economic indices for the value of different caribou elements and compared these indices in the form of scatter-graphs against actual bone transport, as carried out by Nunamiut hunters. Put at its simplest, he argued that low utility elements are left at kill-sites while high utility elements tend to be transported back to camp. If hunters could afford to leave many elements at the kill-site and transport only the choicest parts then this was a "gourmet" strategy. On the other hand, if hunters were in greater need of resources, they would transport more of the poorer elements, leaving just those of lowest utility. This is a "bulk" strategy (Binford 1978).

Binford's economic indices and scatter-graph method became a fairly standard method, amongst many analysts, for the study of skeletal part abundance. Of particular relevance to the subject under discussion, Boyle (1990, 1993, 1994) has used this methodology very extensively to consider element transport strategies at many French Upper Palaeolithic sites, including many important horse assemblages. However, the time is ripe for a thorough review of the whole issue of horse skeletal part frequencies and bone transport strategies. The need for this review arises from three principal areas of concern. The first is related to problems of interpretation, the second to methodological problems and the third to the use of suitable modern reference data.

With regard to interpretation, it has been noted that Upper Palaeolithic horse bone assemblages are often dominated by elements of low economic utility (Outram and Rowley-Conwy 1997; Lam, Chen and Pearson 1999). At sites like Solutré (Olsen 1989) the relative bias towards low utility elements seems sensible given the likely interpretation as a kill site. However, other sites are more problematic. For instance, the Gough's Cave assemblage (Parkin, Rowley-Conwy and Serjeantson 1986) and the La Madeleine assemblage (Boyle 1994) show a strong bias towards low utility elements, suggesting a kill-site, yet these sites are caves with good tool assemblages usually thought to be habitations (Outram and Rowley-Conwy 1997). The difficulty of interpreting horse skeletal part frequencies is further complicated by their lack of correspondence with the patterns seen in other large mammals (Lam, Chen and Pearson 1999). Two such examples would be Reignac (Boyle 1990, 1993) and La Madeleine (Boyle 1994) where the low utility horse pattern does not correspond with the reindeer pattern. It is clear that in many cases the simple application of Binford's methodology to horse assemblages results in interpretations that conflict with our understanding of the sites as inferred from the study of both other animal species and non-bone evidence. These contradictions must be explained. Are they the result of the methodology or are they caused by poorly understood taphonomy?

Moving on to methodological issues, there are a number of problems with Binford's methodology. There are difficulties relating to the economic indices, problems with the application of the scatter-graph method and errors caused by later analysts' misunderstandings of Binford's original methodology and interpretative models. It has been argued that Binford's (1978) index of economic utility, the Modified General Utility Index (MGUI) contains far too many subjective modifications and, as such, no longer really represents a genuine measure of utility based upon uniformitarian principles (Metcalfe and Jones 1988). Metcalfe and Jones (1988) created a new index, the Food Utility Index (FUI), that uses Binford's data but removes some of his subjective modifiers. The FUI was shown to be a better predictor of Nunamiut transport choices than the MGUI (ibid.), yet many analysts continue to use Binford's subjective index. Outram (2000) demonstrated the effect that some of Binford's subjective mathematical modifiers can have on indices and interpretations, particularly his marrow index. A further problem is that not only do people continue to apply Binford's old caribou and sheep MGUIs, they apply these indices to species other than caribou and sheep, including horse. This was due to a lack of suitable data, but the assumption that caribou economic anatomy is a good approximation to horse economic anatomy is not a sound one.

Outram (2001a) has also criticised the scatter-graph method itself. There is nothing inherently wrong with plotting economic utility against relative part abundance. In practice, however, it often leads to errors
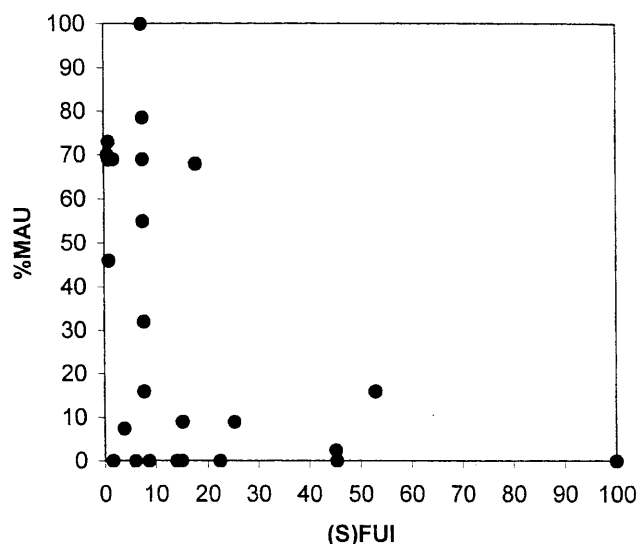
FIGURE 1. A SCATTERGRAPH (AFTER BINFORD 1978) PLOTTING THE STANDARDIZED ECONOMIC UTILITY OF HORSE ELEMENTS AGAINST ELEMENT ABUNDANCE AT GOUGH'S CAVE, SOMERSET, ENGLAND. THE HORSE FOOD UTILITY INDEX IS FROM OUTRAM AND ROWLEY-CONWY (1998, TABLE 6) AND THE GOUGH'S CAVE DATA IS FROM (PARKIN, ROWLEY-CONWY AND SERJEANSTON 1986).

FIGURE 2. DIFFERENT ELEMENT TRANSPORT MODELS (AFTER BINFORD 1978) FOR (A) TRANSPORT DESTINATIONS AND (B) KILL-SITES, WHERE UNWANTED ELEMENTS REMAIN.

of interpretation because people too readily allow their eyes to be drawn into forming dubious patterns. The scatter-graph method also makes it very difficult to study the patterns of individual elements. Take the example of Gough's Cave. If such a scatter-graph is constructed for the horse assemblage (Figure 1) one can see that there is a pattern. It looks remarkably like Binford's (1978) inverse bulk model (Figure 2, i.e. what is left at the kill site after operating a bulk transport strategy). Indeed, Gough's cave is dominated by very low utility elements but there are significant deviations from the inverse bulk curve. Many very low utility elements are actually absent. These are the points in the bottom left of the graph, which should actually be at the top left if they were to follow the model. This is a major deviation but it tends not to be noticed since one's eye is drawn to the general shape. Furthermore, if one does notice these anomalies one cannot immediately tell which elements they represent.

There are many clear examples of false patterns being seen in these scatter-graphs. A particularly obvious example is Boyle's (1990:266) interpretation of the reindeer skeletal part abundance at Reignac, which is described as a 'gourmet' curve without there being any resemblance to either a gourmet or inverse gourmet curve. Yet this interpretation has been accepted and quoted elsewhere (e.g. Lam, Chen and Pearson 1999:345) without comment. Furthermore, throughout Boyle's (1990) extensive survey of Upper Palaeolithic faunas, inverse patterns are mistaken for non-inverse patterns, despite the fact that this has serious implications for the interpretation of locations as either kill or campsites. I simply argue that whilst there may be flaws in Binford's methodology, the situation
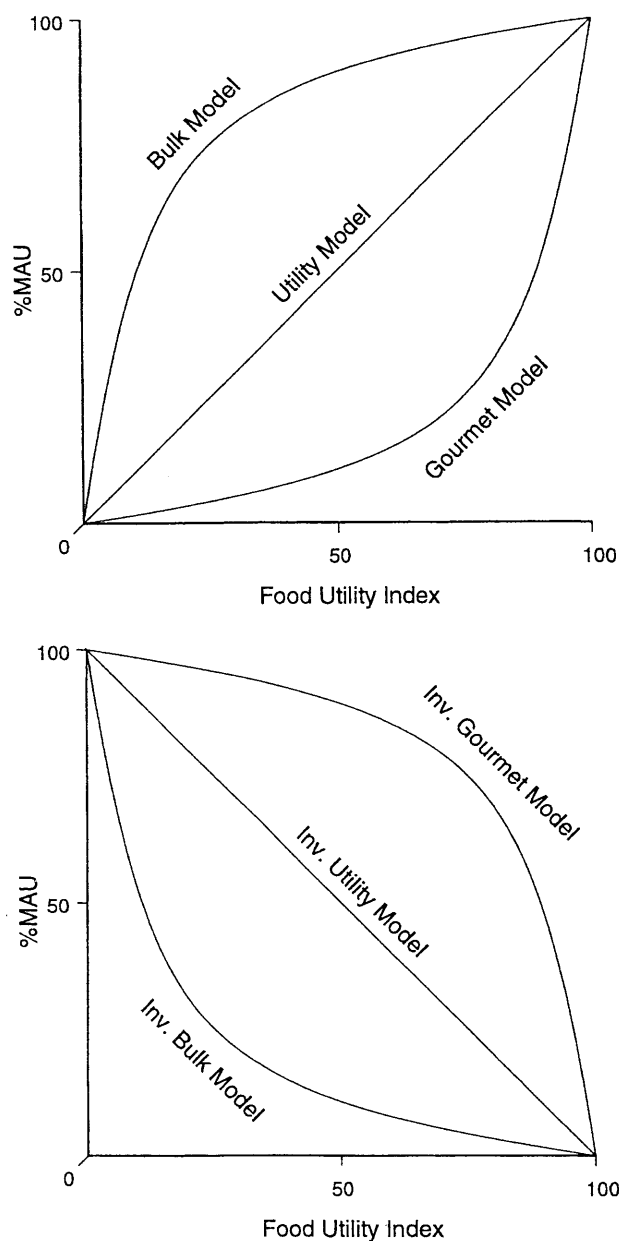
has been made rather worse by the poor application and understanding of his methods.

The final reason why a re-analysis of horse skeletal part frequencies is in order is that there is now more appropriate data. Outram and Rowley-Conwy's (1998) meat, marrow and food utility indices for horse make available more applicable data for the study of economic decisions in element transport. These indices were formulated following the simplified and more objective methods of Metcalfe and Jones (1988). Lam, Chen and Pearson (1999) have produced a set of bone mineral density indices for both horses and reindeer that will prove invaluable in evaluating taphonomic matters. Below, a number of possible causes for the unusual patterns seen in horse

skeletal part frequencies will be discussed in the light of these new data and the methodological and interpretational issues outlined above.

What Causes Low Utility Patterns in Horse Element Abundance?

Relative Food Utility of Body Parts

The basic assumption within Binford's (1978) models is that transport decisions are related to the relative food values of various anatomical units. If the distribution of food resources (meat, adipose fat and bone marrow) on horses is different from that on reindeer, then we would expect a different pattern of representation on sites. If horses had greater utility in their extremities, then the pattern would be explained. Figure 3 shows the standardized FUI values for horse as calculated by Outram and Rowley-Conwy (1997, 1998, table 6). It is clear from this that the bulk of edible tissue lies in the main body and upper limbs of the animal and not in the extremities. In fact, in comparison with caribou, horses have an even greater concentration of food utility in their upper limbs, with the distal limbs having very little utility at all (Outram and Rowley-Conwy 1998:847). This makes the archaeological pattern all the more curious.

The FUI for horse is dominated by the distribution of muscle. However, could the transport of bones be related to marrow content rather than meat? The nutritional value placed on bone fats by hunters, both past and present, is well documented (Speth and Spielmann 1983; Speth 1987; Outram 1998, 1999, 2001b). Outram and Rowley-Conwy (1998, tables 3 and 4) calculated the distribution of bone marrow in horse in terms of both marrow cavity volume and wet weight. It is clear that most of the marrow is also located in the upper limbs (ibid.). Furthermore, it was very noticeable that, in absolute terms, the horse has less marrow for its size than other large mammals. This is due to larger amounts of trabecular bone growth in the upper limbs and very thick bone walls in the lower limbs (Outram and Rowley-Conwy 1998:847). Blumenschine and Madrigal (1993) noticed the same phenomenon in zebra.

The relative distribution of marrow within the horse skeleton does not explain the archaeological patterns we see, but what will the effect of the lower absolute quantities have on transport decisions? These lower absolute values would most likely discourage transport of horse bones over marrowbones from other large mammals. However, if hunters are concentrating on horses alone, and are in need of fat, then they may consider it worth transporting the distal limbs because they need all they can get. A general lowering of resource availability makes poorer sources more attractive, as in a "diet breadth" model (MacArthur and Pianca 1966; Bettinger 1991:84). Certainly, at Trou de Chaleux, Belgium (Charles 1995) the inhabitants thought it worth splitting even horse phalanges for marrow. It is also worth considering the qualitative as well as quantitative. Horse marrow is high in polyunsaturates and essential fatty acids (Hilditch and Williams 1964) and has a lower melting point than marrow from ruminants. Fat high in
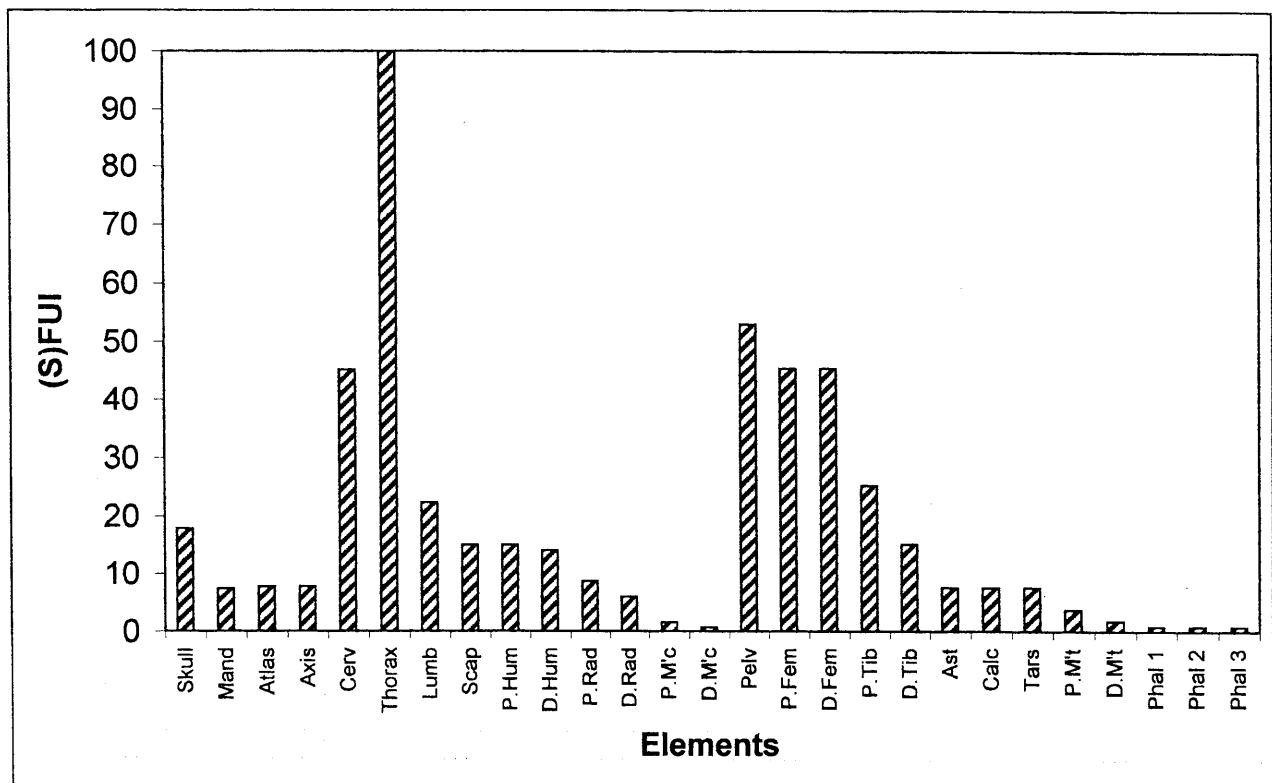

FIGURE 3. A GRAPH TO SHOW THE STANDARDIZED FOOD UTILITY OF HORSE ELEMENTS (DATA FROM OUTRAM AND ROWLEY-CONWY 1998, TABLE 6).

unsaturates is often preferred by hunter-gatherers, for example the Hadza (Levine 1998:90) and the Nunamiut (Binford 1978:24), to harder saturated fats.

Density-Mediated Attrition

It is clearly possible that the unusual pattern we see in the skeletal part abundance of horse could be an artefact of post-depositional taphonomic processes. Ever since Brain's (1967, 1969) experiments with goat bone structural density and bone survival in Hottentot villages, it has been clear that bone density is an important predictor for the survival of different elements subjected to the rigours of post-depositional taphonomic processes. Clearly, if horse bones of high utility are also of particularly low density and the extent of this is greater for horse than it is for reindeer, then we have the solution to our problem. Lam, Chen and Pearson (1999) addressed this question with their detailed study of both horse and reindeer bone mineral densities. They concluded that the bone density patterns of the two species were very similar, and that the differences seen between archaeological reindeer and horse skeletal part frequencies could not be explained in terms of density mediated attrition (ibid.:358). It is certainly true that many high utility elements do have low densities, but this applies equally to reindeer and horse.

The Effect of Quantification without Recording Shaft Fragments

It appears from the above argument that the patterns we see are unlikely to be wholly the result of post-depositional taphonomy. However, there may be other ways of checking the pattern we see. It has been pointed out (Marean and Frey 1997; Bartram and Marean 1999) that zooarchaeologists' quantification methods might be responsible for the large number of reverse utility curves we see. Bartram and Marean (1999:10) draw attention to the fact that many analysts follow the methodology presented in Klein and Cruz-Uribe (1984:17) and record only bone ends. The epiphyses are largely made of spongy bone, particularly on the upper limbs, and are easily destroyed by density-mediated attrition or carnivores. It is suggested that skeletal part frequencies would be much more accurately reconstructed from the quantification of shaft fragments (Marean and Frey 1997; Bartram and Marean 1999) which are normally ignored, because they are more difficult to identify. They go on to test their observation by comparing analyses of both ethnographically derived material and archaeological material, which have been quantified both with and without the inclusion of shaft fragments (Bartram and Marean 1999). They demonstrate that in these cases apparent reverse utility patterns disappear once the shaft material has been included.

This is an extremely important observation and, whilst not all analysts discount shaft fragments, it would seem worth carrying out some re-analysis of a number of sites to check the pattern we see. It is worth stressing again, however,

that this effect does not really explain the patterns we see, unless it can be argued that it affects horses to a greater degree than reindeer. Bartram and Marean (1999) do argue that there is a greater effect on larger animals than smaller ones, although their comparison is between very small gazelle sized and wildebeest sized animals (size class 1 versus 3 under Brain's (1981), size class system for African mammals). This is not quite the same thing as reindeer versus horse, but the issue needs to be taken very seriously. There is, however, some strong evidence that suggests that Bartram and Marean (1999) do not quite have the solution. This involves the abundance of pelves and scapulae.

Pelvis and Scapula Bone Mineral Densities

Bartram and Marean's (1999) argument hinges around the fact that the epiphyses of high utility long bones have low densities and are easily destroyed, whilst low utility, distal limb epiphyses are higher in density and survive better. They argue that upper limb bones probably are present, if only we would count the dense shafts, but crucially they only studied long bone frequencies. This is critical because the pelvis and scapula epiphysis, represent very high utility and high density. This can be seen in Figure 4, where horse bone mineral densities for various elements are plotted. The density of the pelvis acetabulum and scapula epiphysis is every bit as high as the epiphyses of distal limbs, and much higher than the density of upper limb bone ends. There is no reason why these elements should be poorly represented, within Bartram and Marean's (ibid.) argument. However, these two elements are poorly represented at a number of sites with apparent reverse utility assemblages, including Gough's Cave (Parkin, Rowley-Conwy and Serjeantson 1986), La Madeleine (Boyle 1994), Reignac and Roc de Marcamps (Boyle 1990) to name but a few. This issue will be addressed with regard to specific case studies further on. The scapula and pelvis representations, then, are a strong indicator that the pattern we see is not entirely the result of post-depositional taphonomy or systematic distortions of quantification. The pattern still requires an archaeological explanation.

Bone Grease Rendering

The importance of bone marrow has already been referred to above, but one can also extract bone grease from spongy bone via its comminution and rendering. The patterns created by such processing have recently been discussed in some detail by Outram (1998, 1999, 2001b, 2002). Brink (1997) found that the amount of bone grease in bones, (of bison in this case), could be accurately predicted by bone volume and density. The high-volume, low-density upper limb bone epiphyses contain the most grease. If these elements were destroyed in the process of rendering, then a reverse utility pattern would emerge once again. This possible solution suffers from the same problems as the above arguments about post-depositional taphonomy and
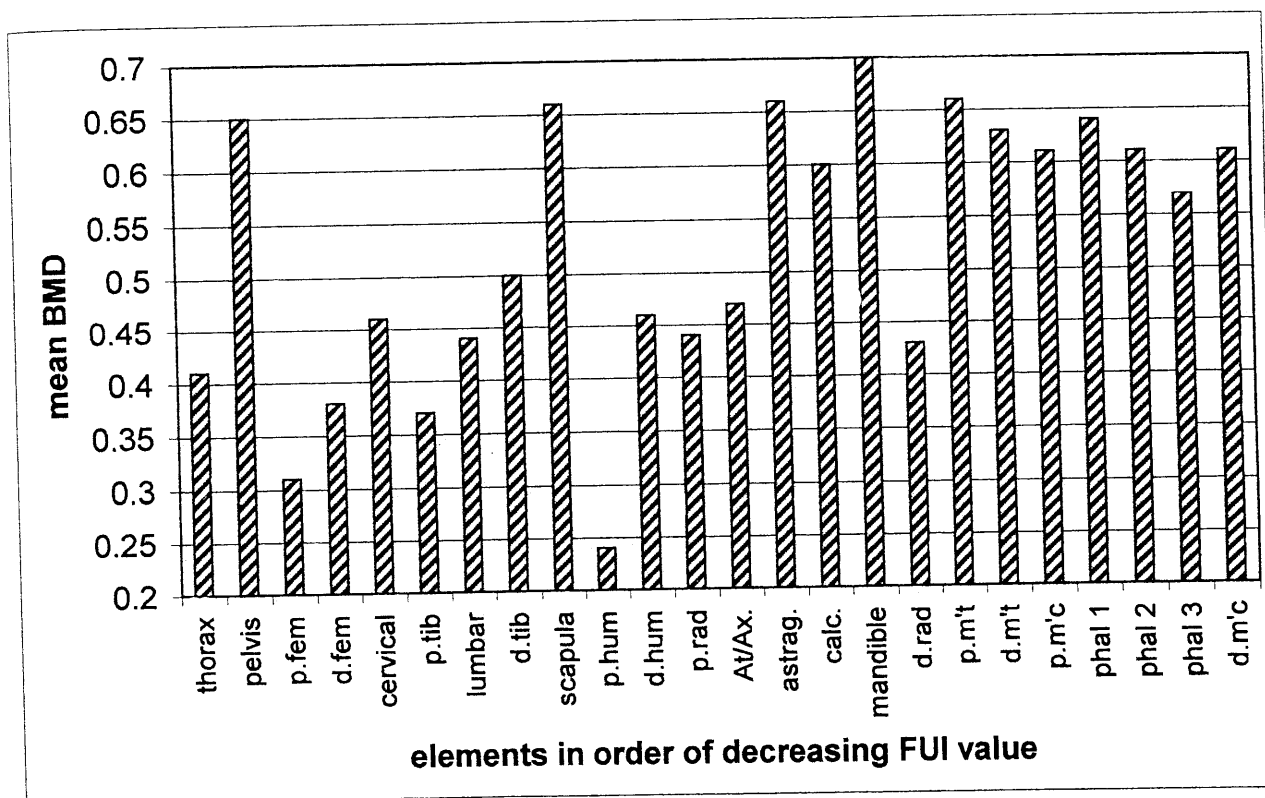
FIGURE 4. A GRAPH TO SHOW THE AVERAGE BONE MINERAL DENSITY OF HORSE ELEMENTS (DENSITY DATA DERIVED FROM LAM, CHEN AND PEARSON 1999, TABLE 1). THE MEAN BMD WAS CALCULATED FROM ALL SCAN SITES ON AXIAL BONES AND FROM THE ARTICULATIONS OF THE PELVIS, SCAPULA AND LONG BONES. ELEMENTS ARE ARRANGED IN DECREASING ORDER OF FOOD UTILITY ALONG THE X-AXIS (FOLLOWING OUTRAM AND ROWLEY-CONWY 1998).

quantification. There is no apparent reason why the pattern should apply only to horse and not to reindeer as well. It is vaguely possible that there could have been a qualitative decision to render horse bones more extensively for fat than reindeer bones. It is also possible that the hunting seasons for the two species were different and the relative need for fat in the different seasons was not the same. This is pure speculation. Furthermore, this still does not explain the absence of scapulae, which do not represent a good source of grease.

Raw Materials for Craft Activities

The use of bone as a raw material in tool manufacture could have several different effects upon skeletal part abundance. Some bones may be destroyed as a result of being processed during craft activities. Some bones may be preferentially selected and brought to the site because of their craft value rather than food value. Some bones may be turned into tools, become classed as artifacts and subsequently not be counted as part of the faunal assemblage (Olsen, personal communication). Lyman (1994:348) shows how element frequencies can be seriously affected by the addition of previously uncounted bone tools.

It seems unlikely that the general absence of horse upper-limb bone epiphyses can be explained in terms of craft activities. Such spongy bone is likely to serve little craft use. However, the presence of horse metapodia could

be related to tool manufacture. These are a good source of dense diaphysis bone suitable for many purposes. It is also true that one might well select horse metapodia for tool manufacture in preference to the metapodia of other animals. Outram and Rowley-Conwy (1998, fig. 8) compare the wall thickness of horse and cattle metatarsals in section and it is clear that the horse represents a much better source of strong, dense bone. It is worth noting that, in the author's experience, reindeer metapodials are even thinner than those of cattle. So, there is perhaps a reason why hunters would consider it worth transporting the distal limbs of horses in preference to those of reindeer. It is clear that the whole issue of bone crafts and tools needs to be more integrated into economic studies of faunal assemblages (Olsen, personal communication). The use of bone in crafts may well represent part of the explanation for the pattern we see.

The Absolute Weight of Parts

Binford's (1978) method for looking at bone transport strategies is based upon the relative value of various anatomical units. The basic assumption is that the whole carcass represents a transportation problem and therefore the carcass must be divided up. Elements of greater economic utility will be transported over those of less utility. This works well for the caribou being transported by the Nunamiut that Binford studied. What happens, however, if the individual anatomical unit itself represents
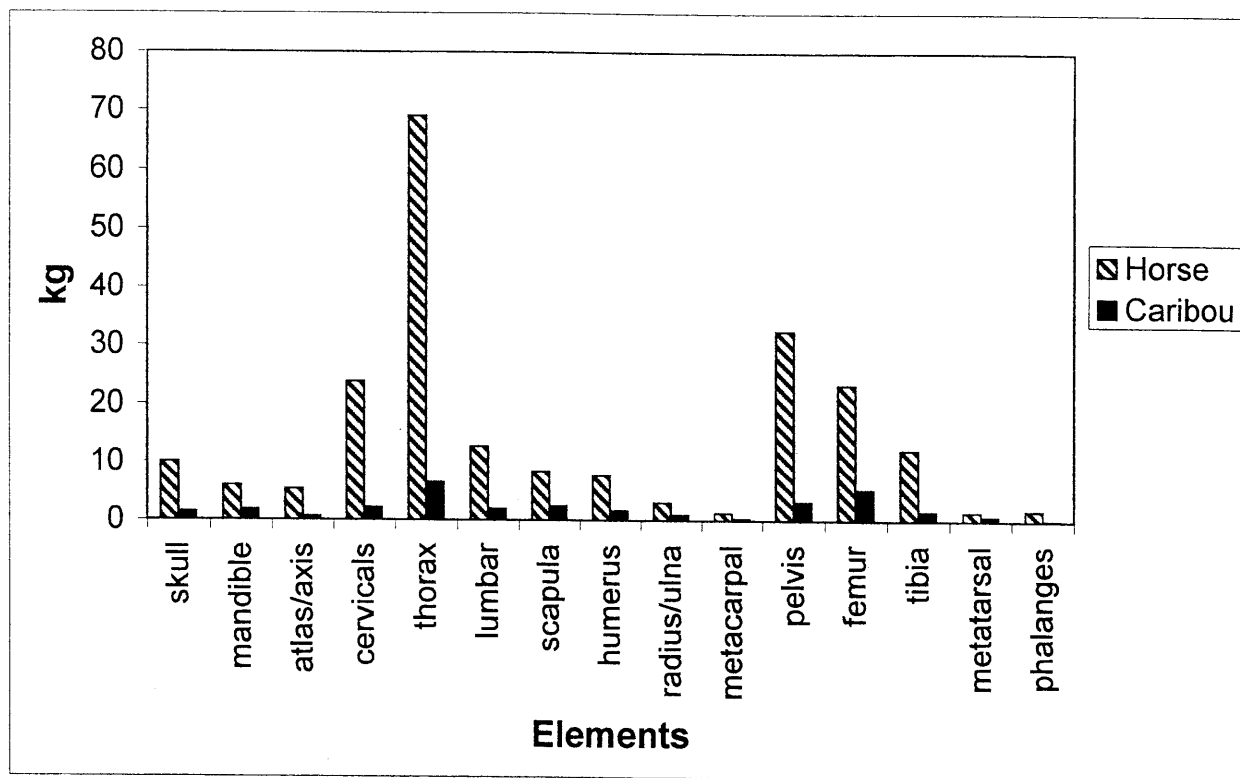
FIGURE 5. A COMPARISON OF ABSOLUTE AVERAGE WEIGHT OF ELEMENTS OF HORSE (DATA FROM OUTRAM AND ROWLEY-CONWY 1998, TABLE 1) AND CARIBOU (DATA FROM BINFORD 1978, TABLE 1.1).

a transport problem? Figure 5 compares the absolute weight of the various parts of caribou (Binford 1978, table 1.1) and horse (Outram and Rowley-Conwy 1998, table 1). It can be seen that horse elements weigh vastly more than caribou elements. The roll of meat (without bone) from the femur of one of the horses studied weighed 28.75 kg (ibid.), and the author had distinct difficulty lifting it up.

It seems highly likely that the models for transport devised by Binford (1978) will not hold true for animals large enough to have elements that present transport problems in themselves. In such cases it is no longer safe to assume that the whole element will be transported as a joint, meat and bone together. In dealing with heavy units like the horse thigh, hunters may well have separated meat from bone to create more manageable packages. The decision to transport the bone or not then becomes an entirely separate issue that is dependent upon the bone's value for food or craft uses. The implications of this are very clear. It could, for instance, be argued that, in the case of the upper limb bones of horse, it is easier to transport the meat separately from the bone. Horse bones have small marrow cavities and the upper limb bones may not have been useful for crafts and, as such, may not have been transported to the camp. Distal limb bones carry little meat, but are much lighter, are a good craft resource (both in terms of bone and useful sinews) and have a certain amount of marrow fat content. They may have been worth carrying. The above scenario is just a tentative suggestion, but it makes the point.

Case Studies

Below, the assemblages from Gough's Cave (Parkin, Rowley-Conwy and Serjeantson 1986), La Madeleine (Boyle 1994) and Reignac (Boyle 1990) are discussed bearing in mind all the above discussion. The skeletal part frequencies and food utility of elements have been displayed graphically, but not as Binfordian scattergraphs. Elements are arranged along the x-axis in decreasing order of food utility. The y-axis represents standardized element abundance (%MAU) and standardized food utility, (s) FUI. Both the element abundance and food utility are standardized to a maximum of 100 to allow plotting on the same y-axis. The solid line represents the (s) FUI as it declines from left to right. If bone transport to a base camp followed utility then element abundance should follow this pattern. The dotted line represents the mirror image of food utility (Inv. FUI), which models what one would expect to be left at a kill-site under the same circumstances. The abundance values for the different elements are represented by symbols (circles or triangles). Circles represent elements with bone mineral densities (BMDs) that fall below the average for those elements represented. Triangles represent elements with above average BMDs. This was derived by calculating average BMD's for each element, from the various scan sites (through epiphyses) used by Lam, Chen and Pearson (1999), and then calculating an average for the whole set of elements studied. These graphs therefore allow one to see the individual representation of each element clearly,

their relationship to food utility and reverse utility and bone mineral density.

Gough's Cave

Let us first consider the Gough's Cave assemblage for horse (Figure 6). It is clear that the pattern does not adhere closely to either food utility or reverse utility. It is also clear that all the well-represented elements are of low utility and high density. Is this human induced or taphonomic? It is interesting to note that both the proximal metacarpal and metatarsal are very poorly represented, despite being both low utility and high density. This is the sort of anomaly that is often missed when simple scatter-graphs are used. There does not seem to be an easy taphonomic explanation for this. Even more interesting, are the pelvis and scapula frequencies. Despite being high-density elements, they are still poorly represented. This brings into play all of the above discussion. This pattern cannot be explained in simple terms of post-depositional taphonomy or quantification methods. One must concentrate on explaining the comparative absence of the pelvis, scapula and proximal metapodia in terms of human activity. Using this method of display makes it much easier to spot such important anomalies, whilst still being able to see the overall pattern at a glance.

La Madeleine VI

Figure 7 shows a similar plot for the horse component of La Madeleine layer VI (Boyle 1994). This can be compared against a similar diagram for the reindeer component (Figure 8), constructed using data pertinent to reindeer. The horse assemblage is very similar to the one from Gough's Cave. Low utility elements are again well represented, but once again the proximal metapodia are not. Once more, the pelvis and scapula, despite their densities, are poorly represented. Other low density, upper limb elements are actually marginally well represented. Of particular interest is the high representation of the distal radius. This is a low utility bone with low density yet it is very well represented. This is yet another strong indicator that the pattern is not entirely dictated by post-depositional taphonomy.

The reindeer pattern (Figure 8) is very different. It does not appear to follow utility or inverse utility very well, but it is certainly not dominated by low utility elements. The scapula is reasonably well represented, as is the low density, distal tibia. Many high density, low utility elements are poorly represented. The reindeer pattern is a mixed one, which could well have resulted from a combination of the effects of differential transport and later taphonomy.
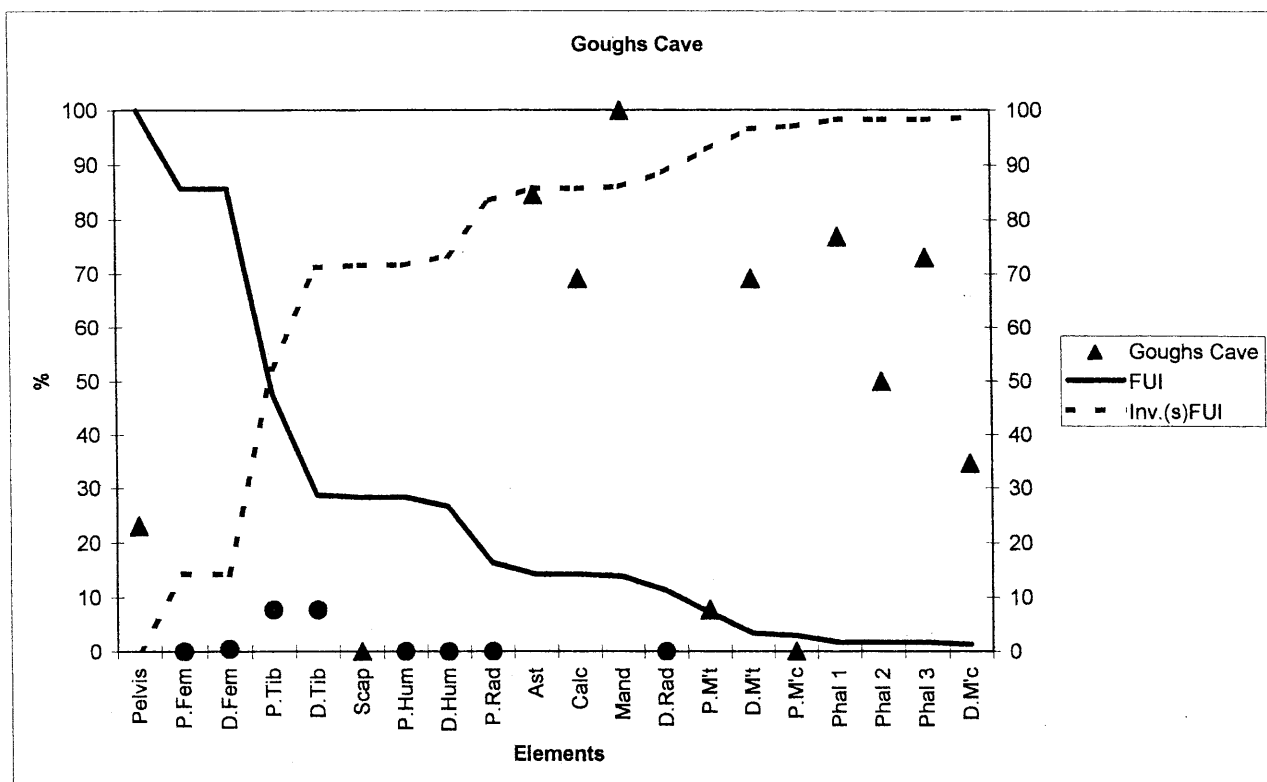

FIGURE 6. A GRAPH COMPARING THE STANDARDIZED HORSE ELEMENT ABUNDANCE AT GOUGH'S CAVE (DATA DERIVED FROM PARKIN, ROWLEY-CONWY AND SERJEANSTON 1986) WITH HORSE (S)FUI (DATA FROM OUTRAM AND ROWLEY-CONWY 1998, TABLE 6) AND INVERSE (S)FUI (AFTER OUTRAM 2001A). ELEMENTS ARE ARRANGED IN DECREASING ORDER OF FUI VALUE ON THE X-AXIS. THE FREQUENCIES OF ELEMENTS WITH MEAN BMDs (FIGURE 4, DATA DERIVED FROM LAM, CHEN AND PEARSON 1999, TABLE 1) THAT ARE ABOVE THE AVERAGE FOR THE ELEMENTS CONSIDERED ARE REPRESENTED BY TRIANGLES. THOSE WITH BELOW AVERAGE BMDs ARE REPRESENTED BY CIRCLES.
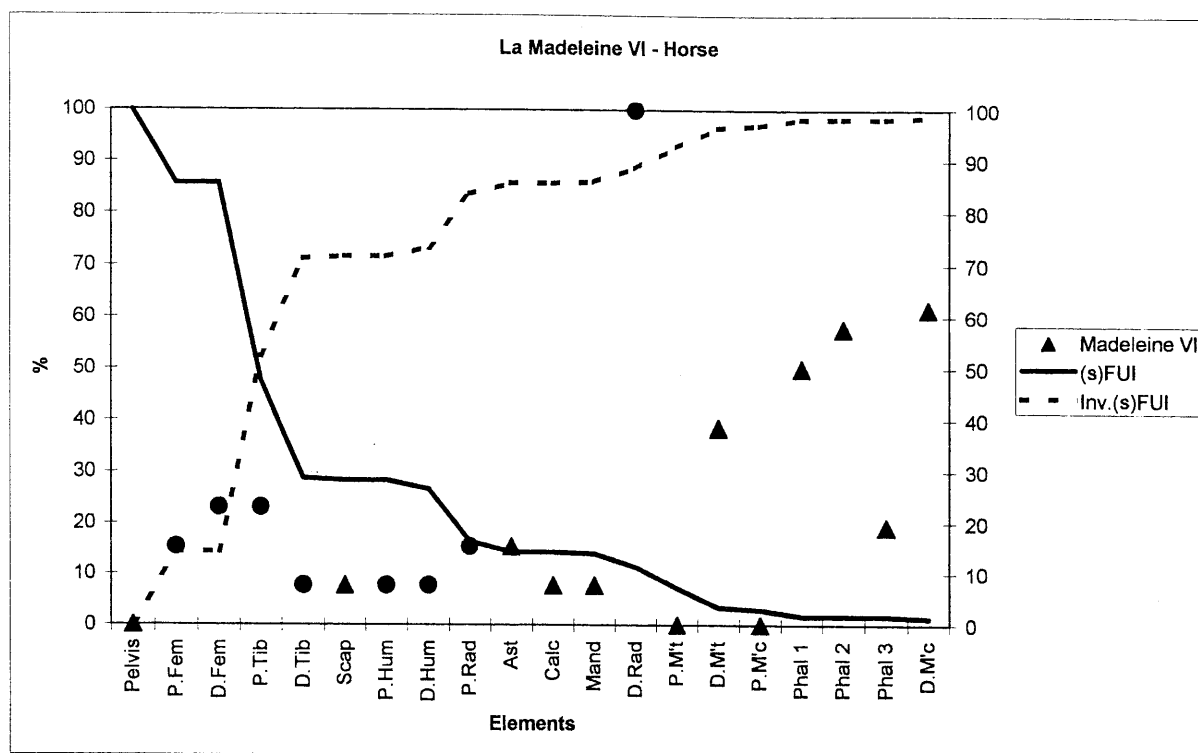
FIGURE 7. A GRAPH COMPARING THE STANDARDIZED HORSE ELEMENT ABUNDANCE AT LA MADELEINE VI, FRANCE (DATA DERIVED FROM BOYLE 1994, TABLE 6) WITH HORSE (S)FUI (DATA FROM OUTRAM AND ROWLEY-CONWY 1998, TABLE 6) AND INVERSE (S)FUI (AFTER OUTRAM 2001A). ELEMENTS ARE ARRANGED IN DECREASING ORDER OF FUI VALUE ON THE X-AXIS. THE FREQUENCIES OF ELEMENTS WITH MEAN BMDS (FIGURE 4, DATA DERIVED FROM LAM, CHEN AND PEARSON 1999, TABLE 1) THAT ARE ABOVE THE AVERAGE FOR THE ELEMENTS CONSIDERED ARE REPRESENTED BY TRIANGLES. THOSE WITH BELOW AVERAGE BMDS ARE REPRESENTED BY CIRCLES.
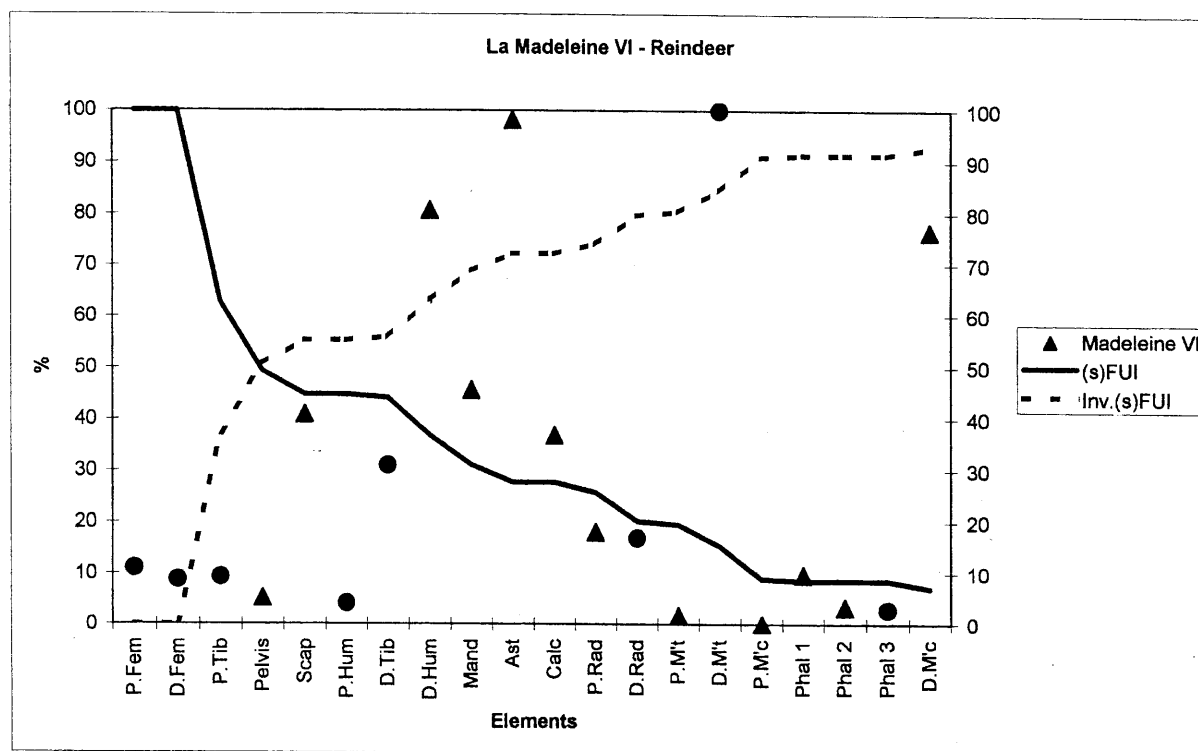

FIGURE 8. A GRAPH COMPARING THE STANDARDIZED REINDEER ELEMENT ABUNDANCE AT LA MADELEINE VI, FRANCE (DATA DERIVED FROM BOYLE 1994, TABLE 6) WITH CARIBOU (S)FUI (DATA FROM METCALFE AND JONES 1988, TABLE 2) AND INVERSE (S)FUI (AFTER 2001A). ELEMENTS ARE ARRANGED IN DECREASING ORDER OF FUI VALUE ON THE X-AXIS. THE FREQUENCIES OF ELEMENTS WITH MEAN BMDS (FIGURE 4, DATA DERIVED FROM LAM, CHEN AND PEARSON 1999, TABLE 1) THAT ARE ABOVE THE AVERAGE FOR THE ELEMENTS CONSIDERED ARE REPRESENTED BY TRIANGLES. THOSE WITH BELOW AVERAGE BMDS ARE REPRESENTED BY CIRCLES.
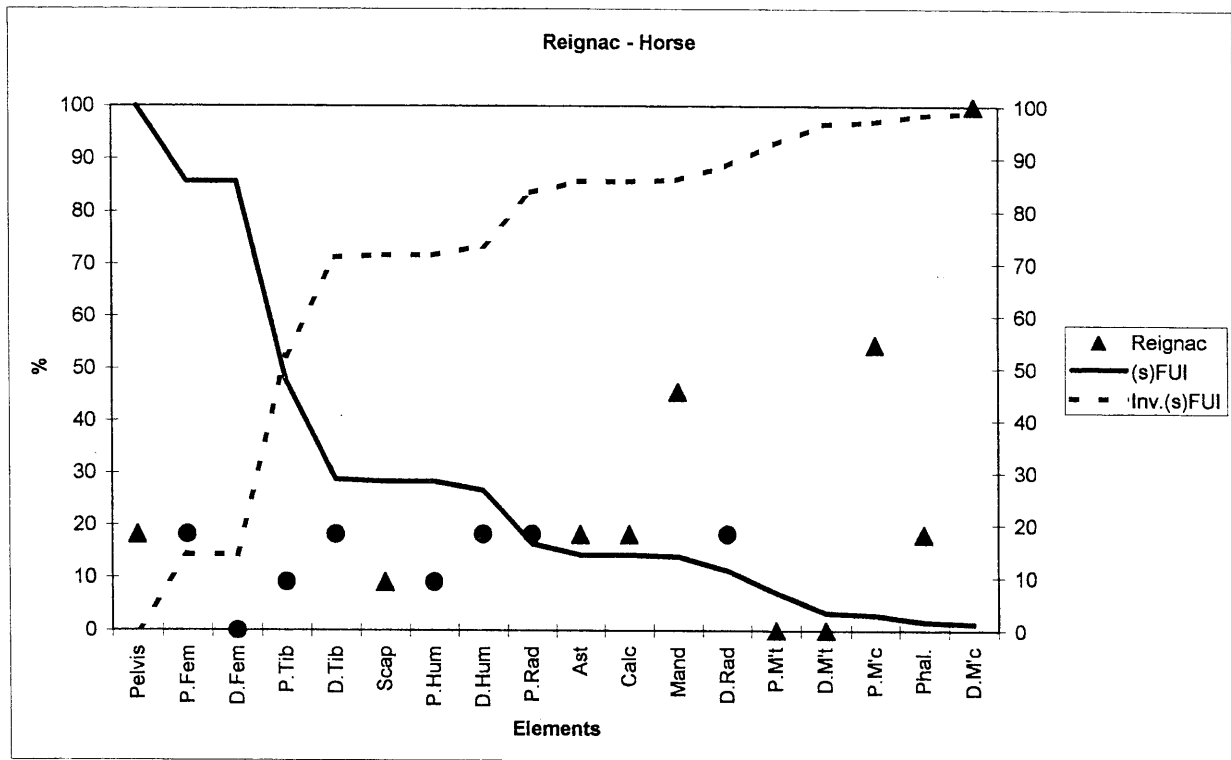
FIGURE 9. A GRAPH COMPARING THE STANDARDIZED HORSE ELEMENT ABUNDANCE AT REIGNAC, FRANCE (DATA DERIVED FROM BOYLE 1990:339) WITH HORSE (S)FUI (DATA FROM OUTRAM AND ROWLEY-CONWY 1998, TABLE 6) AND INVERSE (S)FUI (AFTER OUTRAM 2001A). ELEMENTS ARE ARRANGED IN DECREASING ORDER OF FUI VALUE ON THE X-AXIS. THE FREQUENCIES OF ELEMENTS WITH MEAN BMDS (FIGURE 4, DATA DERIVED FROM LAM, CHEN AND PEARSON 1999, TABLE 1) THAT ARE ABOVE THE AVERAGE FOR THE ELEMENTS CONSIDERED ARE REPRESENTED BY TRIANGLES. THOSE WITH BELOW AVERAGE BMDS ARE REPRESENTED BY CIRCLES.

Reignac

The Reignac horse graph (Figure 9, data from Boyle 1990) once again broadly corresponds with those from Gough's Cave and La Madeleine. In this case, very few elements are well represented, but they are all high density and low utility. The scapula and pelvis are, once again, poorly represented. The interesting feature of this graph is the absence of metatarsals. Like La Madeleine, the Reignac reindeer graph (Figure 10) shows a very great mixture. In this case, there appears to be very little correlation between abundance and utility or abundance and density.

It is hoped that these examples show that there is a genuine pattern emerging in the horse skeletal part frequencies of a number of Upper Palaeolithic sites. The author has also plotted other layers of La Madeleine and also the horse and reindeer patterns of Roc de Marcamps (Boyle 1990) and found very similar patterns. These other examples are not included here for reasons of brevity.

Conclusions

The horse skeletal part abundance at a substantial number of Upper Palaeolithic sites is apparently anomalous. It disagrees with the representation of other species and suggests, according to conventional wisdom, kill-

sites rather than occupation sites. This is against the other evidence that is available. This pattern cannot be explained in simple terms of differential taphonomy. Bone density data just do not support this. Nor can the pattern be explained in terms of a combination of method of quantification and the post-depositional taphonomy of different-sized animals. The representation of pelves and scapulae is strong evidence against this.

The author would argue that the patterning we see is most closely related to the absolute weight of elements and the individual value of horse bones. It is argued that the normal assumptions about body part transport cannot be applied to animals as large as horses. Meat may well be separated from bones prior to transportation. Decisions relating to the transport of individual bones are then made on the basis of judgements about their individual weight, food value, in terms of marrow and grease (both qualitative and quantitative), and craft value, in terms of both bone and sinew. The resultant groups of bones are then modified through butchery, food processing and later post-depositional attrition to leave us with the assemblages we see.

This issue is a very complex one and there are many indices to juggle with. Below are some suggestions relating to future work in this field:
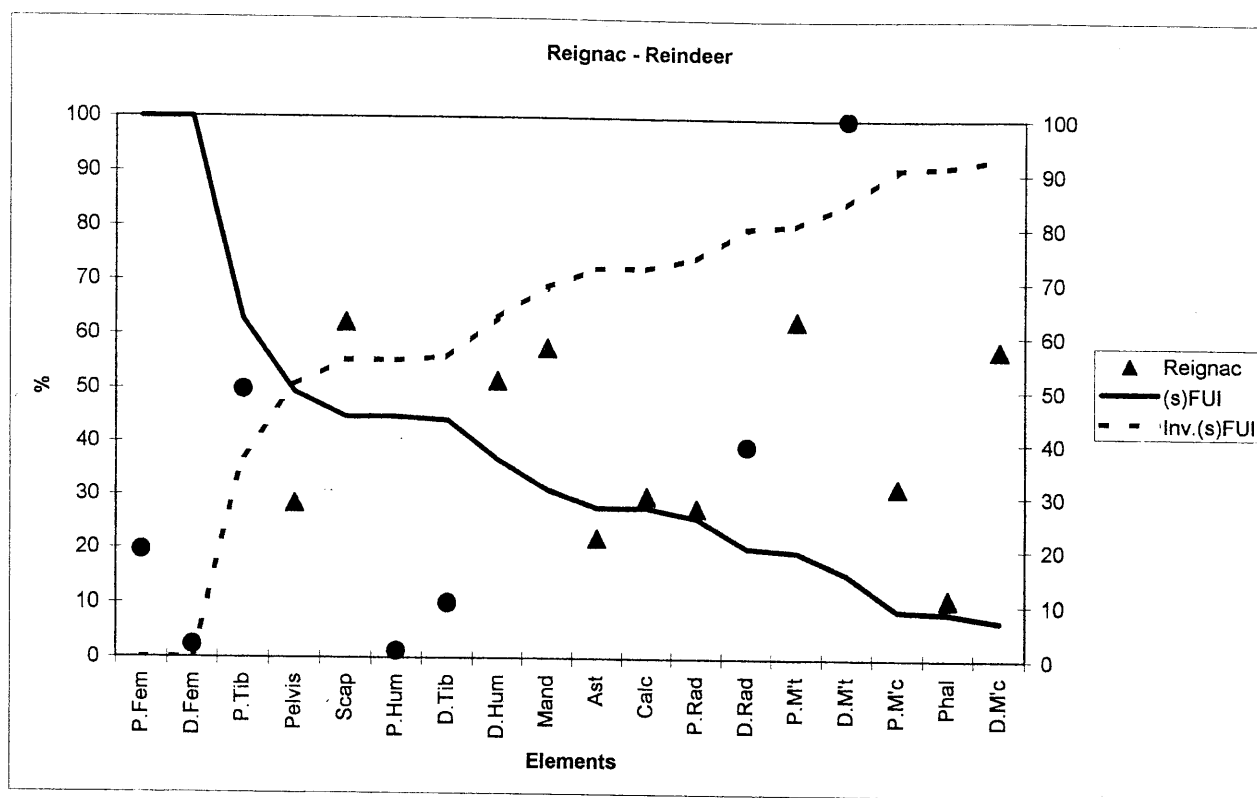
FIGURE 10. A GRAPH COMPARING THE STANDARDIZED REINDEER ELEMENT ABUNDANCE AT REIGNAC, FRANCE (DATA DERIVED FROM BOYLE 1990:339) WITH CARIBOU (S)FUI (DATA FROM METCALFE AND JONES 1988, TABLE 2) AND INVERSE (S)FUI (AFTER OUTRAM 2001A). ELEMENTS ARE ARRANGED IN DECREASING ORDER OF FUI VALUE ON THE X-AXIS. THE FREQUENCIES OF ELEMENTS WITH MEAN BMDS (FIGURE 4, DATA DERIVED FROM LAM, CHEN AND PEARSON 1999, TABLE 1) THAT ARE ABOVE THE AVERAGE FOR THE ELEMENTS CONSIDERED ARE REPRESENTED BY TRIANGLES. THOSE WITH BELOW AVERAGE MEAN BMDS ARE REPRESENTED BY CIRCLES.

1. Simple scatter-graphs plotting abundance against utility should not be used, as important features of the assemblage are often missed. Future methods should make it clear what the individual representation of elements is. The method presented here allows this at the same time as allowing comparison with utility and density.
2. Marean and Frey's (1997) point about the quantification of shafts is a very valid one and it would be wise to follow their recommendations in future analyses (or even re-analyses).
3. When applying indices the appropriate data for the species in question should be applied wherever possible. If it is not possible, then resultant interpretations must be treated with caution.
4. Account should be taken of absolute quantities, not just relative measures, when addressing transport questions.
5. Bone tools should be quantified as part of the faunal assemblage, and not removed from it as artifacts, as often occurs.

The author is of the belief that skeletal part frequencies on Upper Palaeolithic sites are meaningful and indicative of human activities. The satisfactory interpretation of these assemblages will, however, depend upon high standards of analysis, the application of appropriate data and the use of better methods of data display. Most of all, it will require the analyst to be very dextrous in the handling of a plethora of interwoven and interdependent processes and data sets.

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