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Experimental Tests of Middle Palaeolithic Spear Points Using a Calibrated Crossbow

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Controlled experiments using a calibrated crossbow to thrust stone-tipped spears into animal carcasses reveal a relationship between Levallois point morphology and their performance as spear points. A comparative study of morphometric variation of Levallois points from Levantine Mousterian contexts supports the hypothesis that the demand for stone spear points was an important factor in Levallois point production.

Keywords: EXPERIMENTAL ARCHAEOLOGY, STONE TOOLS, SPEAR POINTS, MIDDLE PALAEOLITHIC, LEVALLOIS POINTS.

Introduction

The recent discovery of a Levallois point fragment embedded in the vertebra of an equid from Umm el Tlel, Syria (Boëda *et al.*, 1999) supports the hypothesis that Middle Palaeolithic humans living in Southwest Asia made and used hafted stone spear points (Shea, 1988). Nevertheless, disagreement exists over the degree to which spear point use contributed to Levallois point production and morphological design (Plisson & Beyries, 1998; Shea, 1997, 1998*b*). Morphological variability of Levallois points are key variables in Southwest Asian Middle Palaeolithic cultural variability (Bar-Yosef, 1995: 117–118). If Levallois point morphological variability also encompasses correlated variation in predatory strategies, then Levallois point morphological variability can reveal important dimensions of human biocultural evolution.

There is a vast archaeological and ethnological literature on the physical, functional, and cultural factors influencing the designs of weapon armatures (Knecht, 1997). While we remain open to the possibility that cultural factors influenced Levallois point variation, this study focuses strictly on the physical and functional factors influencing such stone points when they are used as armatures for thrusting spears. We assume that the physical constraints involved in the use of brittle stone points as weapon armatures would have caused the thrusting spear points produced by different human groups to converge around a range of optimal size and shapes configurations. To the extent that optimal size/shape configurations for spear points can be established through experimentation, and to the extent these differ from morphometric optimae for other tasks, it is possible to identify shifts in the design goals governing the production of Middle Palaeolithic stone points. Levallois points from the Levant are particulary amenable to this kind of analysis because few of them are substantially modified by retouch.

This paper reports an experiment using replicas of Levallois points as simulated hand-thrust spear points on animal carcasses. This experiment provides metric criteria for differentiating thrusting spear armatures from knives among larger samples of Middle Palaeolithic pointed stone tools. Examining Levallois point morphometric variability in light of these experiments suggests that a significant portion of Levallois points from Levantine Mousterian lithic assemblages are optimally designed for use as spear points. This emphasis on spear point production and use suggests sophisticated, technologically-assisted predatory strategies existed in the Levantine Mousterian. Viewed together with recent discoveries of wooden javelins from Middle Pleistocene contexts in Germany (Theime, 1997) and new analyses of early Upper Pleistocene faunal assemblages from Africa, Europe, and Asia (Marean &

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Assefa, 1999; Stiner, 1994), these data suggest changes in technologically assisted hunting were important factors in later Pleistocene human evolution.

Background

Lithic evidence identifying the presence and use of palaeolithic stone-tipped weaponry initially derived from subjective morphological criteria. For example, Bourlon (1906: 313–315) suggested that some of the pointed flake-tools from Le Moustier could be effectively hafted and used as spear points. Despite his support for Middle Palaeolithic stone-tipped weapons, his suggestion was not verified by experimentally derived objective criteria. Similarly, Coon's (1951: 60) proposal regarding the effectiveness of pointed implements from the Zagros Mousterian was based on his opinion concerning the appropriate morphology for a stone point. Not until the 1980s were hypotheses with specific test implications proposed for palaeolithic stone-tipped weaponry.

Shea (1988) applied a low magnification use-wear analysis to several Levantine Mousterian assemblages and found evidence for a variety of functions on Middle Palaeolithic stone tools, including spear point use. Holdaway (1989) applied a methodology derived from breakage patterns of Palaeoindian projectile points to pointed implements from two Zagros Mousterian sites, finding no evidence for Middle Palaeolithic stone-tipped spears. These two studies generated considerable debate over the existence of Middle Palaeolithic stone-tipped weaponry (Anderson-Gerfaud, 1990; Holdaway, 1990; Shea, 1990; Solecki, 1992). Corroborating evidence derived from non-lithic sources were sought to avoid the problematic interpretations offered from stone tool analyses (Churchill, 1993; Lieberman & Shea, 1994). More recent studies have supported (Dockall, 1997) or questioned (Plisson & Beyries, 1998) the existence of stone-tipped spears or sought broader ecologically relevant reasons behind the variation in Middle Palaeolithic stone tool assemblages (Shea, 1998*b*). Additional inferences from design theory (Bamforth & Bleed, 1997; Bleed, 1991) and microscopic studies of fracture initiations (Hutchings, 1997) can potentially provide complimentary evidence to identify stone-tipped spears in the archaeological record.

The debate over stone-tipped spears in the Middle Palaeolithic cannot be resolved by reference to unsystematic or subjectively derived studies of stone tools. Instead, by systematically and objectively testing hypotheses about the functional capabilities of Middle Palaeolithic points, experimental archaeology provides a way to move beyond these interpretive stalemates.

Documented experimental studies are surprisingly scarce in the recent debate over Middle Palaeolithic spear points. This gap in experimentation stands in marked contrast to the abundance of experimental studies on spear, dart, and arrow tips from Upper Palaeolithic and more recent industries (Knecht, 1997). There are few published accounts of experiments attempting to use Levallois points, Mousterian points, and similar artifacts as hafted spear armatures, and no studies examining the influence of point morphology on spear point performance. Our experiment assesses thrusting spear point performance systematically for a wide range of Levallois point morphologies. We focus on their possible use as thrusting spears, rather than their possible use as projectile points, because there is a broad archaeological consensus that if Levallois points and allied Middle Palaeolithic tool types were used as weapons armatures, they were most likely used as tips of thrusting spears (Shea, 1997: 81–83). Because Levallois points are found in Middle Palaeolithic assemblages throughout the Old World, the results of our experiments are relevant to archaeological research in many regions. However, Levallois points are relatively common in sites in the East Mediterranean Levant (Figure 1), and for this reason our discussion of the archaeological record focuses on the Levantine Mousterian.

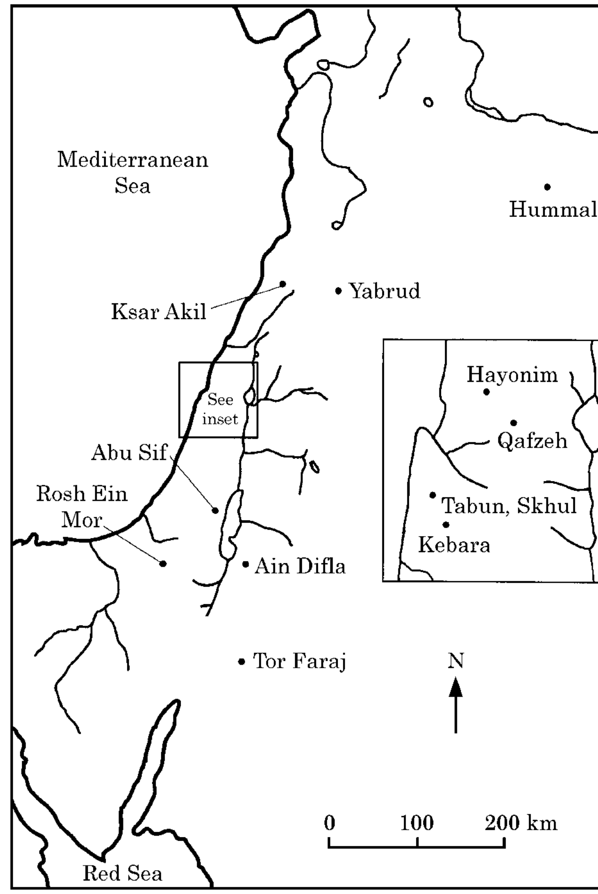

Figure 1. Map of the Levant showing the locations of archaeological sites mentioned in the text.

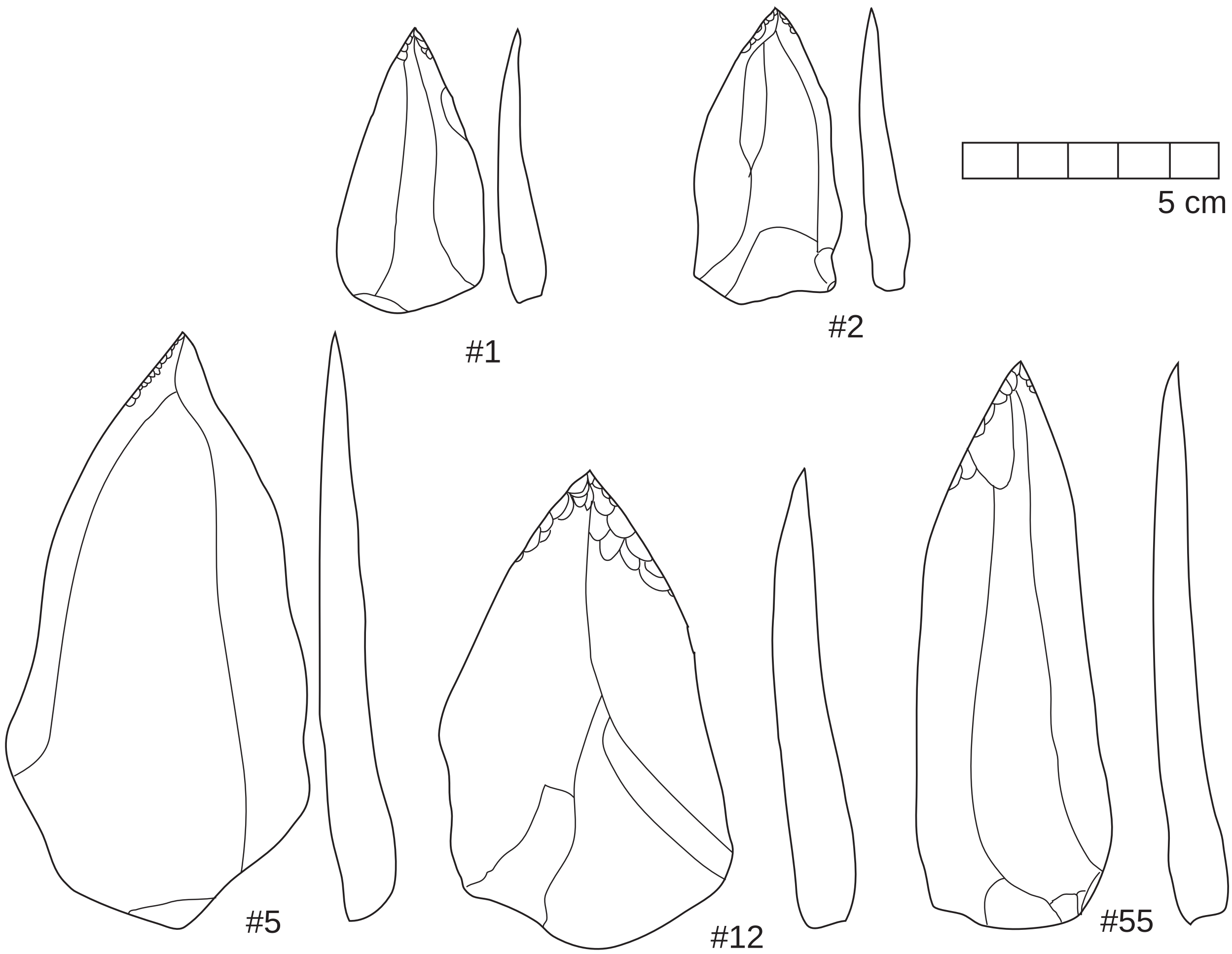

Figure 2. Selected plan and profile views of the Levallois points used in the experiments.

Experimental Methods and Materials

Fifty-four replicas of Levallois points modelled after ones found in Levantine Mousterian assemblages were used as simulated spear points in controlled experiments. These points encompass a wide range of point shapes and sizes, ranging from small isosceles points weighing less than 5 g. to elongated points weighing more than 100 g (Figure 2). All points were made of flint from sources in Israel, and most had minor retouch on their distal end. All points were examined before use, and measured, in order to confirm that their key size dimensions (length, maximum width, maximum thickness) fell within the known range of variation for Levallois points from Southwest Asian assemblages (Shea, 1997: Table 1).

In order to control loading conditions in these experiments, Brown built a "calibrated crossbow", much like the one used by Carrère & Lepetz (1988) to investigate Upper Palaeolithic projectile weapons (Figure 3). Our crossbow, however, was modified to replicate the use of hand-delivered spears. The first such modification involved using two tandem-mounted fibreglass bows to maintain high levels of loading comparable to those in actual spear use (see below). The second modification was that the main shaft on our crossbow was attached to the bowstring and guided into the target by passing the shaft through a plastic aiming tube. These features enabled points to hit their targets as do the tips of thrusting spears, with minimal variation in the angles of incidence or rotation of the spear shaft. Points were attached to wooden foreshafts with synthetic paving tar, a substance with properties similar to the bitumen mastic found in Levantine Mousterian contexts in Syria (Boëda *et al.*, 1998) (Figure 4).

We selected goats for use as targets because their size (about 60 kg), skin thickness (3–4 mm), and skeletal anatomy are similar to species, such as ibex, that are commonly found in Levantine Mousterian contexts (Shea, 1998*b*: S56). Two adult goat carcasses were suspended with ropes so that they swung freely beneath a wooden beam, approximating the resistance properties of a living animal. An exhaustive literature search failed to discover specific information on the force levels involved in the use of two-handed thrusting

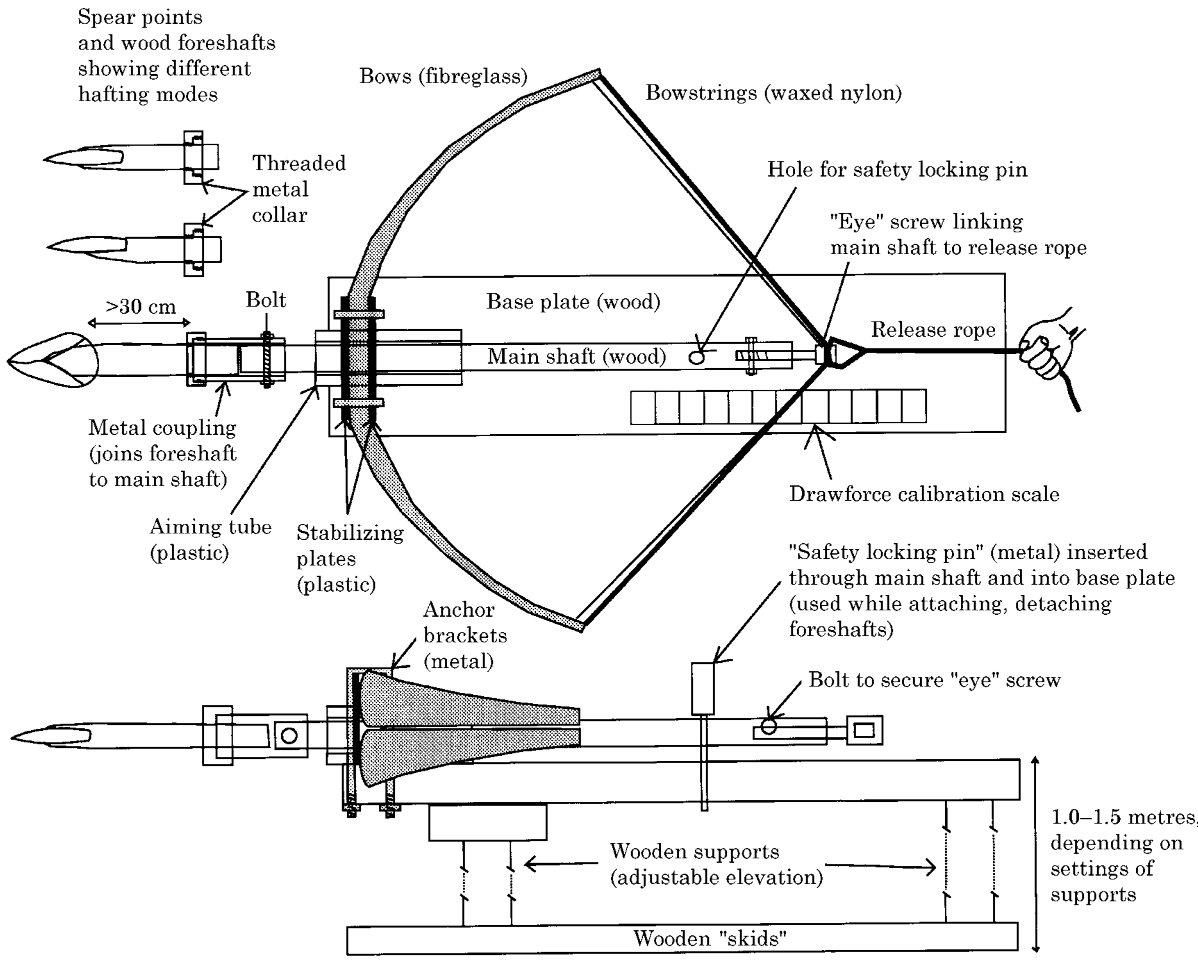

Figure 3. Schematic diagram of the calibrated crossbow used in these experiments.

spears. Lacking such actualistic guidelines, we set the crossbow at a level of force broadly comparable to that in one-handed stabbing, for which there is experimental information (Horsfall *et al.*, 1999; Miller & Jones, 1996). Each point was thrust into the carcass with a constant 28 kg of drawforce. We estimate loading speed at 0·2–0·3 seconds (1·0–1·5 m/sec) and the energy at impact at 28–63 joules. These speeds and energy levels are comparable to those established by kinematic stabbing experiments (Chadwick *et al.*, 1999: 42; Horsfall *et al.*, 1999: 88–89; Miller & Jones, 1996: 187), but they are well below the speeds (18–22 m/sec) and force levels (240–300 J) estimated for throwing spears (Cotterell & Kamminga, 1990: 166; Hughes, 1998: 352).

Points were aimed at the goat's ribcage, and the "impact zone" was shifted after each application. After each thrust, the point was retracted and inspected for wear and/or breakage. Notes and measurements were also made on the depth to which the point penetrated the carcass and the characteristics of the resulting wound. Because we were interested in the lower threshold at which use-damage became visible, experimental point use ceased when we observed macroscopic damage that would be recognizable as wear from spear point use (Plisson & Beyries, 1998; Shea, 1988, 1991). Many of these points will be used in future experiments in order to investigate the outer limits of point performance and mechanical tolerance. It should also be noted that the wounds from these points were so massive that prolonging the use of each point until it broke catastrophically would have required a supply of goats beyond the scope of this study.

At this juncture, we assessed each point's continued potential for use based on the degree to which it was damaged and the labour necessary to restore it to functionality. Points rated "Usable" were those for which the tip retained an acute point in spite of minor damage. Points were rated as "Minor Repair Necessary" if, in our estimation, they could be restored to effective use by light percussion retouch. "Broken" points were those too severely damaged for repairs to

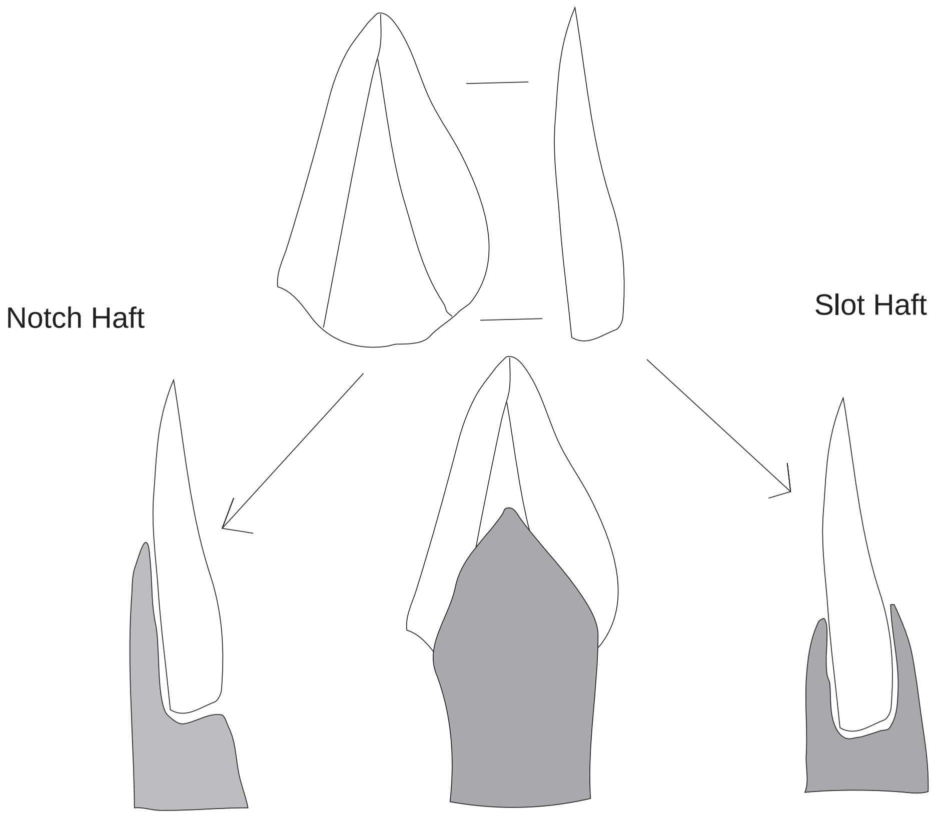

Figure 4. Schematic diagram of various hafting methods employed in this study.

be performed. Although these are subjective characterizations, a more objective measurement, the percentage of original point length remaining after use (Table 1) suggests support for our distinction between tools rated as still "Usable" and those rated as needing "Minor Repair" ($t = -3{\cdot}61$, $P = 0.003$). There are also clear differences between a pooled Usable/Minor Repair group and those tools rated as Broken ($t = -5{\cdot}48$, $P = 0.0003$).

After the completion of the experiments, each Levallois point and its foreshaft were immersed in warm water and soap, and the exposed surfaces of the point were cleaned with a soft nylon toothbrush. Shea then examined each tool for wear traces with a stereomicroscope at magnifications up to 60×. The presence, location, and size of distal breakage, lateral snapping, and edge damage were all recorded.

Table 1. Differences in the percentage of each point remaining after use for experimental points rated as Still Usable, Minor Repair Necessary and Broken

% of original length remaining	Usable	Minor repair	Broken
21–30	0	0	2
31–40	0	0	2
41–50	0	0	0
51–60	0	0	1
61–70	1	0	2
71–80	0	1	2
81–90	0	6	2
91–100	27	8	0

Results

Most Levallois points performed superbly as spear points. Nearly all points penetrated the carcasses to a depth of at least 20 cm. The wounds these points created were massive and lens-shaped in plan view. Even those few points that achieved partial penetrations (less than 20 cm) created large gaping wounds and fractured ribs. Most of the 54 spear points ($N = 32$) exhibited some damage after a single thrust, but a substantial number ($N = 22$) did not exhibit wear until after a second use. No difference in point breakage was observed between the different hafting systems employed. Points set into a notch on the shaft and points enclosed in a symmetrical slot exhibited no differences in point durability. Points secured with mastic and vegetal fibres and those secured with mastic alone also functioned similarly.

Because our experimental tools sample a wide range of archaeological Levallois point sizes and shapes, it is possible to examine the relationship between Levallois point morphology and spear point performance. Many variables relating to cross-sectional area, tip

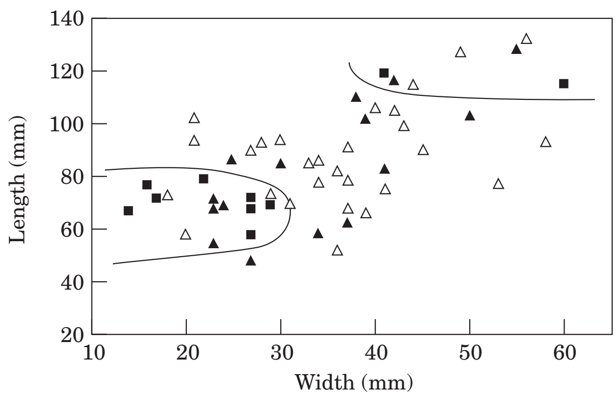

Figure 5. Scatterplot of Levallois points' length and maximum width together with their status as △ "still usable"; ▲ "minor repair necessary"; ■ "broken" at the end of their experimental use.

morphology and lateral symmetry were examined, but the clearest separation of points rated "broken" from those rated "usable" or "minor repair" is achieved by plotting actual length versus maximum width (Figure 5). "Broken" points occur in two clusters at opposite ends of the scatterplot. One (lower left) consists of smaller and narrower points and the other (upper right) is a pair of very large points. We recognize that the latter pair is not much of a cluster, but it also seems likely that there is an upper size limit for Levallois points used as spear points, and it seems plausible to interpret these points as indicating this upper threshold of point functionality. Between these clusters of "broken" points is what may be termed an "optimal zone" of point configurations, an area on the scatter-plot within which all spear points were rated as either "usable" or "minor repair necessary". It does not appear to be possible to separate points rated as "usable" or "minor repair necessary" on purely morphometric grounds.

Most of the Levallois points within the spear point "optimal zone" are relatively broad. Shorter and broader points are mechanically advantageous in low speed/high mass impact, like that associated with hand-delivered spears (Crompton, 1997: 14; Hughes, 1998: 374, Table IX). A short, broad point allows a more secure link between tool, mastic, and handle, resists rolling, and disperses torsional forces into the haft. Longer and/or narrower points minimize drag and improve the effectiveness of high-speed projectile weapons such as spearthrower darts and arrows; but, within the context of relatively low-speed weapons, shorter and wider points withstand mechanical stresses more effectively than long and narrow points.

Comparison to the Archaeological Record

The recognition that some Levallois points maintain their original morphology whereas others break catastrophically when they are used as spear points can help to resolve a current debate about Levallois point production in the Levantine Mousterian. Levantine Mousterian assemblages occur in Lebanon, Syria, Israel, and Jordan in contexts dating to between 47,000–250,000 BP (Bar-Yosef, 1998). Levallois points are present in most Levantine Mousterian assemblages, but their frequency varies widely among assemblages (Shea, 1998*b*). Two contrasting hypotheses have been proposed linking Levallois point function to Levallois point production.

The "spear points" hypothesis (Shea 1995, 1997, 1998*b*) proposes that Levallois points were made primarily for use as spear points, but allows that they were also co-opted for use in other tasks. Our experiments demonstrate that shorter and broader points resist breakage better than longer and narrower points. If Levallois points were manufactured with the intention of using them as armatures for thrusting spears, they should be short and broad. Mean values of length and maximum width for Levallois points designed for use as spear armatures should cluster in the "optimal zone" established in our experiments (Figure 5). More specifically, they should cluster in the lower part of the optimal zone, reflecting a design emphasis on greater breadth within the constraints of a triangular tool form.

An alternative "multipurpose knives hypothesis" (Boëda *et al.*, 1999: 401; Plisson & Beyries, 1998) argues that Levallois points were designed first and foremost as multipurpose knives. A triangular form length is a desirable quality for a multipurpose knife. But, compared to spear points, knives used for multiple purposes accumulate considerable edge-damage and abrasion, necessitating frequent resharpening. Holding width and thickness constant, a longer point preserves more cutting edge and greater potential for resharpening than a shorter point. If Levallois points were made with the intention of using them primarily as multipurpose knives, they should be relatively long. Mean length and maximum width for Levallois points designed as multipurpose knives should cluster in the upper part of the "optimal zone" for spear points, or above it (Figure 4). The "multipurpose knives hypothesis" allows that some Levallois points, like the one from Umm el Tlel, may have been used as spear points, but if this hypothesis is correct, those tools optimally shaped for use as spear points should be a minority in any large and representative assemblage of Levallois points (Plisson & Beyries, 1998: 14). More specifically, we would expect length and width values of such multipurpose knives to cluster in the upper and/or left side of Figure 5.

We can test the predictions of these two hypotheses with data on Levallois point morphometric variability from the following six sites: Kebara Cave (Mount Carmel, Israel), Rosh Ein Mor (Central Negev, Israel), Tor Faraj Rockshelter (Southwest Jordan), Yabrud Rockshelter I (Southwest Syria), and 'Ain Difla (Western Jordan) (Table 2). The overwhelming majority of these points are either unretouched or

Table 2. Mean and 95% confidence intervals for length (mm) and maximum width (mm) of Levallois points from Levantine Mousterian assemblages

Sample (*N* points)	Maximum length mean ± 95% c.i.	Maximum width mean ± 95% c.i.
Kebara Levels IX–XII (295)	49·0 ± 1·5	34·2 ± 1·1
Rosh Ein Mor (102)	58·7 ± 3·4	35·2 ± 1·8
Tor Faraj Rockshelter, Level C (142)	58·6 ± 2·4	35·1 ± 1·6
Yabrud Rockshelter I, Levels 2–9 (102)	64·5 ± 3·1	36·9 ± 1·5
‘Ain Difla (199)	69·7 ± 2·2	25·7 ± 1·4

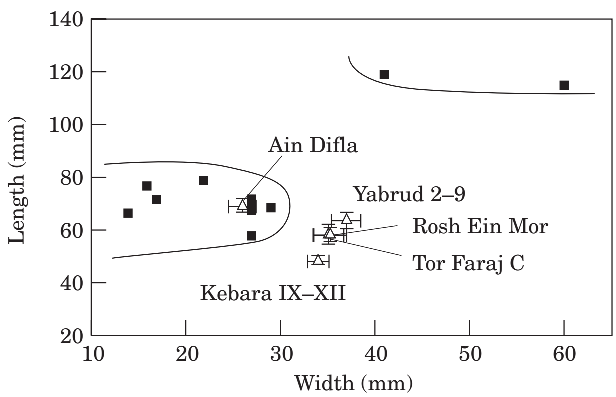

Figure 6. Scatterplot of mean length and maximum width (with 95% confidence intervals) for Levallois points from Levantine Mousterian sites (▲) and the “broken” experimental points (■).

feature only light retouch about the distal tip (otherwise, following common practice, they would have been classified as “Mousterian points”). Figure 6 plots the mean length and maximum width values for the Levallois points from these six sites. For Kebara, Rosh Ein Mor, Tor Faraj, and Yabrud, these values cluster within the lower part of the “spear point optimal zone”, indicating that most Levallois points from these sites are relatively short and broad. This distribution supports the “spear points” hypothesis and contradicts the prediction of the “multipurpose knives” hypothesis. ‘Ain Difla exhibits values outside the optimal zone, suggesting that Levallois point production associated with this assemblage may have emphasized the production of knives, rather than spear points. This interpretation is supported by the results of Roler & Clark’s (1997) microwear analysis of Levallois points from ‘Ain Difla.

While our data suggest Levallois points were designed for use as spear points, previous microwear studies of Levallois points from the Levantine Mousterian suggest that these tools were also used for a variety of tasks (Dockall, 1997; Plisson & Beyries, 1998; Roler & Clark, 1997; Shea, 1988). Similar co-opting of tools designed as weapon armatures for use in other tasks has been documented in numerous

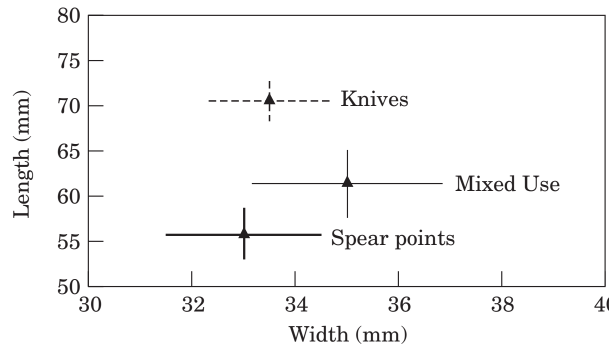

Figure 7. Scatterplot of mean length and width (with 95% confidence intervals) for Levallois points identified by Shea (1991) as worn from use as spear points, knives, and mixed-use tools.

recent archaeological contexts (e.g. Ahler, 1978) and appears to be well in line with a generally loose relationship between form and function among Middle Palaeolithic stone tools (Anderson-Gerfaud, 1990; Beyries, 1987; Shea, 1989). Clearly, such secondary use complicates the “spear points” and “multipurpose knives” hypotheses of Levallois point production. If Levantine Mousterian humans were routinely making and using stone spear points, it seems reasonable to assume that they should have selected longer points for use as knives and shorter points for use as spear points. If the “multipurpose knives” hypothesis is correct, the length of Levallois points worn from spear point use should not differ from Levallois points worn from use in other tasks. Analysis of metric variation among use-worn Levallois points can test the competing models of Levallois point production.

A low-magnification microwear analysis of Levantine Mousterian assemblages (Shea, 1991) identified numerous Levallois points as damaged from use. Length and maximum width measurements are available for 368 mostly unretouched Levallois points from Kebara Cave Levels IX–XIII, Tabun Cave Units I, II and IX, Qafzeh Cave Units XV–XXIV, Hayonim Cave Level E, and Tor Faraj Rockshelter Level C. Using the interpretive criteria discussed in Shea (1988; 1991: 80–112), these points can be divided into the following three functional groups: (1) spear points—points that exhibit wear referable to spear point impact only, (2) knives—points that exhibit wear patterns referable to tasks other than spear point use, such as cutting, scraping, or awling, and (3) mixed use tools—points featuring “impact wear” as well as wear from other tasks. As shown in Figure 7 all these functionally-defined groups of archaeological use-worn points exhibit the pattern of metric variation predicted by the “spear points hypothesis”. Spear points are significantly shorter than knives ($t = -6{\cdot}99$, $P<0{\cdot}01$), and mixed-use tools exhibit intermediate values (see also Table 3). The morphometric variability of use-worn Levallois points from Levantine

Table 3. Mean and 95% confidence intervals for length (mm) and maximum width (mm) of Levallois points with different inferred functions

Functional category (*N*)	Length mean ± 95% c.i.	Maximum width mean ± 95% c.i.
Spear points (104)	56·0 ± 2·6	33·0 ± 1·5
Mixed use tools (57)	61·5 ± 3·7	35·0 ± 1·8
Knives (207)	70·5 ± 2·6	33·5 ± 1·2

Mousterian assemblages also supports the "spear points" hypothesis of Levallois point production.

Discussion

It is well established that the Levantine Middle Palaeolithic witnesses a shift from larger and longer points in the early Levantine Mousterian to more variable morphologies in the later Levantine Mousterian (Bar-Yosef, 1995). What do the results of our experiments suggest about the behavioural factors influencing Levallois point production between these periods?

Levallois points from early Levantine Mousterian assemblages (e.g., Tabun IX, Hummal 1a, Abu Sif B-C, 'Ain Difla) are typically large and elongated, and the results of our experiments suggest many of these elongated points were probably designed for use as knives. The limited faunal evidence available for the Early Levantine Mousterian and the preceding Acheulo-Yabrudian does not indicate a major shift in faunal exploitation behaviour of the sort one might expect if a new hunting weapon technology had been developed (Bar-Yosef, 1989: 174–176; Garrard, 1982). Thus, the inception of Levallois point production in the early Levantine Mousterian may reflect shifts in early human technological organization that are not necessarily correlated with changes in hunting strategies. Instead, these changes may reflect the invention of effective hafting techniques (Clark, 1970: 142) possibly combined with shifts in mobility strategies (Marks, 1989).

Later Levantine Mousterian assemblages dating to between 47,000–130,000 BP, such as those from Tabun Unit I, Skhul B, Qafzeh I–XXIV, and Kebara VIII–XIII, feature shorter and broader points. The apparent late survival of elongated point production in the Negev complicates this picture somewhat, but as shown in Figure 6, the actual dimensions of Levallois points from the Negev do not differ markedly from those in other late Levantine Mousterian assemblages, like Tor Faraj C. Our experiments suggest these kinds of points were more likely designed for use as spear points than as knives. Faunal assemblages from some later Levantine Mousterian contexts are dominated by a few species, such as aurochs (89·5% of NISP at Skhul), fallow deer (71–73% of Ksar Akil 29–36) and gazelle (62% of Kebara, 86% of Hayonim) (Bar-Yosef, 1989: Table 7.3; Speth & Tchernov, 1998). This seemingly correlated shift in the lithic and faunal evidence may reflect more frequent use of highly-scheduled "intercept" hunting strategies in which reliability-enhancing stone weapon armatures would have been most useful (Shea, 1998*b*: S51). The particularly large number of relatively short and broad Levallois points recovered from Kebara Cave (Meignen & Bar-Yosef, 1992) may reflect intensified intercept hunting in the context of decreased residential mobility (Lieberman & Shea, 1994).

Binford (1968) proposed that the Levantine Mousterian sequence encapsulated a shift towards more predatory subsistence strategies. At the time, her hypothesis was rejected by many researchers because it ran counter to the prevailing view of the Middle Palaeolithic as a period of cultural and behavioural stability (e.g., Bordes & de Sonneville-Bordes, 1970). We now recognize that the Middle Palaeolithic was the period in which anatomically-modern humans originated (Klein, 1995), and there is a logical expectation for archaeological evidence of marked bio-behavioural change. Increasingly, closer scrutiny of the Middle Palaeolithic record in the Levant is revealing significant behavioural variability (Lieberman, 1998; Shea, 1998*b*; Stiner & Tchernov, 1998). Although we are considering different evidence from Binford, we feel that our evidence supports her theory that changes in settlement, subsistence, and technological strategies during the later Levantine Mousterian were integral to the origin of modern human behaviour.

Conclusions

Until now, estimates of the role that spear point use played in Middle Palaeolithic industrial variability has been based on ethnographic analogy, microwear interpretations, and the abundance of triangular flakes in lithic assemblages. Each of these approaches is problematical for a variety of reasons (Marks, 1998; Shea, 1998*a*). Evaluating spear point use from functionally-significant metric properties of the points themselves, as we have shown here, is a systematic and objective way to answer questions about the role of spear point use in Levallois point production. This approach to the question of Middle Palaeolithic spear points can serve as an independent check on functional hypotheses originating from other lines of evidence. As in efforts to measure the "curation" of lithic artifacts (Davis & Shea, 1998), the advantage of this approach is that it focuses on specific and readily quantifiable dimensions of archaeological variability that have an empirically-demonstrable relationship to the behaviour in question.

Our comparison of experimental spear points and archaeological stone tools supports the hypothesis that Levallois point production and spear point use were causally connected to each other in the Levantine

Mousterian. We are not arguing that every Levallois point from the Levantine Mousterian was either actually used as a spear point or originally intended for use as a spear point. Rather, we are proposing an hypothesis that can be tested by examining metric variation among Levallois points from individual assemblages (see also Crompton, 1997).

Although we have focused on the link between one stone tool type and one mode of tool use, the relationships between stone tool production and stone tool function in the Middle Palaeolithic are undoubtedly more complex than this. Clearly, such factors as raw material availability (Munday, 1979), the position of individual sites in relation to other landscape features (Binford, 1968), the effects of prolonged human habitation on the structure of local game populations (Lieberman & Shea, 1994: 318), and the availability of alternative, low-risk food sources (plants and small animals) (Shea, 1998*b*: 49) all need to be taken into account in the analysis of Middle Palaeolithic industrial variability. Such multifactorial analysis is, needless to say, a daunting challenge, but it is necessary in order to create more realistic and testable models of prehistoric technological strategies.

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