Journal of Human Evolution 73 (2014) 1–14

Contents lists available at ScienceDirect

Journal of Human Evolution

journal homepage: www.elsevier.com/locate/jhevol

A model of hunter-gatherer skeletal element transport: The effect of prey body size, carriers, and distance

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ARTICLE INFO

Article history:
Received 18 August 2010
Accepted 13 June 2014
Available online 21 July 2014

Keywords:
Skeletal element profile
Optimal foraging theory
High-survival elements
Shannon evenness index
Utility strategies
Skeletal transport models

ABSTRACT

Zooarchaeologists frequently use the relative abundance of skeletal elements in faunal assemblages in conjunction with foraging theory models to infer subsistence decisions made by prehistoric hunter-gatherers. However, foraging models applied to ethnoarchaeological cases have had variable success linking skeletal transport decisions with foraging predictions. Here, we approach this issue with the well-known Hadza data to statistically model the skeletal element transport decisions in response to distance from the residential hub and the number of carriers available for carcass transport. We compare our modeling approach to the traditional skeletal element utility curves from Binford's work with the Nunamiut, and to the more recently proposed Shannon evenness measure. Our approach, based on standard yet powerful statistical modeling techniques, can help researchers gain increased insight into the prey part transport responses of hunter-gatherers. Our analyses treat individual prey skeletal elements by body size as the response variable. The results of this analysis suggest that utility curves, and the Shannon evenness approach as a proxy for utility curves, are problematic for making statements about prehistoric foraging from zooarchaeological data. Transport distance does not explain a significant portion of small prey (size class 2) skeletal element transport variation. However, distance explains a great deal of transport variation in large prey (size classes 4 and 5). Inferences from skeletal element profiles should be made relative to prey body size and the discard probability of individual elements. Understanding the influence of these variables allows construction of a framework for testing archaeological element profiles against ethnographically derived transport models.

Introduction

Hunters often do not transport all nutrients encapsulated in carcasses from kill areas to camp. Instead, chosen anatomical parts are removed and returned for consumption while others are discarded. This seemingly simple fact has significant implications for inferences regarding the evolution of human foraging behavior. Understanding tradeoffs involved in prey acquisition and the subsequent transport decisions made by hunter-gatherers are fundamental goals of ethnoarchaeology and human behavioral ecology. Pioneering research by White (1952, 1953, 1954, 1955), Perkins and Daly (1968), and Binford (1978, 1981), helped to contextualize prey-part patterning observed archaeologically within frameworks of hunter-gatherer butchery and transport practices. Using the relative abundance of skeletal parts in prehistoric faunal assemblages and nutritional rankings, these early examples attempted to link patterns of bones transported to camps and those left at kills to the cultural and economic context within which prehistoric hunters once operated.

Transport inferences derived from zooarchaeological patterning have played a prominent role in discussions of the evolution of hominin subsistence. Several high-profile examples include understanding the proportion of hominin hunting versus scavenging during the Plio-Pleistocene (Potts et al., 1983; Binford, 1984; Bunn, 1986; Blumenschine, 1991; Monahan, 1996), discerning the contribution of scavenging to Neandertal diets and the effectiveness of Neandertals as hunters (Stiner, 1994, 1998; Marean and Kim, 1998; Speth and Tchernov, 1998), the signature of human versus carnivore faunal accumulation (Grayson, 1989; Marean and Frey, 1997), the importance of meat in hominid evolution (Isaac and Crader, 1981; Parkington, 1981; Klein, 1999), the development of urban complexity and subsistence specialization (Zeder, 1988), and

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http://dx.doi.org/10.1016/j.jhevol.2014.06.004
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testing hypotheses of resource over-exploitation and societal collapses (Emery, 1997; Grayson, 2001). Correctly inferring the behavioral processes and mechanisms responsible for the observed skeletal element patterning from prehistoric assemblages is thus no trivial matter to studies of human evolution.

The most widely used inferential framework of prey-part transport is Binford's (1978, 1981) family of curves linking skeletal element abundance with their nutritive concentration (Grayson, 1988; Klein, 1989; Stiner, 1994; Mellars, 1996; Marean and Frey, 1997). Binford suggested skeletal abundance patterning should respond as a function of returned skeletal part nutritive rank, which he termed ‘utility’. Based on observational and experimental data, Binford proposed several anatomical-part utility transport strategies. Using these strategies, butchers were thought to forage for nutrients throughout the body of a prey item, returning the associated anatomical parts to camp (Binford, 1978). The patterning of skeletal element abundances and their respective utility values are known as utility curves, and these have become a standard analytical tool to infer prehistoric hunting and transport practices. Applications of Binford's models to ethnographic data on hunting other than the Nunamiut have had limited success. Inconsistencies between the models' expectations and ethnographic evidence have led researchers to identify transport as contingency-based, and question whether utility curves as transport strategies accurately capture the real-life mechanisms underlying prey-transport decisions (Chase, 1985; Bunn et al., 1988; O'Connell et al., 1988, 1990; Bartram, 1993; Bunn, 1993).

This study explores the effectiveness of Binford's transport curves in explaining hunter-gatherer foraging behavior. A set of skeletal transport models (STMs) are proposed as a method to derive theoretical expectations of skeletal element transport frequency. The proposed models also serve to quantify and compare variation in transport response to variables underlying optimal foraging Theory (OFT). Specifically, variation in handling and transport costs due to transport distance and carriers are identified as significantly explaining the probability of skeletal element transport. Skeletal transport models account for the costs involved in prey and prey part procurement, a key shortcoming of skeletal element utility ranking (MacArthur and Pianka, 1966; Lupo, 2006). Skeletal transport models reflect the mechanisms underlying prey part transport probabilities, and bypass many of the problems of inferring hunting behavior from archaeological expectations that do not account for handling and transport costs.

Background

Nunamiut utility curves

To create linkages between foraging behavior and faunal material that could be used to understand prehistoric foraging decisions, Binford (1978) observed several freshly deposited Nunamiut hunting camps between 1969 and 1972 in northern Alaska. The observed element patterns were argued to reflect the amount of utility (i.e., meat, marrow, and grease) in an element relative to its weight using a food utility index. Binford then proposed three hypothetical transport strategies to reflect the relative frequency of skeletal elements as a function of element utility. He named these: bulk, gourmet, and unbiased transport strategies, identifiable by the resulting shape of a curve drawn through the data points (Fig. 1). The bulk strategy, according to Binford, reflects the maximization of nutrient quantity returned to camp. Thus, anatomical parts of low value would not be transported from the kill area. This strategy, Binford argued, should be practiced when demand for meat is high and hunters attempt to return as much mass as possible to camp. In contrast, the gourmet strategy was thought to maximize the quality of the return by exclusively transporting high utility parts. According to Binford (1978), the gourmet strategy would occur when meat abundance is high; there is little benefit in processing low utility parts, and there is little demand for additional meat. Alternatively, the unbiased strategy occurs when elements are transported in direct proportion to their food utility, which according to Binford should be the normative hunter-gatherer pattern of element transport. The inverse of these, or reverse utility curves, where the lowest utility parts are the most frequently represented, were suggested to result from two possibilities: 1) the residual element profile after high utility parts were transported (such as at a kill site), or 2) from scavenging carcasses already devoid of high utility elements. A sigmoidal curve may suggest a mixed bulk/gourmet strategy. To this list, Faith and Gordon (2007) added the unconstrained pattern where every element is returned regardless of utility. The archaeological expectations of utility curves are straightforward. However, it is less clear how generalizable utility curves are to foraging behavior outside of situational contingent instances, and they are complicated by issues of taphonomic preservation.

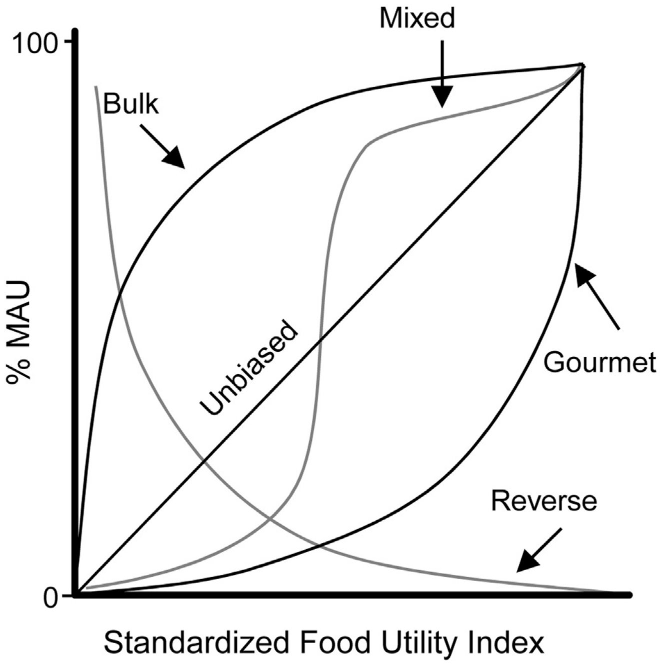

Figure 1. Skeletal element transport strategies described in Binford (1978) (illustration adapted from Marean and Frey, 1997). The Standardized Food Utility index on the x-axis describes the relative amount of usable food weight in a prey body part (Binford, 1978; Metcalfe and Jones, 1988). The Minimum Number of Animal Units (or %MAU) reflects the relative abundance of skeletal parts in an assemblage (Binford, 1984).

Utility curves: considering the costs and shifts in rank

Several factors may limit the value of applying utility models to modern hunter-gatherer information. For example, although Binford developed these hypothetical models based on patterns he witnessed in the Arctic, predictions from these strategies might not be generalizable to hunter-gatherers outside of Arctic conditions. Binford himself was aware of this potential problem (1978). Moreover, insufficient consideration of the taphonomic history of hunter-gatherer faunal return data may also obfuscate the actual net returns of Nunamiut faunal transport (Marean and Cleghorn, 2003). Additionally, as Chase (1985) identified, Binford's proposed utility curves primarily consider the energetic gains of the prey-transport tradeoff process without accounting for costs (Metcalfe