Journal of Archaeological Science: Reports 5 (2016) 499–508

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

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

Sampling to redundancy in an applied zooarchaeology: A case study from a freshwater shell ring in the Mississippi Delta, southeastern USA

Joseph Mitchell [a,*], Evan Peacock [b], Shon Myatt [c]

[a] Department of Geosciences, Mississippi State University, Starkville, MS 39762, United States
[b] Department of Anthropology & Middle Eastern Cultures, Mississippi State University, Starkville, MS, 39762, United States
[c] Babel Street Inc., Starkville, MS, 39762, United States

ARTICLE INFO

Article history:
Received 5 August 2015
Received in revised form 18 December 2015
Accepted 31 December 2015
Available online 15 January 2016

Keywords:
Applied zooarchaeology
Sampling to redundancy
Species–Area Curves
Representativeness
Freshwater mussel shell
Differential preservation

ABSTRACT

Different archeological research goals necessitate different target and measured variables. In applied zooarchaeology, the target can be 1) a full list of taxa present at a site, to allow for biogeographical mapping; 2) species proportions representing those present in site deposits, which in some situations can be argued to represent past faunal communities, one possible target state for habitat reconstruction; or 3) both. For any of these goals, understanding the effects of sampling and differential preservation is key. We investigate the effects of repeated random sampling of a surface assemblage of freshwater mussel shells acquired from a prehistoric site in Sunflower County, Mississippi, southeastern USA. Evaluation of Species Area Curves shows that redundancy in taxonomic presence is reached at an average of ca. 8200 shells, but that meaningful values for diversity measures can be obtained with smaller samples. Comparison with sub-plow zone materials shows that denser, more robust species are over-represented, and thin, rod-shaped species under-represented, in the surface assemblage, while interpretation of the excavated materials is hampered by insufficient spatial sampling. Regardless of such issues, both data sets have value depending on the target variables of interest.

1. Introduction

Understanding how various sampling strategies can influence representativeness, i.e., the similarity between a sample and the community from which it is drawn (Cao et al., 2002), within a collection is a perennial problem for archeologists (Binford, 1964; Nance, 1981; Redman, 1974; Rootenberg, 1964; Vescelius, 1960), and one which requires constant awareness given the diverse contexts, artifacts, and subsequent research questions we face. Identifying how much of an assemblage is 'enough' for a representative sample is a primary concern (Cowgill, 1964), and although the prospect of a "universal sample size" has been discussed (e.g., Mueller, 1974, 1975), ultimately the complexity of the archeological record makes such a generalizing concept problematic (Nance, 1981). Attaining representativeness is a multifaceted problem, as a particular sampling strategy may accurately represent one parameter within a population but under- or over-represent others (Hole, 1980). This is especially true for zooarchaeological deposits, where some remains can suffer severely from differential preservation and/or cultural preferences (e.g., Peacock, 2000). Ultimately, one must be clear as to the problem(s) being addressed and the target and measured variable(s) of interest (Lyman, 2008:11–16) and choose a sampling strategy appropriate for the goals of the research. This is arguably most difficult within the context of commercial archeology, or cultural resource management (Dunnell, 1984), where recovery of a representative sample of all phenomena, at all scales, is the ideal (Peacock and Rafferty, 2007), but where time and budget constraints are a constant concern. Consideration of representativeness has been, and will remain, a perennial topic of concern in archeology.

1.1. Sampling in applied zooarchaeology: implications for freshwater mussel conservation

Zooarchaeological deposits have recently proven to be a valuable avenue for explaining ecological and environmental change through time within an applied (natural resource conservation and management) context (Frazier, 2007, 2010; Lauwerier and Plug, 2004; Lyman, 1996, 2006; Lyman and Cannon, 2004; Peacock et al. 2011, 2012; Wolverton and Lyman, 2012). For example, freshwater mussel (Bivalvia: Unionidae, Margaritiferidae) shells are a common constituent of the archeological record throughout much of the United States. Despite being historically diverse and abundant, these animals are currently acknowledged as one of the world's most imperiled faunal groups (Bogan, 2008; Grabarkiewicz and Davis, 2008; Haag, 2009; Lydeard et al., 2004; Machtinger, 2007; Neves et al., 1997). Archeological mussel remains from waterways where modern biological surveys have not been carried out, or where previous historical data are limited in scope, can be very useful in an applied sense, as data obtained from shell-bearing sites can be used to

* Corresponding author.
E-mail address: jam393@msstate.edu (J. Mitchell).

http://dx.doi.org/10.1016/j.jasrep.2015.12.020
2352-409X/

establish pre-industrial ranges and expected natural proportions of species in river systems now extensively altered by impoundment and pollution (Mitchell and Peacock, 2014; Peacock, 2000, 2002; Peacock and Chapman, 2001; Peacock and Mistak, 2008; Peacock et al., 2014; Randklev and Lundeen, 2012). Such information should be useful for aquatic biologists and land managers charged with habitat restoration and the protection of endangered species (Peacock, 2012). Ultimately, these deposits can illustrate how mussel populations have changed over time and whether that change is a result of increased human ecological disturbance. Using archeological assemblages in this capacity can potentially give insight on the trajectory of ecological change toward modern-day mussel communities, thus allowing for better protection and conservation of the world's endangered bivalve species. Assessing any historical, human-induced changes in a sensitive fauna requires establishing a baseline against which modern impacts can be measured. In order to argue that archeological faunas represent such a baseline, it must be demonstrated that these samples are robust, and that the various factors that might affect them have been considered and accounted for to the best of our ability (Peacock et al., 2012).

Though the potential for new information with applied value is intriguing, when employing zooarchaeological data in this capacity we must first accurately establish past communities as ecological targets (Grayson, 2001; Lyman and Cannon, 2004; Mitchell, 2012; Stahl, 1996). Ideally, archeological shell deposits, especially longer-term deposits, accurately represent what was available in the local prehistoric mussel community (Matteson, 1958, 1959; Parmalee and Klippel, 1974; Parmalee et al., 1972; see also: Baker, 1923, 1930, 1936, 1941), given repeated sampling over different portions of local mussel beds (i.e., space and time averaging – Peacock, 2000) by prehistoric shellfishers. Adequate sampling thus ideally will produce data representative of the archeological deposit, which, unless demonstrated otherwise, may be taken as representative of past faunas (see Peacock et al., 2012 for ways to assess representativeness at the drainage-basin scale, including consideration of the so-called "cultural filter").

1.2. Sampling to redundancy

The concept of "sampling to redundancy," as discussed by Dunnell (1984), Leonard (1987), and others is central to the theme of representativeness. Sampling a population to redundancy is predicated on determining the "adequate" number of samples required to properly characterize that population, where the effects of incrementally adding sample units is measured until representativeness is achieved (Lyman and Ames, 2004:331). This approach has been applied to both archeological faunal specimens (e.g., Butler, 1987; Lyman and Ames, 2004, 2007) and paleontological remains (e.g., Wolff, 1975).

For decades plant and animal ecologists have noted the importance of sample size when studying species richness (e.g., Boecklen and Gotellie, 1984; Brown, 1995; Gaston, 1996; Lomolino, 2000; MacArthur and Wilson, 1967; Meltzer et al. 1992; Plog and Hegmon, 1993; Rosenzweig, 1995; Scheiner et al., 2000, 2011; Simberloff and Abele, 1922; Tjorve, 2003; Williams, 1964). This dynamic, known as the "species–area relationship" (SAR), is a fundamental concept of community ecology (Angermeier and Schlosser, 1989; Arrhenius, 1921; Boecklen, 1986; Chapman and Underwood, 2009; Evans et al., 1955; Gleason, 1922; Krebs, 1989; Leonard and Jones, 1989; Schoener, 1986; Ugland et al., 2003), representing a general pattern in which cumulative species grow as the number of samples increase (i.e., either in sampled area, or sampling volume) (Helmus and Ives, 2012). This relationship can be plotted via a Species Area Curve (SAC, hereafter), which is simply an X:Y chart depicting taxonomic frequency over area sampled (e.g., Cain, 1938; Coleman et al., 1982; Conner and McCoy, 1979; Crawley and Harral, 2001; Fisher et al., 1943; Palmer and White, 1994) and is a basic method used to sample for redundancy. Plotting a SAC consists of adding successive samples together where the *x*-axis measures an aggregate series of samples. As new samples are added, the value of the target variable (e.g., species richness) is monitored on the *y*-axis. When the value of the target variable is stable across numerous sample additions (i.e., the plot-line "levels-off"), it can be argued a representative sample has been attained, and any new information is redundant as it has previously been accounted for. If the SAC does not level off, however, further sampling potentially can provide new information, and representativeness has yet to be reached (Lyman and Ames, 2007:1986).

There are numerous techniques for constructing SAC's (see Lyman and Ames, 2007:1986–1988), all depending on the variable(s) of interest. Here we consider SAC's in relation to applied zooarchaeology, specifically focusing on shellfish remains, using cumulative species richness (NTAXA; see Grayson and Delpech, 1998) as the primary variable of interest and employing materials obtained from an archeological site in the southeastern USA as a test case. We primarily address sampling to redundancy in surface-collected materials obtained from the plow zone; as will be discussed below, such remains cannot in themselves be considered representative of overall site deposits due to post-depositional alteration. However, shell reported from surface collections does have value in both an applied and an archeological research sense, and our work has implications for assessing the adequacy of surface-collected assemblages of ceramics, stone tools, or any other kind of artifact. While we thus recognize the limitation of our current study from a purely applied perspective, there nonetheless are heuristic lessons to be gained by shifting our target and measured variables to explore representativeness of the surface of the plow zone at our study site. We also include a brief comparison of surface, plow zone, and sub-plow zone materials to illustrate the effects of differential preservation and spatial sampling on the respective assemblages.

2. Materials and methods

2.1. Field methods

The collection used in this study was obtained in the summer of 2009 by the Mississippi State University (MSU) archeology field school from the late prehistoric (ca. AD 700–1200) Kinlock site (22SU526). Kinlock (see Fig. 1) is located in Sunflower County, Mississippi, southeastern USA on agricultural property fronting the Big Sunflower River. The site lies in the Yazoo Basin of the Lower Mississippi River Alluvial Valley, also known as the Delta. It consists of a plaza, a semicircular shell ring containing abundant domestic debris, and as many as 6 earthen mounds (Carlock and Rafferty, 2009; Phillips, 1970).

A controlled-surface collection (CSC) was conducted on the shell-ring portion of the site, and 3 excavation units were also dug, a 1×1 m and a 0.50×0.50 m unit in areas of high shell density and a 1×1 m unit in the essentially shell-free plaza. While conducting the CSC, the area was gridded into 4×4 m units, each of which was further subdivided into separate 2×2 m squares. Artifacts were collected in accordance to their specific 2×2 (i.e., NW, NE, SE, or SW quarter of the master grid square). For mussel shell, only shells with intact umbos (i.e., the beak portion) were collected, as this portion of the shell is generally diagnostic for identification, as well as ensuring that individual valves are only represented once. All other artifacts were collected, except for ceramics less than ca. 2.4 cm (the size of a U.S. 25-cent piece) across. Shell was gathered in one 2×2 m unit out of every 4×4 by alternating between NW, NE, SE, and SW quarters in clockwise fashion with every pass, thus collecting ca. 25% of the available surface shell. This strategy was used for the sake of time and, due to the sheer abundance of shell, was intended to reduce the sample size to a manageable level. For further information on sampling strategy, recovery methods, and unit sizes see Mitchell (2012).

2.2. Taxonomic analysis

Shell was analyzed to the genus and species level in accordance with freshwater mussel guides (e.g., Parmalee and Bogan, 1998; Willams