Chapter 13

Projectile Technologies of the African MSA

Implications for Modern Human Origins

Alison S. Brooks
Lisa Nevell
George Washington University, Washington DC 20052

John E. Yellen
National Science Foundation, Arlington, Virginia 22230

Gideon Hartman
Harvard University, Cambridge, Massachusetts 02138

ABSTRACT

One of the most significant barriers to understanding the emergence of Late Palaeolithic adaptations is the absence of a comparative analytical framework encompassing African MSA/LSA and Eurasian Middle/Late Palaeolithic industries. Projectile armatures, varying widely in time and space, constitute many of the original "fossiles directeurs" of the Eurasian Upper Palaeolithic, and their development may have been important in the eventual dominance of anatomically modern humans across this region. At an earlier date, the African MSA is distinguished from most Middle Palaeolithic industries of Eurasia by the complexity and patterned variation of projectile armatures, as well as by their numerical dominance in many industries. This paper will review the patterning of projectile armatures in Africa, discuss alternative approaches to analysis, and present a comparative study of armatures from two African regions and the Levant. We argue that the small size of many MSA points implies the existence of a complex projectile technology rather than simple spears.

INTRODUCTION

Middle Stone Age (MSA) assemblages of Africa, especially those from sub-Saharan regions, have rarely been compared directly to Middle Paleolithic (MP) assemblages outside Africa. Until very recently, results of excavations in Middle Stone Age (MSA) sites were mostly published in regional journals or local presses, and often included only limited illustrations. Even more complete and well-illustrated publications did not furnish easy comparisons with assemblages from the Near East and elsewhere in Eurasia. African archaeologists almost never followed examples from the Levant in using Bordes' (1961) typology or another European typology, modified as necessary, to describe their finds.

For much of the MSA, the Bordes typology and others like it would obscure fundamental regional differences, as well as the major differences between the MSA and the MP outside Africa. This is because the focus of Bordes' typology is on scrapers, which often form the dominant and most elaborated category in European MP assemblages. Many of the more formal categories of tools in MSA assemblages from tropical Africa are points, not scrapers (Figure 1). Carefully retouched bifacial and unifacial points may dominate the retouched or formal tool component, while scrapers, although sometimes more numerous, often form a far more heterogeneous grouping, many of them recycled from points, or manufactured from a similar template and using similar techniques of retouch. Initial reports on Blombos in South Africa, for example, noted that 52% of the retouched stone tools were bifacial points and fragments (Henshilwood and Sealey 1997, n.d.). Points were used to define the original MSA and its variants (Goodwin 1928), and are present at early sites like Gademotta and Kukeleti (Wendorf and Schild 1974).

The focus of this paper is the distinctiveness of the African MSA; however it is important to note that the patterning of points in the MSA does have implications for two aspects of the debate on behavioral modernity. First, the MSA points' complexity and their clear use as projectile armatures (*e.g.*, Volman 1984; Harper 1994; Würz 1997; Milo 1998) in what may have been a variety of specialized compound artifacts implies cognitive sophistication. The process of assembling diverse elements into a compound artifact such as a projectile could be seen as analogous to the process of assembling words into a sentence. There is a grammar and an order to the tool assembly process that is partly universal and partly culturally specific; furthermore, each element of the tool can be exchanged for a different one, changing the meaning and the function of the resulting product.

The second contribution of MSA stone points to the behavioral modernity debate is the regional and chronological specificity of MSA points, which has implications for the social organization of the producers. Wilmsen (1974) has argued that the form of projectile points is more tightly constrained by aerodynamic requirements than the form of other stone tools is constrained by function; consequently, he argues that points are the most likely candidates to reflect regional "styles". Projectile armatures must be able to replace broken armatures, so the haft into which they are placed also imposes limitations on the projectile size and form. Having a system of exchange within social networks further encourages similarity of point form so that the product remains interchangeable within a

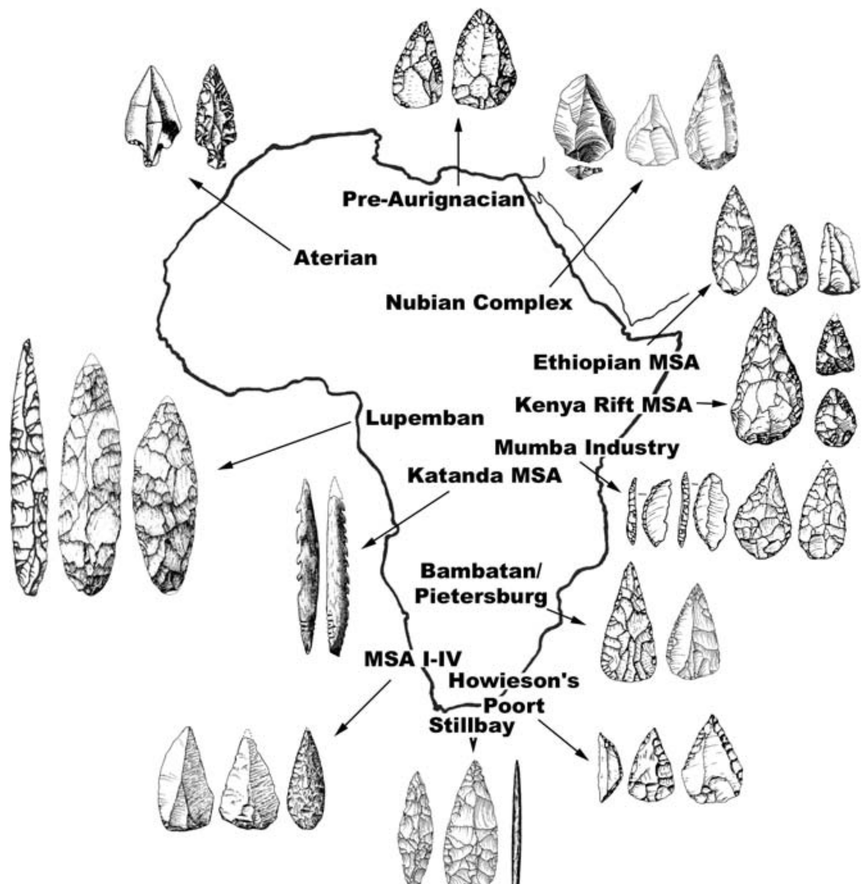


Figure 1. African points of the Middle Stone Age [adapted from McBrearty and Brooks (2000)].

cultural group. Wiessner (1983) argued from ethnographic data that even where forms were extremely limited by raw materials regional styles emerged (*e.g.*, fence wire in Wiessner's ethnographic example). Men hunt well for only a few years but continue to make arrow points for most of their lives; consequently, arrows are frequently given to hunters in exchange for a claim on the eventual kill. Hunting success is influenced by the hunter's familiarity with an armature; this kind of social trade network would therefore be expected to encourage homogeneity in the size and shape of projectile points. Thus social organization, especially the development of exchange networks, constrains point styles and creates sharp discontinuities at social boundaries, whether these boundaries are linguistic, ethnic or simply a result of an empty buffer zone between group ranges.

In 1988, Desmond Clark wrote an important summary entitled "The Middle Stone Age of East Africa and the beginnings of regional identity". Much of the "regional identity" of his title concerned not only ways in which the East African MSA was distinctive, but differences within East Africa, especially in the forms of points. Within the Horn of Africa alone, Clark (1988:297) contrasted ". . . . the markedly subtriangular points of Gorgora [in the north], the pointed leaf-shaped forms at Porc Epic and Gademotta [both in the Ethiopian Rift], and the Levallois points at Midhishi in Somalia."

Point variants were also used to define different regional and chronological variants of the South African MSA, including the Stillbay points of the Cape coast, with their pointed bases, the Howiesons Poort geometrics of the Cape Province and surrounding regions, the elongated Pietersburg points of the Transvaal and the triangular Bambata points of Botswana and western Zimbabwe. Many of these point types are similar in size and are made with a similar range of raw materials including local quartz and quartzites, as well as exotic silcretes and other silicified materials. As Clark (1988) argued (see Figure 1), East Africa also includes several regional and chronological variants. At Mumba in Tanzania, for example, small triangular points occur throughout the long MSA sequence and are joined in the later "Mumba" industry (*ca.* 65–45 thousand years ago) levels by a group of highly formalized medium-sized crescent-shaped geometric points (Mehlman 1979, 1989, 1991). North African points also exhibit regional and chronological variants, including Nubian point types in the Nile Valley, and various tanged and leaf-shaped Aterian points throughout the Sahara and North African littoral. In the Central African region, not only is there a range of elongated Lupemban points, but also assemblages of miniature triangular points such as those described by Mercader and Marti (1999) for Cameroon and by Robbins *et al.* (2000) for Rhino shelter in northern Botswana.

In addition to lithic points, MSA sites have also yielded bone points from two different regions of Africa in association with MSA lithics and which are dated to early Oxygen Isotope Stage (OIS) 4, approximately 70,000–90,000 years ago. The cylindrical points of Blombos and Klasies on the South African coast (Henshilwood and Sealey 1997) and the barbed points of Katanda in the Rift Valley of eastern Congo (Yellen 1988; Brooks *et al.* 1995, 2004; Yellen *et al.* 1995; Brooks and Yellen 2004) are markedly different in style, yet may both be associated with a new economic activity, fishing.

The study of excavated assemblages with MSA points from two different regions of sub-Saharan Africa demonstrates how these differ from each other and from points described for the Levantine Mousterian. MSA points may also have been used in fundamentally different ways from Levantine examples.

THE SAMPLE

≠Gi Site, Botswana

The first region to be compared is in the Kalahari Desert of Western Botswana, on the Namibian border (Figure 2). The MSA-LSA site of ≠Gi , with MSA horizons dated to *ca.* 77,000 years BP, is located on the eastern edge of the deepest pan

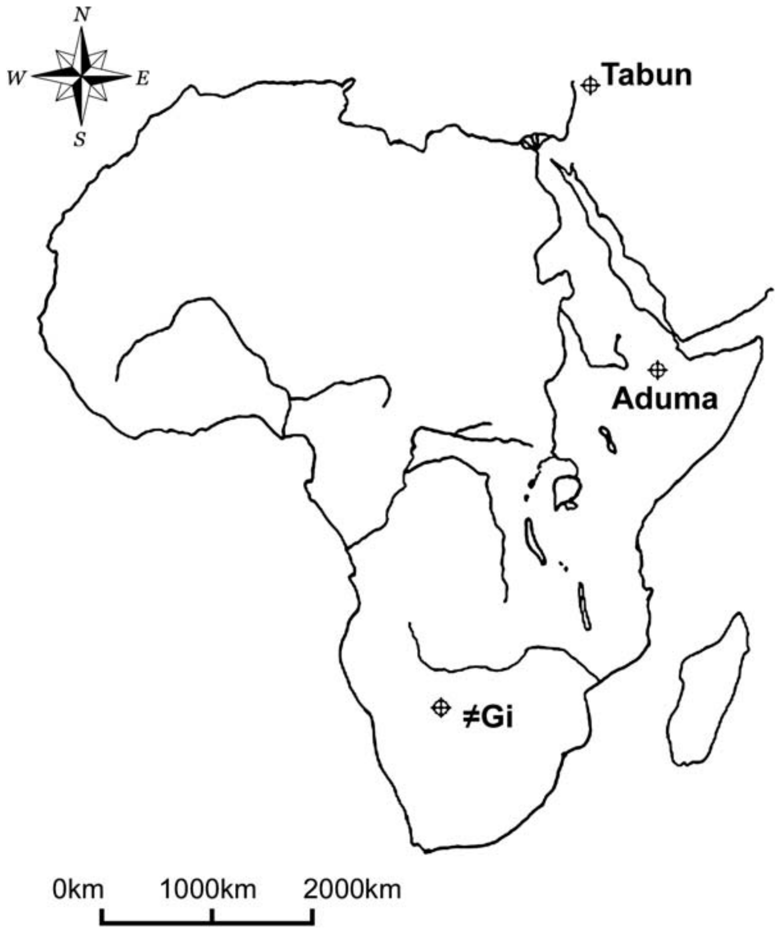


Figure 2. Locations of three sites analyzed in the text, ≠Gi, Aduma and Tabun.

or depression in the area (Brooks *et al.* 1980, 1990; Brooks and Yellen 1987; Brooks 1998). To the present day (2003) the pan serves as an ambush hunting venue, whose use is limited to the end of the rainy season when water scarcity concentrates game around this one remaining water source. In the site's LSA levels, crescents, which are interpreted as arrow armatures, far outnumbered scrapers. In the underlying MSA levels, points were the dominant tool class, constituting 41% of the *ca.* 1,500 retouched pieces. Many additional points had been recycled into scrapers and knives.

The points at ≠Gi are predominantly small, triangular, and bifacial, averaging *ca.* 41 mm in length, with some examples close to 30 mm. Bases are heavily thinned and modified, presumably for hafting. Although some points are entirely unifacial, most have some degree of bifacial working, either just at the base, over part of the edge, or over the entire ventral surface (Figure 3). Maximum width, usually at the base, was tightly controlled (Figure 4). This was in spite of the use of a wide

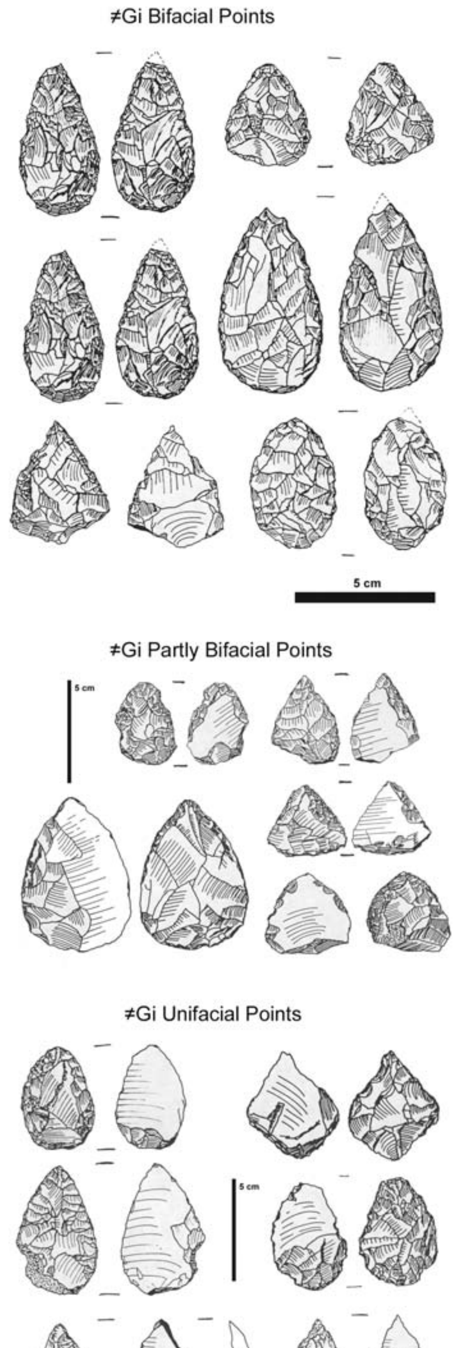


Figure 3. ≠Gi points.

Figure 4. Photo of ≠Gi points.

range of raw materials including chert, jasper, chalcedony and quartzite. These materials occurred in both tabular form in local outcrops and in medium to large size cobbles in the conglomerate below the MSA horizons. Since they are made on discoidal cores, the flakes' bulbs and striking platforms are frequently on the corner rather than in the center of the base. Not only are the platforms heavily modified or removed by retouch, but we noted that the side opposite the one ending in a striking platform is often slightly wider, as if in an effort to compensate for the increased mass on the striking platform side. We began to develop a measurement system to detect this asymmetry, in addition to reflecting differences in size, shape and process of manufacture.

≠Gi points are markedly smaller than typical MP points from outside Africa, although mean thickness is slightly greater (14.1 mm) since this is a discoidal rather than a Levallois technology. Point bases are heavily retouched and width is controlled, suggestive of hafting. In addition, the ≠Gi sample exhibits multiple examples of projectile impact damage, including hinge fractures, broken tips, and burination spalls (shown in Figure 5), and micro-striations, the latter possibly due to hafting wear. Their size places them at the lower limits of ethnographically known spear armatures and within the range of ethnographically known spear thrower darts and larger arrowheads, as well as in the lower range of non-microlithic projectile points (Thomas 1976). It is perhaps not surprising that the associated ≠Gi MSA faunal remains suggest commonalities with South African LSA hunters, such as those at Nelson's Bay Cave (Klein 1989, 1992, 1999).

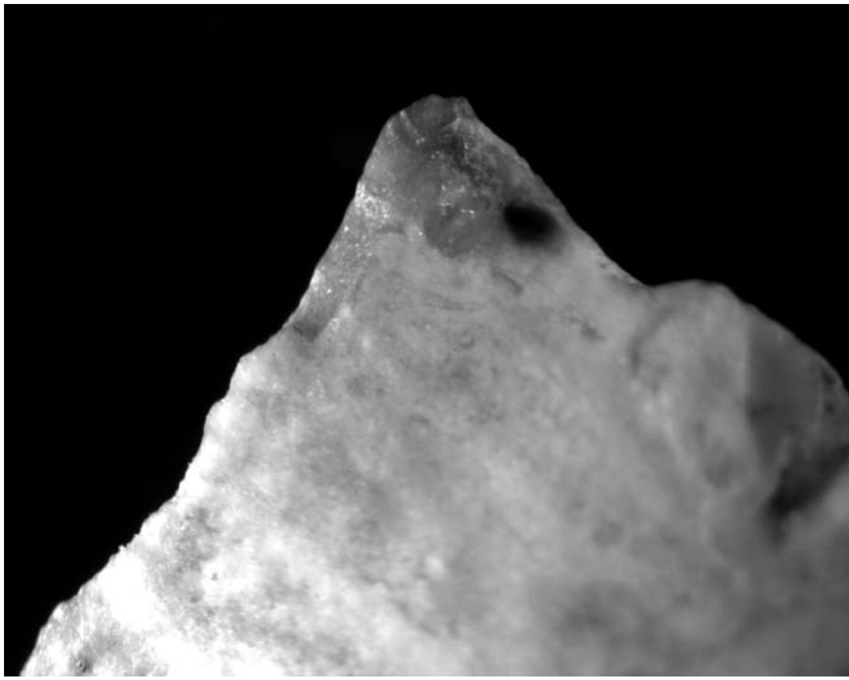


Figure 5. Microphoto of burination spall (X40) [photo taken by Robin Teague].

Aduma Sites, Middle Awash, Ethiopia

Our second point sample comes from the region of Aduma, in the Middle Awash Valley of Ethiopia (Haile-Selassie *et al.*, 2004; Yellen *et al.* in press). Here we excavated a series of sealed archaeological occurrences spread over 15 km^2 of small relict erosional hills on the west bank of the river. The dominant feature of the Aduma landscape is a massive series of silts lacking any marked soil horizons, overlying the cobble pavement at the A-1 site, and interstratified elsewhere with sands and fine gravels towards the base. This silt unit is termed "Ardu II". We have divided the rest of our sites, for comparative purposes, into three groups: the sand/fine gravel/basal silt layers (Ardu II-base), the massive silts above (Ardu II), and the site A-5 soil horizon at the Ardu II/III contact between the massive silts and the overlying dark colluvial level. Based on a preliminary assessment, the entire sequence appears to represent a relatively short interval, dating to late OIS 5 or early OIS 4, and is almost certainly older than 70,000 years BP. The A-1 lag surface is likely to be considerably older, possibly representing a hyper-arid period of deflationary activity during OIS 6, or earlier, paralleling the expansion of African arid zones during OIS 4 and 2.

At site A-1, a lag of MSA materials rested on an old cobble pavement incorporating multiple erosional cycles. An excavated sample was recovered from the base of silts overlaying a cobble layer. Variants of Levallois technology dominate the lithic assemblage, although discoidal and small blade cores are also present. The points and cores include forms typical of later horizons, but are dominated by unique types not seen in the overlying levels. These include large bifacial points or small bifaces (Figure 6:F), and large "Mousterian" type points on big Levallois flakes (Figure 6:E). Obsidian is used for approximately half the points and for at least one extremely large pointed "biface" core; other materials include fine

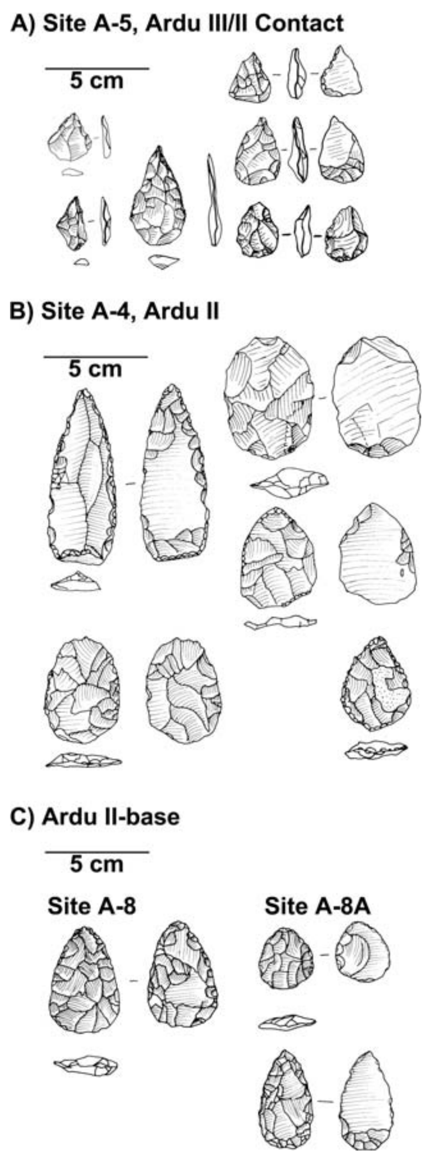


Figure 6. Aduma Points.

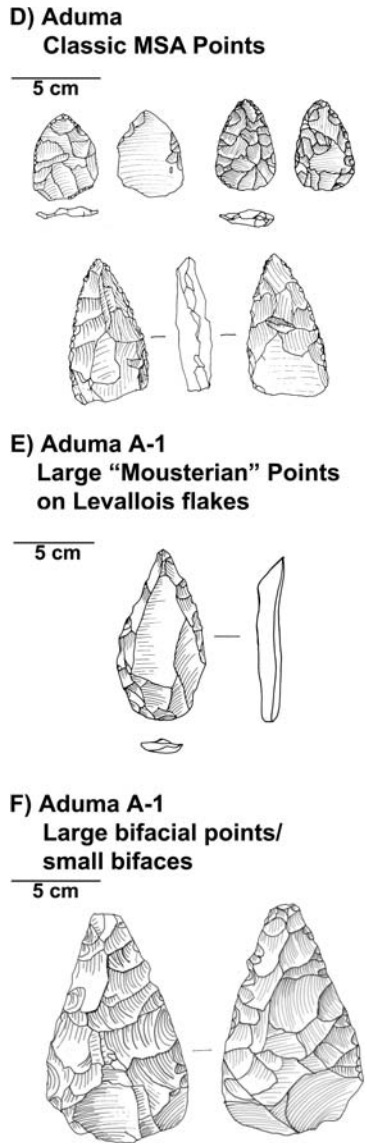


Figure 6. (*Continued*)

volcanics and cherts. The presence of types identical to those found higher in the sequence could signal stratigraphic admixture. Unfortunately, we have not been able to derive a date for this horizon consistent with those suggested for the later horizons.

Seventy-six to 93% of all points in these later levels are made of obsidian. The dominant point types of Ardu II (silt) and Ardu II base (gravel) include classic

Table 1. Point type percentage

	Tabun B (n=9)	Tabun C (n=10)	Tabun D (n=31)	Aduma 1 (n=16)	A8 Gravel (n=69)	A4 Silt (n=33)	Aduma 5 (n=39)
Point biface	0	0	0	6.3	0	0	0
Mousterian Point	0	10	26	31.3	0	0	0
Levallois Point	100	60	42	18.8	0	0	2.6
Classic MSA Point	0	0	0	18.8	12.7	36.4	5.1
Short Broad Point	0	0	0	0	19.7	33.3	7.7
Small Blunt Point	0	0	0	0	0	0	10.3
Pointed blade	0	10	32	0	1.4	6.1	0
Acute tip Point	0	20	0	0	8.5	9.1	23.1
Pint/Perforator	0	0	0	6.3	18.3	0	15.4
Perforator	0	0	0	6.3	23.9	3	28.2
Miscellaneous	0	0	0	12.5	9.9	12.1	5.1
Perforator-borer	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	2.6
Broken	0		0	18.8	14.5	0	0

MSA points with trimmed bases and highly invasive bifacial and unifacial retouch (FIG 6:D). These are much less common in the uppermost horizon, which is dominated by small acute-tip and blunt points and point-perforators (Figure 6:A, Table 1). Point-perforators and perforators are also found in the Ardu II base. This probably reflects differences in landscape and site function. A group of short broad points also appears in this basal level and diminishes in frequency thereafter. The uppermost level (Ardu II/III) is distinguished by the very small size of the point component with some points measuring less than 2 cm in length. Like the ≠Gi points, the average Ardu II and II/III points fall within the ethnographic spear thrower dart and large arrow range in length, but the Ardu II/III points are so small that they do not overlap at all with the range of length of ethnographic spear points.

Tabun Cave, Israel

Because the points from Aduma were made to a large extent on Levallois flakes and flake/blades, we compared them to a series of 56 points from levels at Tabun B, C, and D in the Levant to explore the differences between African points and Levantine Mousterian points. The upper horizons, Tabun B and C, are probably roughly contemporary with the Ardu II and II/III, while Tabun D may be older than or approximately contemporary with the very early Aduma A-1 assemblage. The Tabun B and C points were classed predominantly as Levallois points; Mousterian and acute-tip points as well as pointed blades were somewhat more common in the underlying Tabun layer D (Table 1). We note, however, that the Tabun sample was taken from old collections excavated by Garrod (Garrod and Bate 1937) held at the National Museum of Natural History, Smithsonian

Institution. This collection is biased in favor of complete and aesthetically pleasing artifacts, and this comparison should be regarded as only suggestive.

RESULTS

Our point measurement system involves a total of 25 variables describing attributes of the blank, the divergence and shape of the sides, point asymmetry, marginal retouch, and treatment of the base. In this comparison we will focus on only a few of these: overall dimensions, the angle described by the sides of the point from the tip to the maximum distance of each side from the midline, the marginal retouch pattern, and treatment of the butt (Figure 7, Table 2). Points which lay more than two standard deviations from the mean were considered outliers. African hunter-gatherers today use bows and arrows in addition to larger tool types and by analogy we propose that projectile technology in the MSA was adopted as part of a broad toolkit; diagrams representing trends in point size and shape do not depict outliers. The number of points measured and the number of outliers excluded is reported for each analysis (Figures 8, 9, 10 and 11), as is the sample size, mean, and standard deviation of the total sample (Table 2).

Tabun points (Figure 8a) become markedly shorter through time from layers D to B, but width is held remarkably constant over time so that the youngest points are very broad for their length. Note that the average length of Tabun points varies

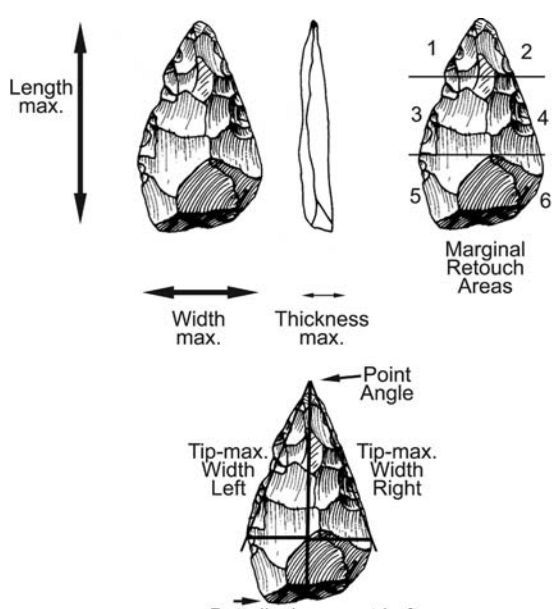


Figure 7. Point attributes and measurements.

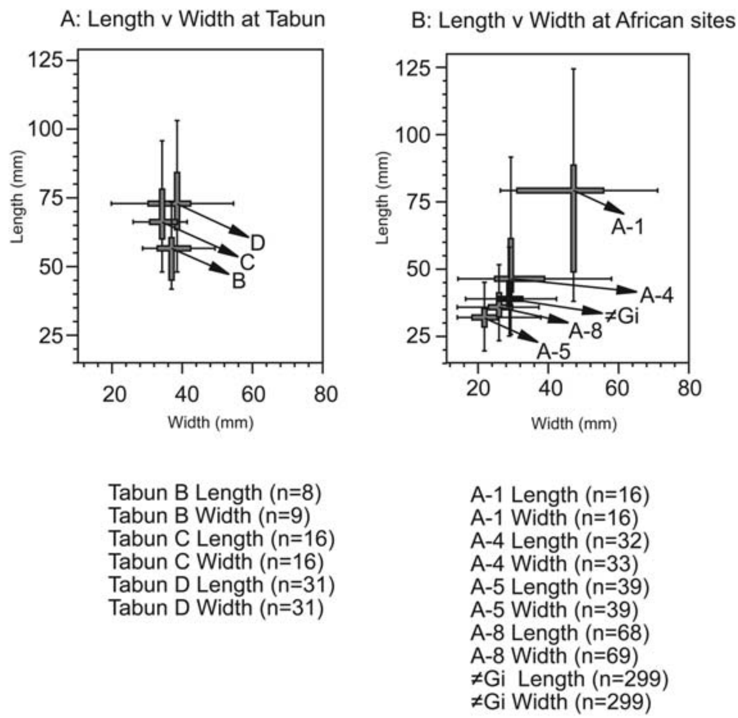
Table 2. Metric values of points at Tabun, Aduma and ≠Gi

	Length (mm)	Width (mm)	Thickness (mm)	Angle (degrees)	Weight/ predicted (g)
Tabun B N	8	9	9	9	9
Mean	53.6	36.7	7.2	55.6	12.6
Std. Deviation	11.1	7.6	1.9	8.8	6.0
Tabun C N	16	16	16	10	14
Mean	67.8	34.4	8.3	46.0	16.8
Std. Deviation	12.5	8.1	2.4	11.7	11.9
Tabun D N	31	31	31	31	31
Mean	71.9	35.9	8.7	45.5	19.0
Std. Deviation	13.9	8.9	2.3	10.3	9.6
≠Gi N	16	16	16	16	16
Mean	74.0	46.8	14.1	55.3	50.1
Std. Deviation	24.9	14.7	3.8	11.8	43.9
Aduma 1 N	68	69	69	68	68
Mean	35.4	27.4	9.0	61.2	8.8
Std. Deviation	7.4	10.0	2.3	15.6	6.0
Aduma 8 N	32	33	33	32	32
Mean	48.5	32.8	10.7	57.3	19.7
Std. Deviation	16.3	10.8	4.7	19.1	20.2
Aduma 4 N	39	39	39	37	39
Mean	32.5	23.9	7.3	55.8	6.6
Std. Deviation	11.0	8.6	2.7	13.9	6.8
Aduma 5 N	299	299	260	299	299
Mean	40.2	30.1	10.2	70.5	11.8
Std. Deviation	8.4	6.1	2.7	10.6	7.2

from *ca.* 70 mm in the lower levels to *ca.* 50 mm in Level B, well within the range of ethnographic spear heads. The comparable distributions at Aduma and ≠Gi are shown in Figure 8b. In general, at Aduma, both length and width decrease regularly through time and in constant relation to each other.

The relationship between thickness and width is compared between the two regions and follows a pattern similar to the relationship between length and width. At Tabun, (Figure 9a) thickness decreases slightly from D up to B, but width is held relatively constant. On the other hand, at Aduma (Figure 9b), thickness and width both decrease through time in a constant ratio. As a result of maintaining a constant width through time while decreasing length and thickness, the point angle at Tabun becomes duller over time (Figure 10a). One interpretation of this pattern is that the hafting requirements remained constant, without regard for the functional quality of the point itself. At Aduma on the other hand (Figure 10b) the point angle is relatively invariant through time, averaging between 55 and 60 degrees, suggesting that consistency in the functional attributes of the point itself was more important than consistency of the hafting scheme.

Perhaps the most important attribute in the development of a projectile technology is weight, since Newton's second law predicts that a lighter projectile must



Cross plot sample size
included sample (# of outliers not shown)

	late		early	early			late
	Tabun B	Tabun C	Tabun D	≠Gi	Aduma 1	Aduma 8	Aduma 4	Aduma 5
Length	8(0)	16(0)	31(0)	285(14)	16(0)	67(1)	32(0)	36(3)
Width	9(0)	14(2)	31(0)	290(9)	16(0)	67(2)	33(0)	37(2)
Thickness	9(0)	15 (1)	31(0)	257(3)	15(1)	65(4)	32(1)	38(1)
Angle	9(0)	10(0)	30(1)	299(0)	16(0)	68(0)	32(0)	36(1)
Weight/*Predicted Weight*	9(0)	12(2)	30(1)	282(17)	15(1)	64(4)	31(1)	35(4)

Figure 8. Distribution of Length *vs*. Width at Tabun (A) and African sites (B). Box plots show the mean and one standard deviation, whiskers show 1 to 2 standard deviations. Outliers not shown.

be propelled with greater acceleration to achieve the same force or penetration (or, conversely, a more forceful propulsion system allows use of a lighter projectile). While the haft certainly contributed a major part of total projectile weight, functional considerations would require that haft and point weights be related, so that a large heavy haft would tend to be armed with a large heavy point. Point weight decreases through time in both Africa and the Levant, but much more so in the African sample, reaching averages of as low as 6.6 grams at some of the Aduma sites (Figure 11a, b).

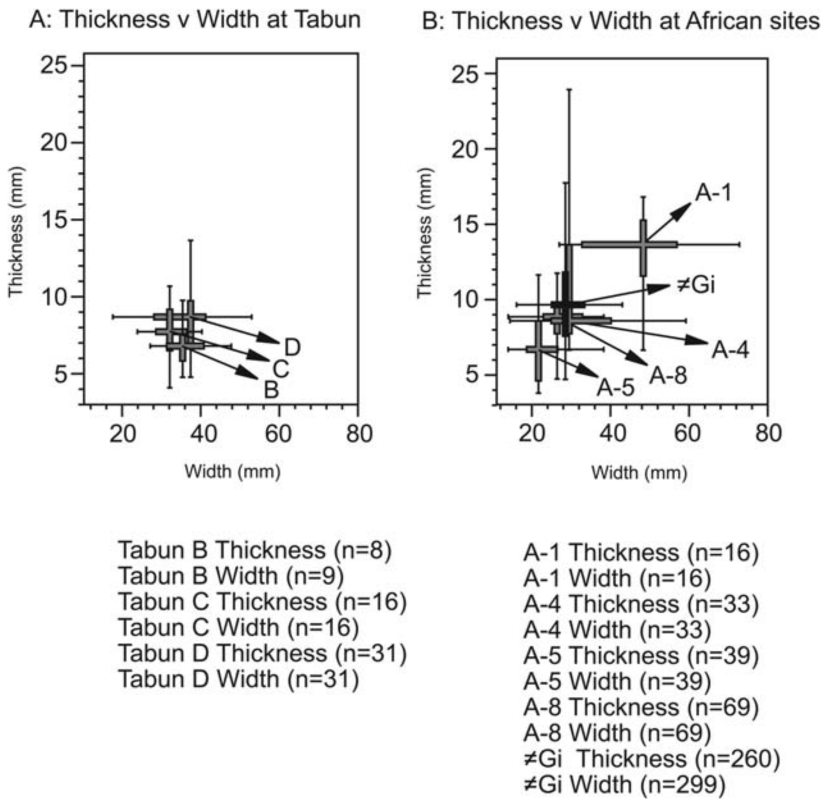


Figure 9. Distribution of Thickness *vs.* Width at Tabun (A) and African sites (B). Box and whisker plots as in Figure 8. In figure 9A: Tabun B thickness and width (n = 9 for each measurement); Tabun c thickness and width (n = 16 each); Tabun D thickness and width (n = 31 each); figure 9B: A-1 thickness and width (n = 16 for each measurement); A-4 thickness and width (n = 33 each); A-5 thickness and width (n = 39 each); A-8 thickness and width (n = 69 each); ≠Gi thickness (n = 260); ≠Gi width (n = 299).

While all pieces from ≠Gi and Tabun were weighed on an O-Haus triple beam balance, weights of points at Aduma were estimated from the volume. We used the total of 0.5 times maximum width times maximum length times maximum thickness (0.5 W × L × Th) as a proxy for the volume of a roughly triangular point. For the ≠Gi sample, the regression formula calculated for weight against this volume was

$$\text{Weight (g)} = 0.750 + (\text{Volume in mm}^3 \text{ times } 0.001684).$$

The adjusted r^2 value (0.944) was significant beyond 0.001 level, indicating that the formula accounts for 94% of the variance in the ≠Gi point sample. We used this regression formula to predict the weights of points from Aduma for which we did not have direct measurement of the weight. Since the obsidian of

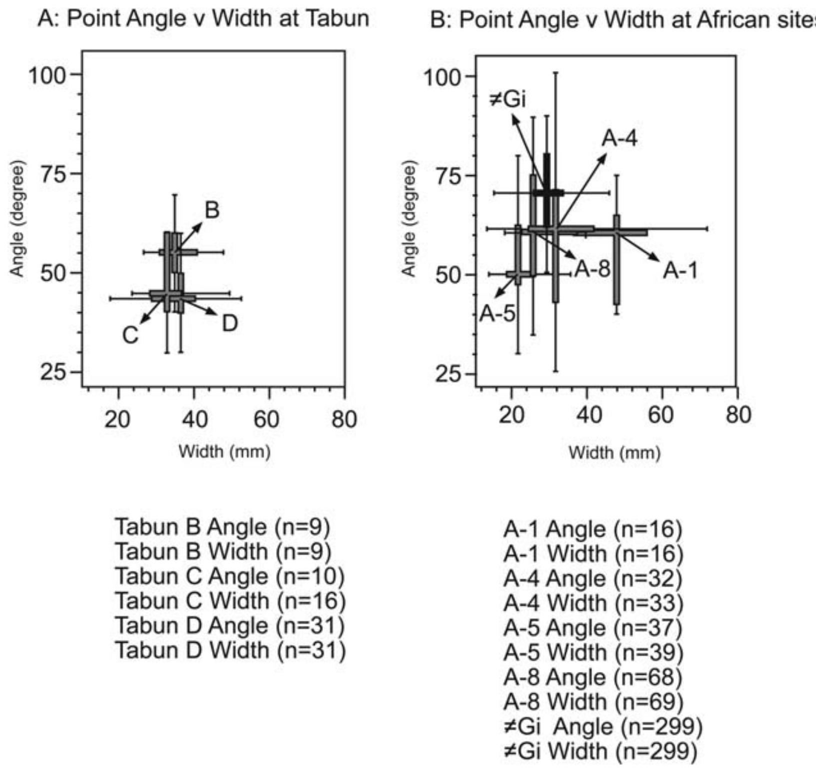


Figure 10. Distribution of Point angle *vs.* Width at Tabun (A) and African sites (B). Box and whisker plots as in Figure 8.

the Aduma points is lighter than the quartzite and silcrete of the ≠Gi points, the actual values are likely to be even lower than the estimated ones. For Tabun, the comparable formula was

$$\text{Weight} = 0.426 + (\text{Volume} \times 0.001571).$$

The adjusted r^2 value was 0.914, which accounts for 91% of the variation and is significant to the .000 level. Regression formulae which predict the mass based on the area of a point were derived separately using comparative material from either Africa or the Levant, both formulae describe a large potion of the variation in the samples, both formulae are highly significant, and both formulae provide reasonable estimates of the mass of Aduma points.

Marginal retouch is another area in which Aduma MSA points are distinguished from Tabun points (Figure 12). Each piece was divided into six retouch areas, three per side, and the presence, position and nature of the retouch, if any, were noted for each area While some points from the earliest Tabun sample are retouched, a greater portion of Aduma points are retouched in every level. The pieces that are retouched at Aduma are more completely retouched (retouched in

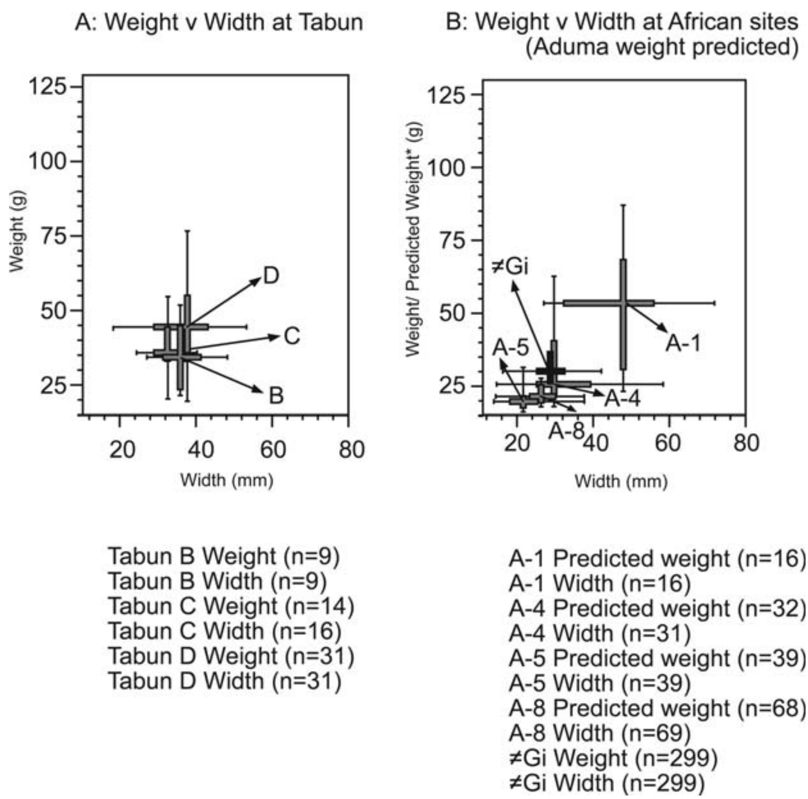


Figure 11. Distribution of Weight *vs.* Width at Tabun (A) and African sites (B). Box and whisker plots as in Figure 8.

more areas of each piece) than the Tabun points. While inverse, or ventral, retouch is rare throughout, it is actually most common in Tabun D. Bifacial retouch, on the other hand, is virtually absent in the Tabun sample and present at significant frequencies throughout the Aduma sample, except for the uppermost level. Invasive retouch, a hallmark of the classic MSA, is found at low levels in Tabun D (although not in B or C), but at Aduma, it rises along with the frequency of classic MSA points to a maximum in the Ardu II silt sites, then decreases slightly at the top.

Finally, striking platforms of complete pieces are virtually unmodified in the Tabun assemblage but up to 50% are thinned or removed on the Aduma points. Overall, the earliest Aduma points from A-1 are most similar to the Tabun points from Level D. If one were to argue from the points for a moment of contact or expansion in either direction, this time period represents the most likely candidate. The later points in both areas dating to late OIS 5 and early OIS 4 are increasingly divergent in style.

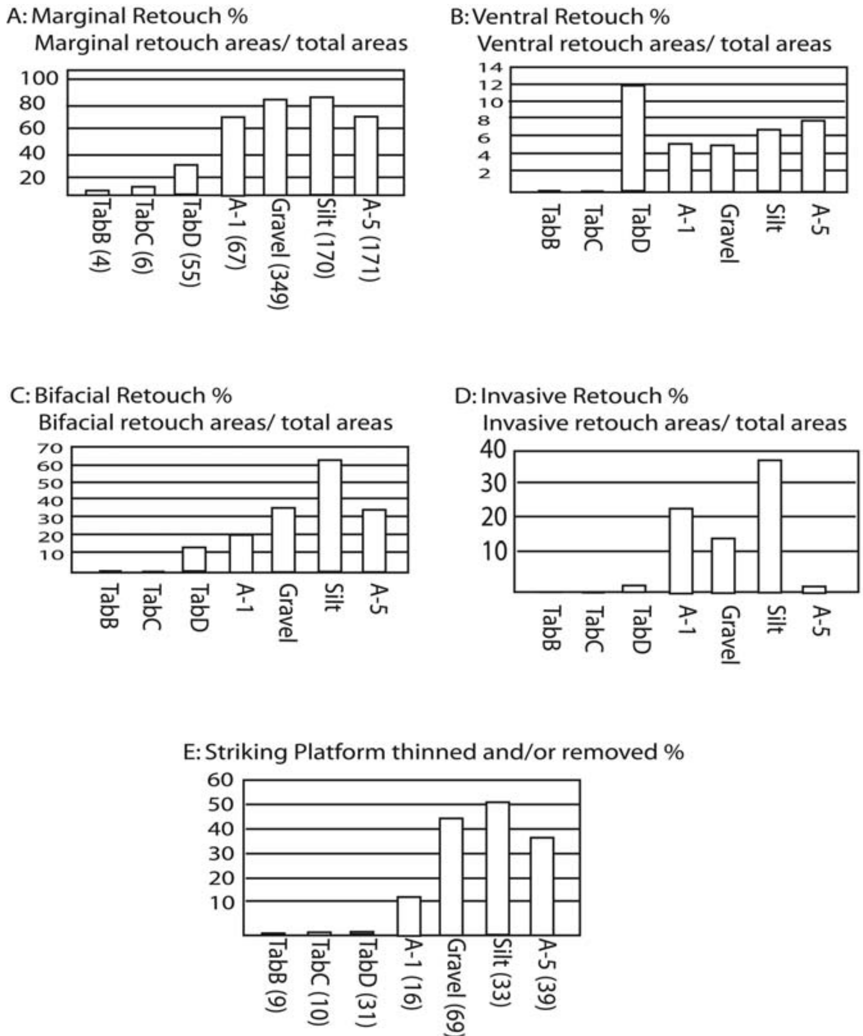


Figure 12. Comparative retouch on points at Tabun and African sites. Sites are arranged with the oldest Tabun (Tab D) and African (A-1) sites in the center, with others ordered regionally by decreasing age to the left and right respectively. Marginal, ventral, bifacial and invasive retouch (Figure 12: A–D) are expressed as the percentage of areas retouched over the total number of areas available for retouch (3 per side – distal, central, proximal, 6 per piece with left and right side calculated separately). Striking platform thinning/removal is expressed as number of modified striking platforms over total number of complete points.

ETHNOGRAPHIC COMPARISONS

While it is difficult to reconstruct the entire projectile system from the lithic remains, North American archaeologists have used ethnographic examples to derive correlations between lithic attributes and projectile systems. This type of correlation, of course, does not encompass the possibility of now-vanished projectile systems relating to an earlier evolutionary stage. The most cited study is that of D.H. Thomas (1976) who examined 142 stone-tipped projectiles from ethnographic contexts housed at the American Museum of Natural History. His results showed that while some arrowheads were large and weighed between 11 and 17 g, most were very small, and weighed 4 g or less. Spear thrower darts, on the other hand, varied between *ca.* two and eight grams.

The Aduma points tend increasingly toward the dimensions of spear thrower darts or arrows, and hold point angle constant. Although ethnographic and archaeological examples of spear throwers are not known from any African site, spear throwers are present at a much later date on all the other inhabited continents and begin to appear at a time when African LSA armatures already fall within the size range of modern arrowheads (at <1.5 g). The early diminution of African stone armature may indicate that Africa passed through a spear thrower stage at an earlier date.

DISCUSSION AND CONCLUSIONS

In summary, the regional and chronological diversity and specificity of MSA points, their small size, the emphasis on control and standardization of basal morphologies, and point angles, and the extensive use of bifacial retouch can be thought of as a complex of features; this complex distinguishes MSA points after 100,000 years ago from those of the Levantine Mousterian. The decrease in point size and weight within the MSA suggest concomitant development of a system that could propel projectiles over greater distances, increasing hunting success while decreasing risk to the hunter. The projectile system, whether a bow and arrow or more likely, a spear thrower, would have involved organic materials that have not survived. In both Europe and North America, the use of spear throwers may have preceded in some instances the use of the bow and arrow. Since the early Upper Paleolithic of Europe is also characterized by small and/or light (bone) projectile armatures (*e.g.*, Bricker *et al.* 1995; Brooks *et al.* 1995; Cattelain 1997; Perpère 1997; Hays and Lucas 2001, *etc.*) several authors have argued for early use of a complex projectile system, despite the absence of actual examples of either bows or spear throwers.

The adoption of a complex projectile system during the MSA, in combination with the development of complex economic, social and symbolic systems signified by such finds as increased use of marine and lacustrine resources (Brooks *et al.* 1995; Yellen *et al.* 1995; Henshilwood and Sealey 1997; Crawford *et al.* 1999; Poeggenpohl 1999), regional point "styles" (Clark 1988; McBrearty and Brooks

2000), incised ocher plaques (Henshihlwood *et al.* 2002), long distance transport of raw materials (Merrick *et al.* 1994), and beads (Hare *et al.* 1993; Kuhn *et al.* 2001) would have resulted in lowered risk to individual hunters and increased survivorship of both individuals and populations (McBrearty and Brooks 2000). Increased survivorship, in turn, could explain the successful expansion of anatomically modern humans out of Africa at *ca.*60,000 years BP. The apparent similarity of even earlier point technologies in Africa and the Near East to one another, exemplified respectively by Aduma A-1 and Tabun D, could also explain the failure of earlier anatomically modern African populations to expand beyond the Near East, as well as the absence of significant technological differences over time between the earliest modern humans and Neandertals in the Near East. Apart from possible comparisons to a few small points from the Later MP of the Caucasus (*e.g.*, Doronichev and Galovanova 2003), European MP bifacial point technologies are closer in size to the A-1 and Tabun assemblages than to the evolved MSA points of sub-Saharan Africa.

ACKNOWLEDGEMENTS

The research in Botswana and Ethiopia was supported by NSF grants to Brooks and Yellen, and to Brooks and Clark, as well as by grants from the National Geographic Society, L.S.B. Leakey Foundation, Smithsonian Institution, and the George Washington University Committee on Research. We would like to acknowledge the assistance of Robin Teague and Paul Constantino of the George Washington University Hominid Paleobiology Program, in collecting information, photos and preparing materials for this paper. The drawings of points were done by Wendy Bruneau (≠Gi) and Fekru Haile Mariam (Aduma). In addition, we would like to express our gratitude to Tim White, the late Desmond Clark, Yonas Beyene and the other directors of the Middle Awash Project, and especially the governments and peoples of Botswana and Ethiopia, who made possible the excavations on which the paper was based. Lisa Nevell and Gideon Hartman were supported by an NSF IGERT grant and by a George Washington Presidential Fellowship to GH.

REFERENCES CITED

Bordes F. 1961. *Typologie du Paléolithique ancien et moyen*. Bordeaux : Delmas.

Bricker H.M., A.S. Brooks, R.B. Clay and N. 1995. Les fouilles de H.L. Movius Jr. à *l'abri Pataud*: généralités. In H.M. Bricker (Ed.), *Le Paléolithique supérieur de l'abri Pataud (Dordogne): les fouilles de H.L. Movius Jr: suivi d'un inventaire analytique des sites Aurignaciens et Périgordiens de Dordogne*, pp. 11–30. Paris: Editions de la Maison des Sciences de l'Homme.

Brooks A.S., A.L. Crowell and J.E. Yellen 1980. ≠Gi: a Stone Age archaeological site in the northern Kalahari Desert, Botswana. In R.E.F. Leakey and B.A. Ogot, (Eds.), *Proceedings of the Eighth Panafrican Congress of Prehistory and Quaternary Studies (Nairobi, 1977),* pp. 304–309. Nairobi: The International Louis Leakey Memorial Institute for African Prehistory.

Brooks A.S. and J.E. Yellen 1987. The preservation of activity areas in the archaeological record: ethnoarchaeological and archaeological work in northwest Ngamiland, Botswana. In S. Kent (Ed.), *Method and Theory of Activity Area Research: An Ethnoarchaeological Approach*, pp. 63–106. New York: Columbia University Press.

Brooks A.S., P.E. Hare, J.E. Kokis, G.H. Miller, R.D. Ernst and F. Wendorf 1990. Dating Pleistocene archaeological sites by protein diagenesis in ostrich eggshell. *Science* 248: 60–64.

Brooks A.S., D.M. Helgren, J.M. Cramer, A. Franklin, W. Hornyak, J.M. Keating, R.G. Klein, W.J. Rink, H.P. Schwarcz, J.N.L. Smith, K. Stewart, N.E. Todd, J. Verniers and J.E. Yellen 1995. Dating and context of three Middle Stone Age sites with bone points in the upper Semliki Valley, Zaire. *Science* 268: 548–553.

Brooks A.S. 1998. Open air sites in the Middle Stone Age of Africa. In N. Conard and F. Wendorf (Eds.), *Middle Paleolithic and Middle Stone Age Settlement Systems*, pp. 249–253. Forli: A.B.A.C.O.

Brooks A.S. and J.E.Yellen 2004. Bones of contention: bone tools and the emergence of modern human behavior. *Abstracts of the 69th Annual Meeting of the Society for American Archaeology, Montreal Canada*, p. 65. Washington DC: Society for American Archaeology.

Brooks A.S., F.J. Feathers, G. Hartman, N. Tuross, F. d'Errico and J.E. Yellen 2004. Middle Stone Age bone points from Katanda (D.R. Congo): new perspectives on age and association. Poster presented at the Annual Meeting of the Palaeoanthropology Society, Montreal Canada, March 30–31, 2004.

Cattelain P. 1997. Hunting during the Upper Paleolithic: bow, spearthrower, or both? In H. Knecht, (Ed.), *Projectile Technology*, pp. 213–240. New York: Plenum.

Clark J.D. 1988. The Middle Stone Age of East Africa and the beginnings of regional identity. *Journal of World Prehistory* 2: 235–305.

Crawford M.A., M. Bloom, C.L. Broadhurst, W.F. Schmidt, S.C.G.C. Cunnane, K. Gehbresmeskel, F. Linseisen, J. Lloyd-Smith and J. Parkington 1999. Evidence for the unique function of docasahexaenoic acid during the evolution of the modern human brain. *Lipids* 34 (Supplement): S39–S47.

Doronichev V. and L. Golovanova 2003. Bifacial tools in the Lower and Middle Paleolithic of the Caucasus. In M. Soressi and H.L. Dibble (Eds.), *Multiple Approaches to the Study of Bifacial Technologies*, pp. 77–107. Philadelphia: Museum of Archaeology and Anthropology, University of Pennsylvania.

Garrod D. 1937. The Near East as a gateway of prehistoric migration. In G.G. MacCurdy (Ed.), *Early Man, as Depicted by Leading Authorities at the International Symposium, the Academy of Natural Sciences, Philadelphia, March 1937*, pp. 33–40. Philadelphia: J.B. Lippincott Company.

Garrod D.A.E. and D.M. Bate 1937. *The Stone Age of Mount Carmel*. Oxford: Clarendon Press.

Goodwin A.J.H. 1928. An introduction to the Middle Stone Age in South Africa. *South African Journal of Science* 25: 410–418.

Haile Selassie Y., B. Asfaw and T.D. White 2004. Hominid cranial remains from Upper Pleistocene deposits at Aduma, Middle Awash, Ethiopia. *American Journal of Physical Anthropology* 123: 1–10.

Hare P.E., G.A Goodfriend, A.S. Brooks, J.E. Kokis, and D.W. von Endt 1993. Chemical clocks and thermometers: diagenetic reactions of amino acids in fossils. *Carnegie Institute Washington Yearbook* 92: 80–85.

Harper P.T. 1994. *The Middle Stone Age Sequence at Rose Cottage Cave: A Search for Continuity and Discontinuity*. Ph.D. Dissertation, University of the Witwatersrand.

Hays M.A. and G. Lucas 2001. Experimental investigations of Aurignacian Dufour bladelets. In M.A. Hays and P.T. Thacker (Eds.), *Questioning the Answers: Re-solving Fundamental Problems of the Early Upper Paleolithic* (BAR International Series S1005), pp. 109–116. Oxford: Archaeopress.

Henshilwood C. and J.C. Sealey 1997. Bone artefacts from the Middle Stone Age at Blombos Cave, Southern Cape, South Africa. *Current Anthropology* 38: 890–895.

Henshilwood C. and J.C. Sealey (n.d.). *Blombos Cave, South Africa*. Unpublished excavation report. Department of Archaeology, University of Cape Town.

Henshilwood C.S., F. d'Errico, R. Yates, Z. Jacobs, C. Tribolo, G.A.T. Duller, N. Mercier, J.C. Sealy, H. Valladas, I. Watts, I. and A.G. Wintle 2002. Emergence of modern human behaviour: Middle Stone Age engravings from South Africa. *Science* 295:1278–1280.

Klein R.G. 1989. Biological and behavioral perspectives on modern human origins in Southern Africa. In P. Mellars and C.B. Stringer (Eds.), *The Human Revolution: Behavioral and Biological Perspectives on the Origins of Modern Humans*, pp. 529–546. Edinburgh: Edinburgh University Press.

Klein R.G. 1992. The archaeology of modern human origins. *Evolutionary Anthropology* 1: 5–14.

Klein R.G. 1995. Anatomy, behavior, and modern human origins. *Journal of World Prehistory* 9: 167–198.

Klein R.G. 1998. Why anatomically modern people did not disperse from Africa 100,000 years ago. In T. Akazawa, K. Aoki and O. Bar-Yosef (Eds.), *Neandertals and Modern Humans in Western Asia*, pp. 509–522. New York: Plenum.

Klein R.G. 1999. *The Human Career*. 2nd Edition. Chicago: University of Chicago Press.

Klein R.G. 2000. Archaeology and the evolution of human behavior. *Evolutionary Anthropology* 9: 17–36.

Knecht H. 1993. Early Upper Palaeolithic approaches to bone and antler projectile technology. In G.L. Petersen, H.M. Bricker and P. Mellars, (Eds.) *Hunting and Animal Exploitation in the Later Palaeolithic and Mesolithic of Eurasia,* pp. 33–47. Washington DC: Archaeological Papers of the American Anthropological Association.

Knecht H. 1997. Projectile points of bone, antler, and stone: experimental explorations of manufacture and use. In H. Knecht (Ed.), *Projectile Technology*, pp. 191–212. New York: Plenum.

Kuhn S.L., M.C. Stiner, D.S. Reese and E. Güleç 2001. Ornaments of the earliest Upper Paleolithic: new insights from the Levant. *Proceedings of the National Academy of Sciences USA* 98: 7641–7646.

McBrearty S. and A.S. Brooks 2000. The revolution that wasn't: A new theory of the origin of modern human behavior. *Journal of Human Evolution* 39: 453–563.

Mehlman M.J. 1979. Mumba-Höhle revisited: the relevance of a forgotten excavation to some current issues in East African prehistory. *World Archaeology* 11: 80–94.

Mehlman M.J. 1989. *Late Quaternary Archaeological Sequences in Northern Tanzania*. Ph.D. Dissertation, University of Illinois, Urbana.

Mehlman M.J. 1991. Context for the emergence of modern man in Eastern Africa: some new Tanzanian evidence. In J.D. Clark (Ed.), *Cultural Beginnings: Approaches to Understanding Early Hominid Lifeways in the African Savanna* (Römisch-Germanisches Zentralmuseum, Monographien 19), pp. 177–196. Mainz: Forschunginstitut fur Vor-und Fruhgeschichte.

Mercader J. and R. Marti 1999. Archaeology in the tropical forest of Banyang-Mbo, SW Cameroon. *Nyame Akuma* 52: 17–24.

Merrick H.V. and F.H. Brown 1984. Obsidian sources and patterns of source utilization in Kenya and northern Tanzania: some initial findings. *African Archaeological Review* 2: 129–152.

Merrick H.V., F.H. Brown and W.P. Nash 1994. Use and movement of obsidian in the Early and Middle Stone Ages of Kenya and northern Tanzania. In S.T. Childs (Ed.), *Society, Culture, and Technology in Africa* (MASCA 11 [Supplement]), pp. 29–44. Philadelphia: Museum of Archaeology and Anthropology, University of Pennsylvania.

Milo R.G. 1998. Evidence for hominid predation at Klasies river mouth, South Africa, and its implications for the behaviour of early modern humans. *Journal of Archaeological Science* 25: 99–133.

Perpère M. 1997. Les pointes de la Gravette de la couche 5 de l'abri Pataud: réflexions sur les armes de pierre dans les outillages *Périgordiens*. *Colloque International: la chasse dans la Préhstoire, Treignes 1990* (ERAUL), pp. 9–15. Liège: Université de Liège.

Poeggenpohl C. 1999. *Workshop 5: Fish Remains in Archaeological Sites*. Capetown: World Archaeological Congress.

Robbins L.H., G.A. Brook, M.L. Murphy, A.C. Campbell and A.C. Melear 2000. Late Quarternary archaeological and palaeoenvironmental data from sediments at Rhino Cave, Tsodilo hills, Botswana. *South African Field Archaeology* 9: 17–31.

Shea J.J. 1988. Spear points from the Middle Paleolithic of the Levant. *Journal of Field Archaeology* 15: 441–450.

Shea J.J. 1997. Middle Paleolithic spear point technology. In H. Knecht (Ed.), *Projectile Technology*, pp. 79–106. New York: Plenum.

Thomas D.H. 1978. Arrowheads and atlatl darts: how the stones got the shaft. *American Antiquity.* 43: 461–472.

Volman T.P. 1984. Early prehistory of southern Africa. In R.G. Klein (Ed.), *Southern African Prehistory and Paleoenvironments*, pp. 169–220. Rotterdam: Balkema.

Wendorf F. and R. Schild 1974. *A Middle Stone Age Sequence from the Central Rift Valley, Ethiopia*. Wroclaw: Zaklad Narodowy im. Ossolinskich.

Wiessner P. 1983. Style and social information in Kalahari San projectile points. *American Antiquity* 48: 253–276.

Wilmsen E.N. 1974. *Lindenmeier: A Pleistocene Hunting Society*. New York: Harper & Row.

Würz S. 1997. *The Howiesons Poort at Klasies River: From Artefacts to Cognition*. M.A thesis, University of Stellenbosch.

Würz S. 1999. The Howiesons Poort backed artifacts from Klasies River: an argument for symbolic behavior. *South African Archaeological Bulletin* 54: 38–50.

Yellen J.E. 1998. Barbed bone points: tradition and continuity in Saharan and sub-Saharan Africa. *African Archaeological Review* 15: 173–198.

Yellen J.E., A.S. Brooks, E. Cornelissen, M.H. Mehlman and K. Stewart 1995. A Middle Stone Age worked bone industry from Katanda, Upper Semliki Valley, Zaire. *Science* 268: 553–556.

Yellen J.E., A.S. Brooks, D.M. Helgren, M. Tappen, S. Ambrose, R. Bonnefille, J. Feathers, G. Goodfriend, K. Ludwig, P. Renne and K. Stewart in press. The archaeology of Aduma: a Middle Stone Age site in the Awash Valley, Ethiopia. *PalaeoAnthropology*.