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Points and prey: a quantitative test of the hypothesis that prey size influences early Paleoindian projectile point form

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ABSTRACT

Understanding the causes of variation within and between projectile point types is an important task for Paleoindian archaeologists since they rely heavily on points to investigate such things as settlement dynamics and hunting practices. One long-held explanation for the variation in early Paleoindian point form is that prey size influenced the size and shape of projectile points. The study reported here evaluated this hypothesis with standard and geometric morphometric data recorded on Clovis and Folsom points from the Southern Plains and Southwest that are associated with mammoth or bison remains. Points used to hunt mammoth were found to be larger and of a different shape than points used to hunt bison, which supports the hypothesis. However, when both point type and prey size were taken into account, the results ran counter to predictions. Potential explanations for this discrepancy are discussed.

1. Introduction

Clovis and Folsom are the two best-known early archaeological complexes in North America. Clovis assemblages have been found throughout the contiguous United States, southern Canada, and northern Mexico (Holliday, 2000; Sanchez, 2001). The oldest Clovis assemblage dates ca. 13,300 calendar years before present (calBP) and the youngest ca. 12,800 calBP (Holliday, 2000). So far, Folsom has been found only in western North America, mainly in the Great Plains and Rocky Mountains. It appeared shortly after 13,000 calBP and disappeared around 11,900 calBP (Taylor et al., 1996; Holliday, 2000; Collard et al., 2010).

Projectile points are the key diagnostic artifacts of Clovis and Folsom assemblages. Clovis points are bifacially flaked and fluted with parallel to slightly convex sides and concave bases (Wormington, 1957). Folsom points are lanceolate or lozenge shaped (Wormington, 1957). They also tend to be smaller and lighter than Clovis points and have more-invasive flutes. Both point types are thought to have been used with darts delivered by atlatl (Hutchings, 1997).

Prey size has been argued to be a major influence on the size and shape of Clovis and Folsom points. An early statement to this effect can be found in Cotter (1938). In explaining the variation in the size of Clovis and Folsom points recovered from Blackwater Draw, New Mexico, Cotter hypothesized that large points were designed to hunt mammoth, medium-sized points were intended for bison and game of moderate size, and small points were made for small game. Among the other authors who have linked the form of Clovis and Folsom points to prey size are Sellards (1952), Hemmings (1970) and Haynes (1964). The former two authors argued that large Clovis points were used to hunt mammoth, whereas smaller Clovis points were used for smaller game such as bison and horse. Haynes (1964) suggested that the change from Clovis points to Folsom points coincided with the shift from hunting mammoth to the hunting of bison.

Currently, the status of these claims is uncertain. Experimental studies indicate that a projectile point's size and shape can affect its ability to penetrate hide and its durability, which is consistent with the hypothesis (Odell and Cowan, 1986; Frison, 1989; Hughes, 1998; Cheshier and Kelly, 2006; Sisk and Shea, 2009; Waguespack et al.,

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2009). However, Haury et al. (1953, 1959) challenged the link between prey size and point form in the case of Clovis. These authors pointed out that Clovis points of a wide range of sizes are associated with mammoth at the sites of Naco and Lehner in Arizona, and argued that this indicates that Clovis Paleoindians did not preferentially use large points to hunt mammoth.

In view of this uncertainty, we tested the hypothesis that prey size influenced Clovis and Folsom projectile point form by comparing the size and shape of points associated with the remains of either Columbian mammoth (*Mammuthus columbi*) or ancient bison (*Bison antiquus*). Adult Columbian mammoth are estimated to have been eight times heavier than adult ancient bison (~8000 kg versus ~900 kg) (Smith et al., 2003). Thus, we reasoned that, if the hypothesis is correct, there should be significant differences in the size and shape of projectile points associated with the two species.

2. Materials and methods

The study included 74 complete, previously typed projectile points (Table 1). Eleven are Clovis points associated with bison remains, 36 are Clovis points associated with mammoth, and 27 are Folsom points associated with bison.

Bison remains have been recovered from a number of Clovis sites (Waguespack and Surovell, 2003), but only four sites have yielded complete Clovis points that can be linked with bison remains—Blackwater Draw, Jake Bluff (Oklahoma), Murray Springs (Arizona), and Lehner (Fig. 1). At Blackwater Draw, Sellards excavated a Clovis bison kill from the Gray Sands at the south end of the North Pit (Hester, 1972). The assemblage included the remains of least seven animals and three complete Clovis points. At Jake Bluff, remains of at least 14 bison were found at the bottom of an arroyo along with four complete Clovis points (Bement and Carter, 2003). Area 4 at Murray Springs yielded the remains of at least 11 bison plus three complete Clovis points (Haynes and Huckell, 2007). A complete Clovis point and bison remains were also recovered from Area 3 at Murray Springs, but the point was equally close to mammoth remains, so it cannot be linked to either species. Several complete Clovis points were found in association with animal remains at Lehner (Haury et al., 1959). One was recovered from within the ribs of a bison. We included all the complete Clovis points from Blackwater Draw, Jake Bluff, and Murray Springs that are associated with bison remains in our sample of Clovis-bison points. We also included the complete point from the bison kill at Lehner.

In order to reduce the potential confounding effects of ecological and cultural variation, we limited our sample of Clovis-mammoth points and Folsom-bison points to the two regions in which Clovis bison kills have been found, the Southern Plains and Southwest. The specimens in our sample of Clovis-mammoth points come from three sites on the Southern Plains—Blackwater Draw, Domebo (Oklahoma), and Miami (Texas)—and three sites in the Southwest—Escapule (Arizona), Lehner, and Naco (Fig. 1). The specimens in our sample of Folsom-bison points come from six sites on the Southern Plains—Blackwater Draw, Cooper (Oklahoma), Folsom (New Mexico), Lake Theo (Texas), Lipscomb (Texas), and Lubbock Lake (Texas) (Fig. 1). All the points in our Clovis-mammoth sample are unambiguously and exclusively associated with the remains of mammoth, and all the points in our Folsom-bison sample are unambiguously and exclusively associated with bison remains.

We obtained both size and shape data from the points. The former comprised values for three measurements—length, width, and thickness. These values were either taken from published sources or recorded by BB with digital calipers. The only points for which it was impossible to generate a complete set of size data were the six Folsom-bison points from Lipscomb. We did not include values for thickness for these points because we could not find the relevant values in the literature and were unable to measure the points directly.

The shape analysis methods we used are from the field of geometric morphometrics (e.g., Bookstein, 1991; Bookstein et al., 1985; Dryden and Mardia, 1998; Rohlf and Bookstein, 1990; Slice, 2005, 2007). The methods allow patterns of variation in shape and size to be investigated within a well-understood statistical framework that yields relatively easily interpreted numerical and visual results. The methods deal with coordinate data as opposed to the interlandmark distances of traditional morphometrics and operate within a non-Euclidean shape space (Kendall, 1984), the geometric and statistical properties of which are both well defined and highly desirable (O'Higgins, 1999, 2000).

Following Buchanan and Collard (2010), the steps taken in acquiring, processing, and extracting shape variables were as follows:

1. *Image acquisition*. Digital images of points were used to capture landmark data. For nearly flat objects such as projectile points, a two-dimensional approach produces limited information loss (Velhagen and Roth, 1997).
2. *Choice and digitization of landmarks*. We used three primary and 20 secondary landmarks to capture point shape. Two primary landmarks were located at the base of the point and were defined by the junctions of the base and the blade edges. The third primary landmark was located at the tip. Line segments with equally spaced perpendicular lines were used to place the secondary landmarks along the edges of the blades and the base. These "combs" were superimposed on each image using the MakeFan6 shareware program (www.canisius.edu/~sheets/morphsoft.html). The 23 landmarks digitized for each artifact are shown in Fig. 2. The landmarks were digitized using tpsDig2 shareware (Rohlf, 2004).
3. *Superimposition of landmarks*. This procedure was carried out to reduce the confounding effects of the digitizing process and to control for size differences among the specimens (Rohlf, 2003; Rohlf and Slice, 1990). Landmark superimposition entails three steps. First, the set of landmark coordinates are centered at their origin or "centroid," and all the configurations are scaled to unit centroid size. Next, the consensus configuration is computed. Lastly, each landmark configuration is rotated so as to minimize the sum-of-squared residuals from the consensus configuration. The superimposition of landmarks was carried out using the tpsSuper program (Rohlf, 2004).
4. *Projection to tangent Euclidean space*. In order to carry out traditional statistical analyses, it was necessary to project the landmarks to tangent Euclidean space (Rohlf, 1998; Slice, 2001). This procedure was also carried out using the tpsSuper program (Rohlf, 2004). We conducted a regression of the distances in the tangent space against the Procrustes distances to determine the fit between the specimens in shape space and linear tangent space. This test was carried out using the tpsSmall program (Rohlf, 2004). The correlation between the two distances was strong (correlation = 0.9999; root MS error = 0.0001), indicating that the projection was adequate.
5. *Extraction of partial warps and the uniform component*. Partial warps are eigenvectors of the bending-energy matrix that describe local deformation along a coordinate axis. Uniform components express global information on deformation. The first uniform component accounts for variation along the *x*-axis of a configuration, whereas the second uniform component accounts for variation along the *y*-axis. Together, partial warps and uniform components represent all information about the