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Toward a Morphometric Phylogeny of Caddo Ceramics: A Test of 3D Geometric Morphometrics

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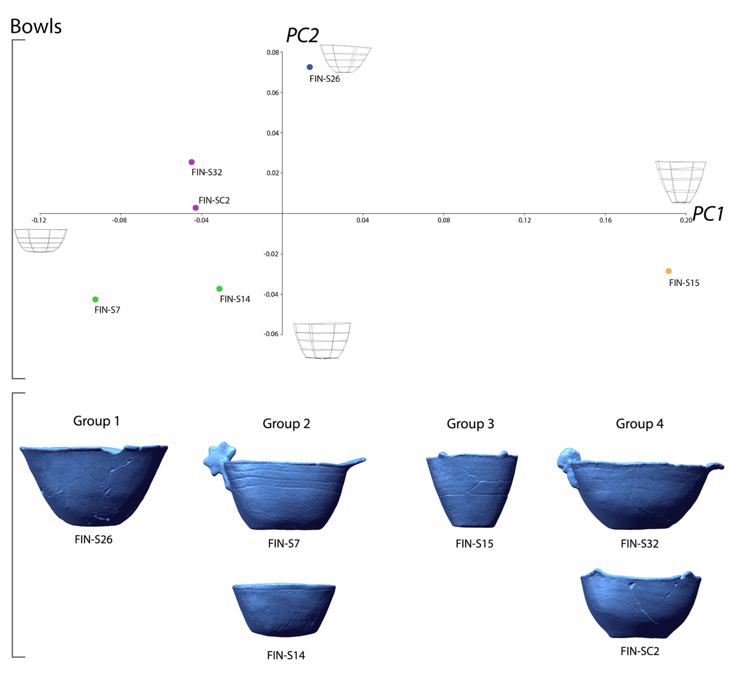
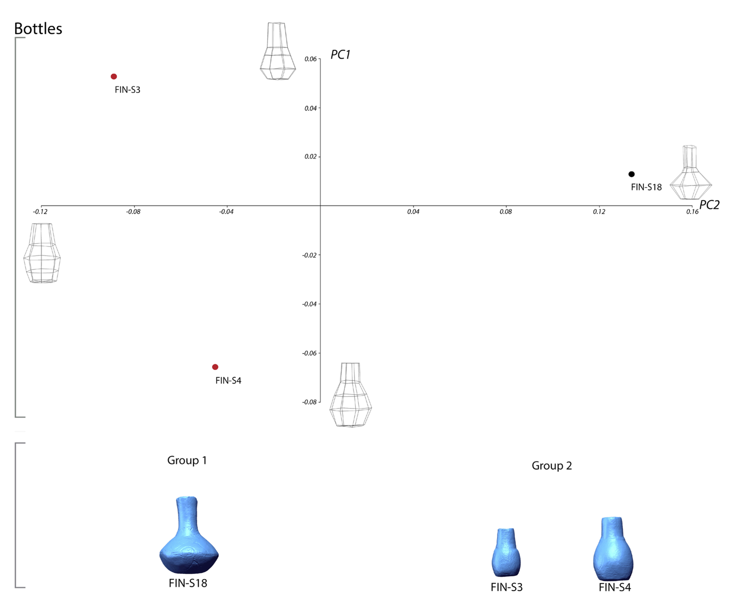
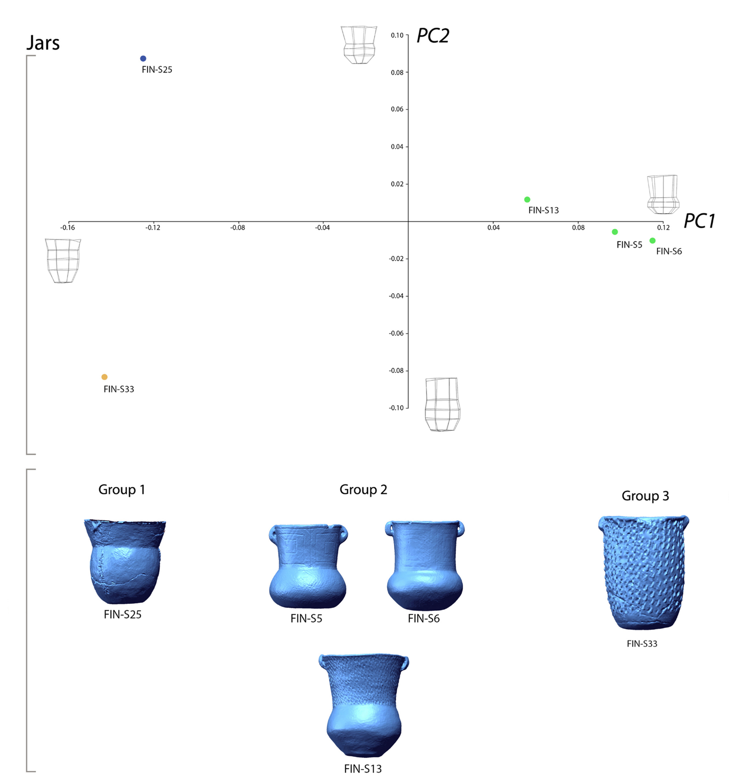
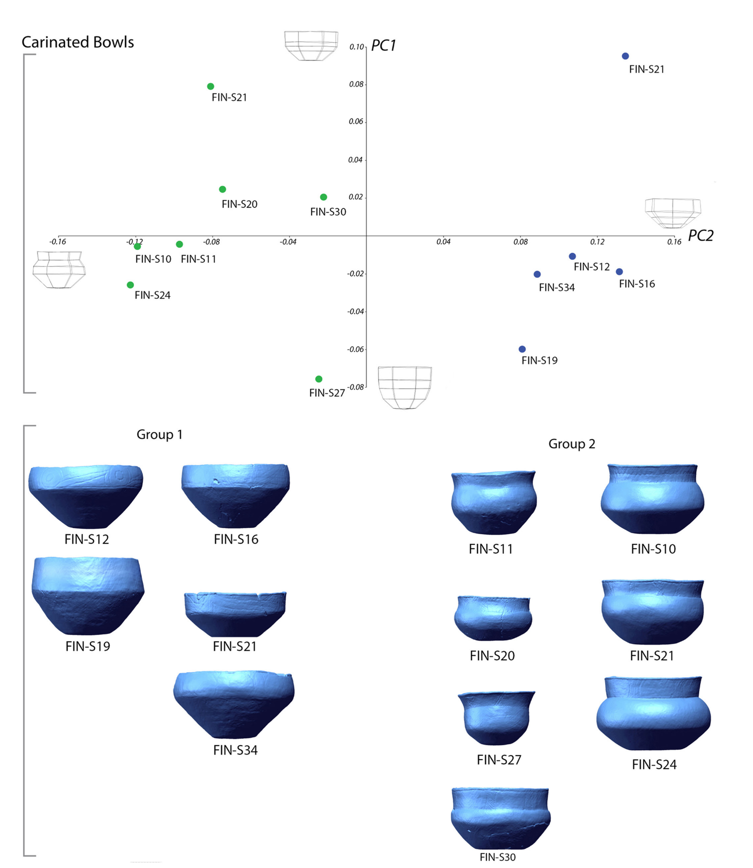




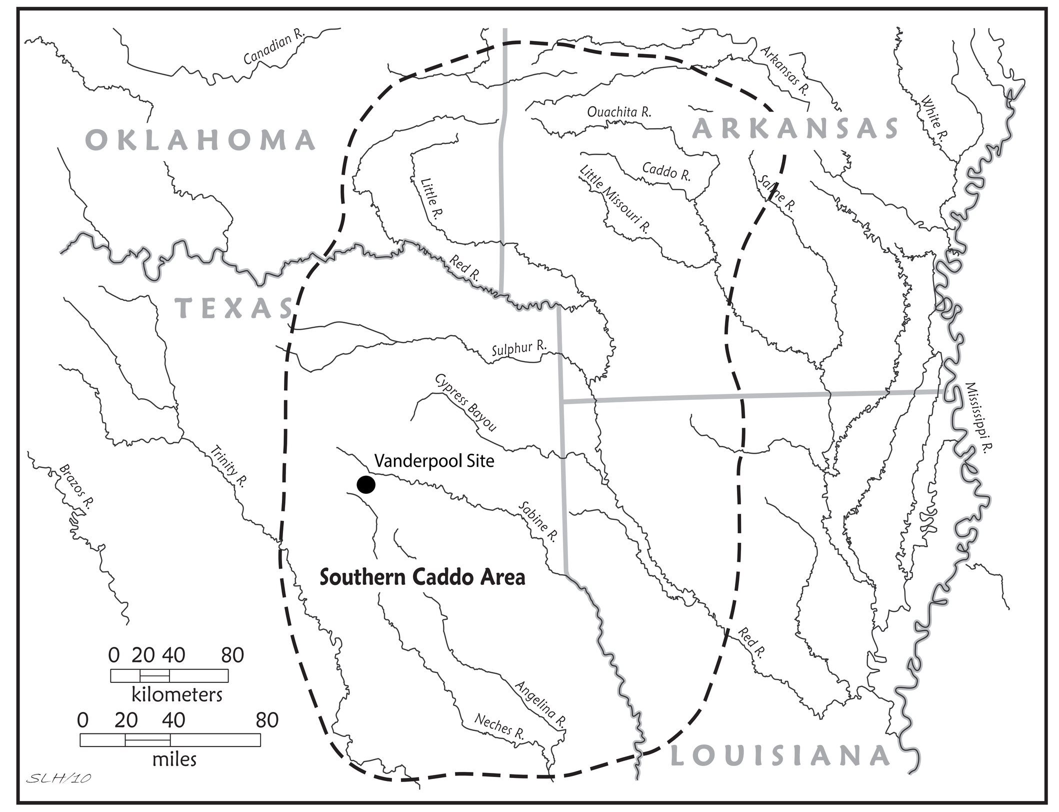




Introduction

Before profitable discussions of cultural transmission in Caddo communities can be undertaken using ceramic vessel form, there is a need to explore whether there are substantive, and measurable, amounts of variation that exist within Caddo ceramic vessel forms. We began our exploratory study of morphometrics with NAGPRA vessels from the Washington Square Mound site (41NA49) in Nacogdoches County, Texas (Selden 2013). That analysis served as the basis for the study reported here, which developed during a subsequent NAGPRA documentation effort at the Gregg County (Texas) Historical Museum (GCHM) (Perttula et al. 2013). The collection from the Vanderpool site represents a small fraction of the total number of vessels documented during the course of that work, in which it became clear that some varieties of vessel form appeared more regularly within and across these assemblages than did others.

Analyses of stone tools and debitage using 3D geometric morphometrics have received considerable recent attention in the archaeological literature (Bretzke and Conard 2012; Clarkson 2013; Lin et al. 2010; Lycett and Cramon-Taubadel 2013; Lycett et al. 2010; Sholts et al. 2012). Similarly, 3D scanning technology as an archaeological tool to study ceramics has been outlined by Karasik and Smilansky (2008), and 3D data have been employed as a means to better document (Grosman et al. 2008), classify (Gilboa et al. 2004; Karasik and Smilansky 2008), and illustrate (Gilboa et al. 2012) prehistoric ceramics, but to our knowledge it has not been used to study vessel form. In the following sections we outline the methods, application, and implications of applying geometric morphometrics to understanding differences in form among the Vanderpool vessels.



Methods

Data collection took place at the GCHM, where three-dimensional scans of the Vanderpool vessels were generated using a handheld ZScanner 700CX and ZScan software. Post-processing of the 3D images—generating point clouds, meshes, textures, and 2D screen captures for each vessel in Geomagic Verify (3D inspection software) and Geomagic Design X (3D reverse-engineering software)—required the greatest investment of time and was conducted at the Center for Regional Heritage Research (CRHR) at Stephen F. Austin State University. The data were saved in a variety of formats and are publicly available in CRHR:ARCHAEOLOGY—the CRHR's digital repository (CRHR 2014).

Vessel form is determined by measuring redundant landmark coordinates. Using the "reference point" function in Geomagic Design X, data were generated from 41 landmarks: one in the center of the base (CB), eight around the periphery of the base at the juncture of the lower body (PB), eight within the area of the lower body (BD), eight from the upper body (UB), eight from the bottom of the carination or neck (CN), and eight from the rim (RI). In the event that a vessel did not have a carination or neck, the CN point was placed equidistant between the UB and RI points.

Using the categories of vessel form that archaeologists working in the Caddo region have used (see Suhm and Jelks 1962), the vessels were assigned to one of five categories: (1) jar (n = 5), (2) bottle (n =3), (3) carinated bowl (n = 12), (4) bowl (n = 6), and (5) compound vessel (n = 1). Since there is only one compound vessel, it was not used in the morphological analysis. Point data generated from each vessel were exported from Geomagic Design X, opened and saved in Microsoft Excel, and organized by folk categories in Notepad prior to import in version 2.5 of Morphologika. Once imported, each folk category of vessels was independently subjected to a generalized Procrustes analysis (GPA), then principal components analysis (PCA). Morphologika results were then exported to version 3.2.2 of R (www.r-project.org) for a k-means cluster analysis, which was plotted on a 3D scatterplot.

Results

Although sample size from the Vanderpool site is small, the results demonstrate that a detailed analysis of ceramic vessel form is a useful tool in archaeological application.

Bowls

The PCA analysis for Caddo bowls demonstrates that the first three PCs account for 71.51%, 15.56%, and 7.49% of variation, respectively, or 94.56% of the total variation. The wireframes indicate that morphological variation in the Vanderpool ceramic bowls is not limited to a specific area of the vessel.

Jars

The PCA analysis for Caddo jars from the site demonstrates that the first three PCs account for 69.15%, 16.53%, and 11.69% of variation, respectively—97.37% of the total variation. The wireframes in Figure 3a appear to indicate that the majority of shape fluctuation in jars occurs across the entire range of vessel morphology and is not limited to a single landmark/point location.

Bottles

The PCA analysis for Caddo bottles demonstrates that the two PCs account for 79.33% and 20.67% of variation in the small sample. The wireframes indicate that the majority of shape variation occurs principally in the body of the vessel, but a secondary area of variation occurs in the neck of these bottles.

Carinated Bowls

The PCA analysis for Caddo carinated bowls indicates that the first three PCs account for 61.93%, 14.89%, and 6.72% of variation, respectively, which accounts for 83.54% of the total variation. Although there is some degree of variation in vessel rim, the wireframes show that the majority of shape variation in carinated bowls occurs in the body of the vessels.

Summary

The 3D morphometric analysis found considerable diversity in vessel form across the assemblage. In some cases, the morphometric groups were found to correlate with burials (jars, bottles, and bowls), with the exception of the carinated bowls—both angular and globular—that appear across burials 3–5. In this sample, pigment associated with angular carinated bowls is red (FIN-S16), whereas white pigment is associated with globular carinated bowls (FIN-S20).

Discussion and Conclusion

Temporal and spatial considerations concerning ancestral Caddo sites, communities, and artifact assemblages are categorized in large part on the basis of a taxonomy focused on ceramic decorative elements and motifs, but distinctive vessel attributes also play a role in taxonomic assignments (Suhm and Jelks 1962). Whereas stone tool taxonomies—initially defined in Suhm et al. (1954)—continue to evolve (see Turner et al. 2011)—no comprehensive update to Suhm and Jelks' (1962) ceramic taxonomy has been developed in the Caddo area. The modest efforts described here are meant to be a step in that direction.

Although the results of our analysis could be applied to a variety of theoretical models, it is within evolutionary archaeology that we see the greatest potential. Several recent 3D morphometric studies of stone artifacts gainfully enlist evolutionary theory in studies of morphological variability (Bretzke and Conard 2012), technological origins (Lycett et al. 2010), stability and variability (Lycett and vonCramon-Taubadel 2013), the transmission of technological knowledge (Sholts et al. 2012), and phylogenetics (Lycett 2009). Given recent syntheses and analyses of chronometric data in the Caddo region (Selden 2012; Selden and Perttula 2013), and the temporal resolution garnered through recent innovative studies of decorative elements and motifs (Early 2012; Girard 2012), we believe that a large-scale study of vessels aimed at the gradual production of a regional phylogeny is worthwhile. Such a study would need to enlist both quantitative data from morphometric analysis and qualitative data from decorative elements and motifs to produce significant analytical and theoretical progress regarding cultural transmission processes that occurred within and across the ancestral Caddo region.

Acknowledgements

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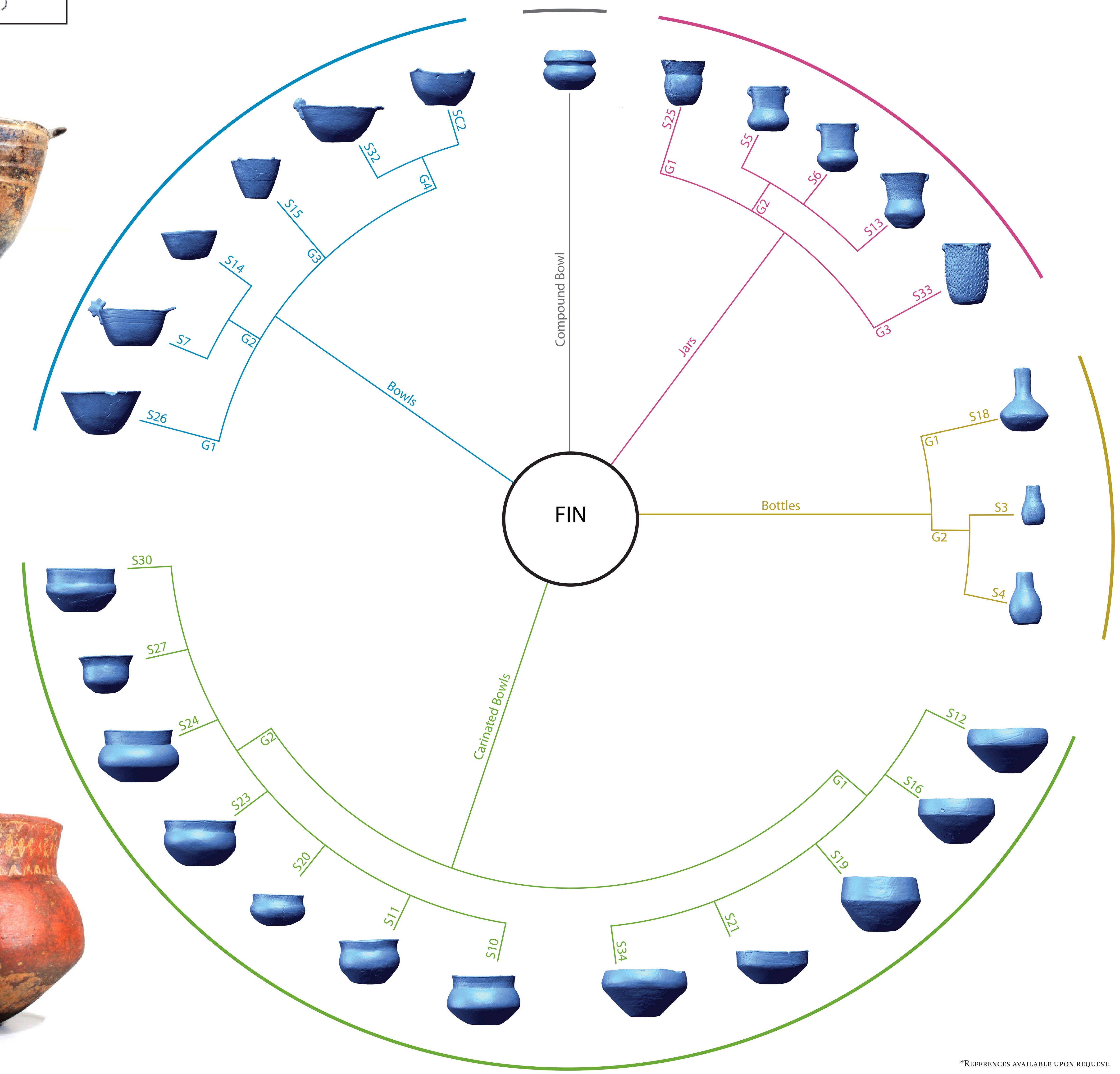

*References available upon request.