Chapter 8
Projectile Damage and Point Morphometry at the Early Middle Paleolithic Misliya Cave, Mount Carmel (Israel): Preliminary Results and Interpretations

Alla Yaroshevich, Yossi Zaidner, and Mina Weinstein-Evron

Abstract This contribution presents analyses of projectile damage and morpho-metric characteristics of various point types from the Early Middle Paleolithic Misliya Cave, Mount Carmel, Israel. All the types present in the assemblage exhibit diagnostic impact fractures. Four types, i.e., Levallois points, Abu Sif points, Hummal points and the newly defined Misliya points appear to be the most frequently used as tips of hunting weapons. These four types differ in their morpho-metric characteristics, as well as in terms of the frequencies of diagnostic impact fractures. We suggest that the variability in points may reflect the use of different kinds of weapons, including composite projectiles – a possibility supported by the faunal evidence from Levantine MP sites and Misliya Cave, in particular. Whether the diversity in point types and sizes reflects use in different kinds of hunting weapons or variability within the same kind, the study can contribute significantly to our understanding of the technological and subsistence transformations associated with the emergence of the Middle Paleolithic in the Levant.

Keywords Early Middle Paleolithic • Levant • Hunting weapons • Impact fractures • Blade technology • Mount Carmel

Introduction

The appearance of points in flint tool assemblages is one of the distinctive features characterizing the emergence of the Middle Paleolithic (MP) in the Levant. This tool class is especially dominant and diverse during the early phase of the period, the Early Middle Paleolithic (EMP). A variety of blanks obtained through different reduction methods, including prismatic blade technology (e.g., Bar-Yosef 1998), were modified into points with a broad array of forms from simple Levallois points (unmodified) to carefully and intensively retouched Abu Sif points (Copeland 1985; Gordon 1993; Wojtczak 2011; Zaidner and Weinstein-Evron 2012). The latter became the type fossil of the Early Levantine Mousterian (Copeland 1975, 1983; Neuville 1951; Meignen 1998, 2011).

The appearance of stone points in the prehistoric record implies changes in hunting related technology. Indeed, studies by Shea (1988, 1989a, b, 1991, 1993) identified the function of Levallois points from a number of Levantine Mousterian sites as tips of hunting weapons based on the presence of projectile damage (but see Plisson and Beyries 1998 for an alternative view suggesting that Levallois points were mainly used for cutting plant material). Retouched point types from an EMP context have never been studied in detail with regard to their function as projectile weapons, thus the connection between the variability of point assemblages and hunting weapons technology associated with the emergence of the MP remains poorly understood.

The global prehistoric record has provided only a few findings directly indicating use of particular kinds of weapons. Use of simple projectiles is evident from wooden spears found in several European sites (Dennel 1997; Theime 1997 and references therein). The earliest complex projectiles, i.e., spearthrowers and darts, as well as bows and arrows came from the context of the European Upper Paleolithic (Rust 1943; Garrod 1955; Rausing 1967; Stodiek 1992, 1993; Morales and Straus 2009). The function of the

A. Yaroshevich (✉)
Israel Antiquities Authority, P.O. Box 586, 91004 Jerusalem, Israel
e-mail: allayaroshe@gmail.com

Y. Zaidner · M. Weinstein-Evron
Zinman Institute of Archaeology, University of Haifa, 31905 Haifa, Israel
e-mail: yzaidner@research.haifa.ac.il

M. Weinstein-Evron
e-mail: evron@research.haifa.ac.il

Radu Iovita and Katsuhiro Sano (eds.), *Multidisciplinary Approaches to the Study of Stone Age Weaponry*, Vertebrate Paleobiology and Paleoanthropology, DOI 10.1007/978-94-017-7602-8_8

MP/MSA (Middle Stone Age) points as tips of hunting weapons is evident from findings of points embedded into vertebrae of large ungulates (i.e., Milo 1998; Boëda et al. 1999) and the presence of fractures diagnostic of impact. These were found on Levantine (Shea 1988, 1989a, b, 1991, 1993), European (Villa and Lenoir 2006; Villa et al. 2009a; Villa and Soriano 2010) and African points (Lombard et al. 2004; Lombard 2005, 2007, 2008; Villa and Lenoir 2006; Lombard and Pargeter 2008; Villa et al. 2009b) and interpreted, in most cases, as tips of simple projectiles, i.e., spears for thrusting or throwing by hand.

Several recent works indicate that particular types of MSA points served as tips of complex projectiles. Brooks and colleagues (2006) suggested that the decrease in point length, width, thickness and weight alongside the unchanging angle of the distal tips (55°–60°) during the MSA sequences in Botswana and Ethiopia reflects adoption of a complex projectile system. Another metric characteristic, Tip Cross Sectional Perimeter (TCSP), based on the maximal width and maximal thickness (see below for calculation) of various MSA point types and compared with ethnographic North American dart tips showed a theoretical plausibility that points from Porc Epic cave in Ethiopia served as tips of darts thrown with spearthrower (Sisk and Shea 2009, 2011). Lombard and Philipson (2010) and Lombard (2011) showed that backed segments, the type fossil of the MSA Howiesons Poort culture, were used as transversal arrowheads. This interpretation is based on several kinds of evidence including the location and the direction of macro- and micro- Diagnostic Impact Fractures (DIF), residue location and the small size of the segments.

Here we present analyses of projectile damage and morpho-metric characteristics of points from the EMP Misliya Cave, Mount Carmel, Israel. The aim of this contribution is to describe the variability of the point assemblage and to provide possible interpretations for the diversity of the types and sizes in terms of their use as tips of hunting weapons. We believe that our contribution will comprise a base for further investigations of hunting-related technological transformations associated with the emergence of the MP in the Levant.

The Site and the Point Assemblage

Misliya Cave is located on the western slopes of Mount Carmel, slightly to the south of Nahal (Wadi) Sefunim, at an elevation of ca. 90 m, some 12 km south of Haifa (Fig. 8.1) and ca. 7 km north of Nahal Me'arot (Wadi el-Mughara) and the caves of Tabun, el-Wad and Skhul (Garrod and Bate 1937; McCown 1937; Jelinek 1982a, b; Jelinek et al. 1973). Excavations in 2001–2010 revealed a rich EMP layer spread over the Upper Terrace of this collapsed cave (Fig. 8.2), below a residual rock shelter or overhang (Weinstein-Evron et al. 2003). The dating of the archaeological sequence is still in process. Preliminary TL dates on burned flint artifacts from the site suggest that they are older than 200 ka (Valladas et al. 2013), thus corroborating the dates recently obtained for the same cultural phase in the nearby Tabun Cave (ca. 260–190 ka BP; Mercier and Valladas 2003, and references therein) and at Hayonim Cave, in the western Galilee (230–170 ka BP; Mercier et al. 2007) and broadly assigning the site to marine isotope stage (MIS) 7. An ongoing technological and typological analysis of the lithic industry indicates that points of various forms comprise about 40% of the tool assemblage (Zaidner and Weinstein-Evron 2012).

The typological classification of points is based on their morphological and technological features as follows: **Levallois points** (Fig. 8.3a); **Retouched Levallois points** (Fig. 8.3b); **Abu-Sif points** (elongated Mousterian points): points retouched along both edges by continuous and

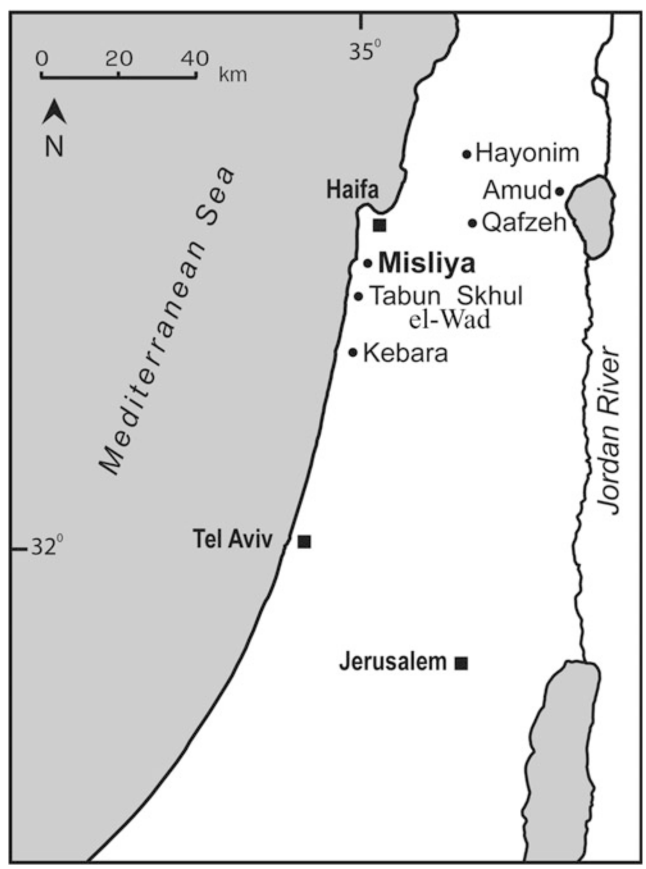

Fig. 8.1 Location map

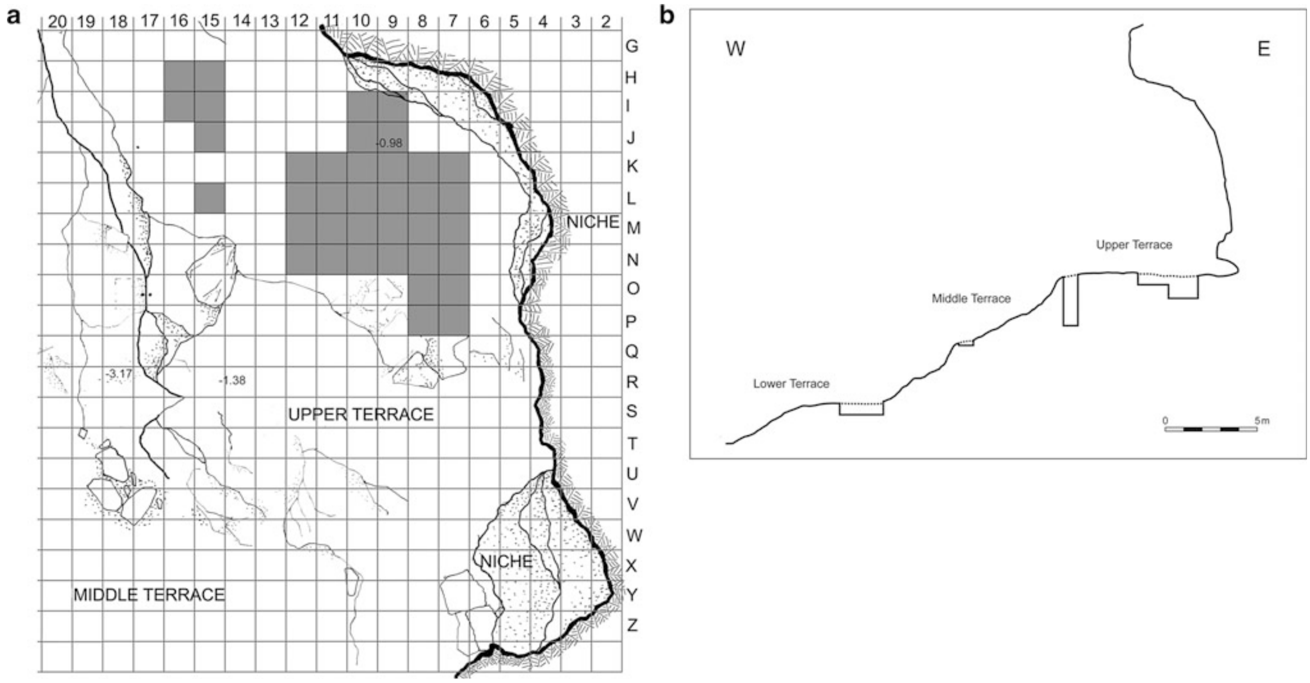

Fig. 8.2 Misliya Cave, excavated area. **a** Plan; **b** section through the three terraces

invasive or short retouch. These are made either on elongated Levallois points, elongated flakes or narrow blades (Fig. 8.3c, d); **Hummal points**: points with one fully or almost fully retouched edge opposite an edge that is either unretouched or retouched only on the tip (Fig. 8.3e). Made predominantly on blades, some are possibly made on Levallois blanks. The retouch is usually regular but not invasive and changes only slightly the original form of the blank; **Misliya points** a newly defined point type, with tip modified by abrupt retouch in the form of an oblique truncation (Fig. 8.3f). Misliya points are made on small thin blades, Levallois as well as non-Levallois, or on small Levallois points; **Points with bifacial, alternate or ventral retouch**: points made on Levallois and non-Levallois elongated blanks and modified with invasive retouch which may be either bifacial, alternating or on the ventral surface (Fig. 8.3g); **Off-set points**: points with retouch creating either an oblique truncation or an arch-like back (Fig. 8.3h). In both cases the tip of the point is offset relative to the striking axis of the blank.

For the present project we studied points from the material excavated until the 2009 season. The assemblage consists of 291 points. Levallois points (N = 90) comprise the largest group; the second largest group are Hummal (N = 46) followed by retouched Levallois points (N = 36), Abu Sif points (N = 36) and Misliya points (N = 21). Points with bifacial, alternate or ventral retouch (N = 9) and off-set points (N = 7) complete the studied assemblage. Fifty broken distal tips which could not be assigned confidently to any particular type were not included in the analysis. Figure 8.4 represents the distribution of the points within the EMP layer of Misliya Cave, showing possible contemporary use of various types.

Methods

Types and Frequencies of Diagnostic Impact Fractures

Fischer et al. (1984) delineated two types of macro-fractures, *spin-off* (Fig. 8.5a) and *step terminating bending* (Fig. 8.5b) as diagnostic of projectile impact (Hayden 1979). These two types, along with burin-like removals – another type of impact damage described in experimental studies (e.g., Barton and Bergman 1982; Bergman and Newcomer 1983) were recognized in subsequent archery experiments and analyses of archaeological points (e.g., Odell and Cowan 1986; Nuzhnyy 1989, 1990, 1999, 2008; Lombard et al. 2004; Lombard and Pargeter 2008; Yaroshevich 2010; Yaroshevich et al. 2010; Petillon et al. 2011). On a microscopic level, diagnostic impact damage appears as linear polishes and striations (Fischer et al. 1984; Crombe et al. 2001). Recent experiments

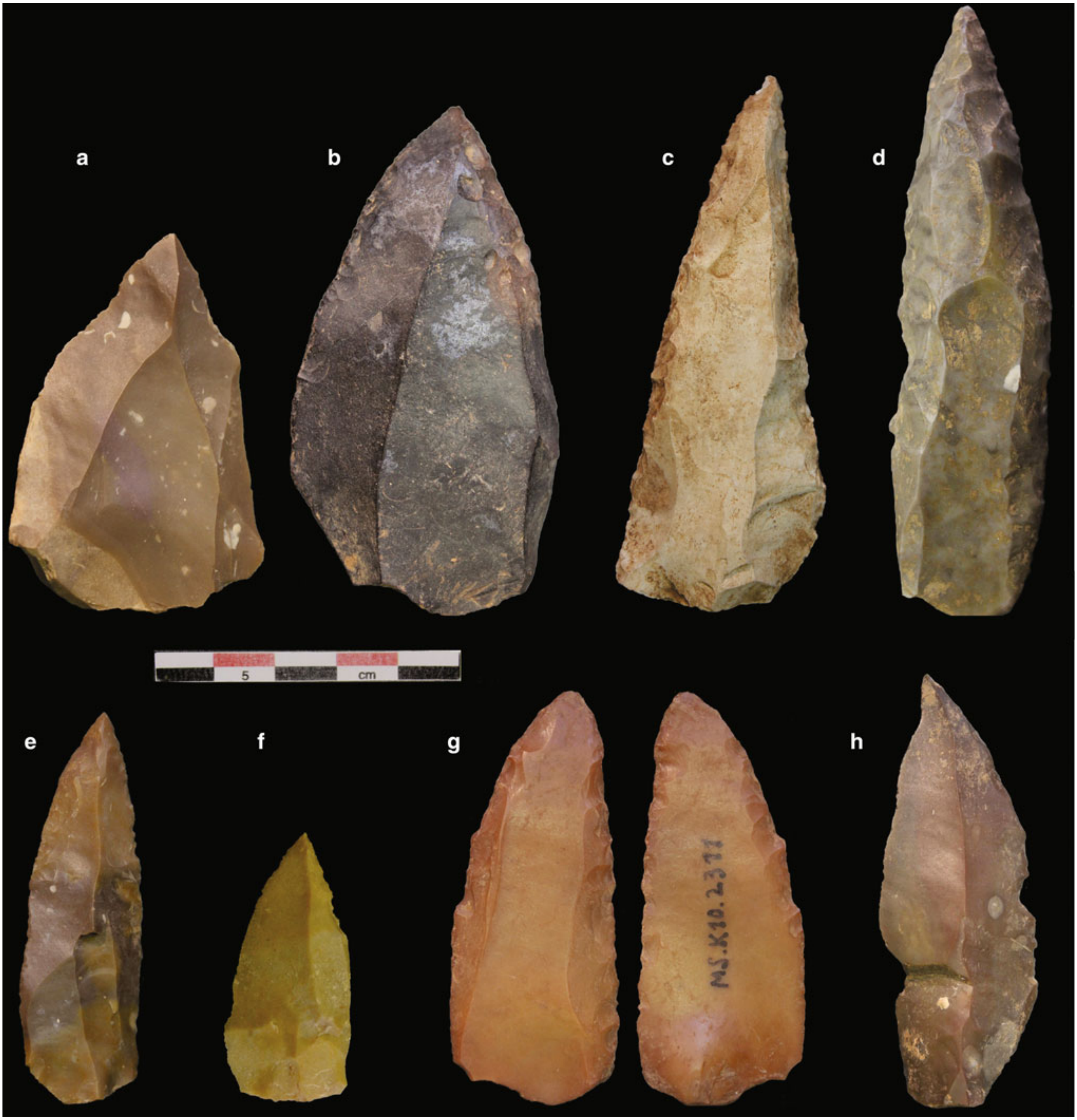

Fig. 8.3 Misliya Cave, point types. **a** Levallois point; **b** Retouched Levallois point; **c**, **d** Abu Sif points; **e** Hummal point; **f** Misliya point; **g** points with bifacial, alternate or ventral retouch; **h** off-set points

by Pargeter (2011) showed that step terminating bending fracture, spin-off fracture and burin-like fractures can occur in low frequencies (up to 3%, depending on the type of the fracture) as a result of trampling. Therefore, the frequencies of macro-fractures are important for delineating projectile function of archaeological stone points.

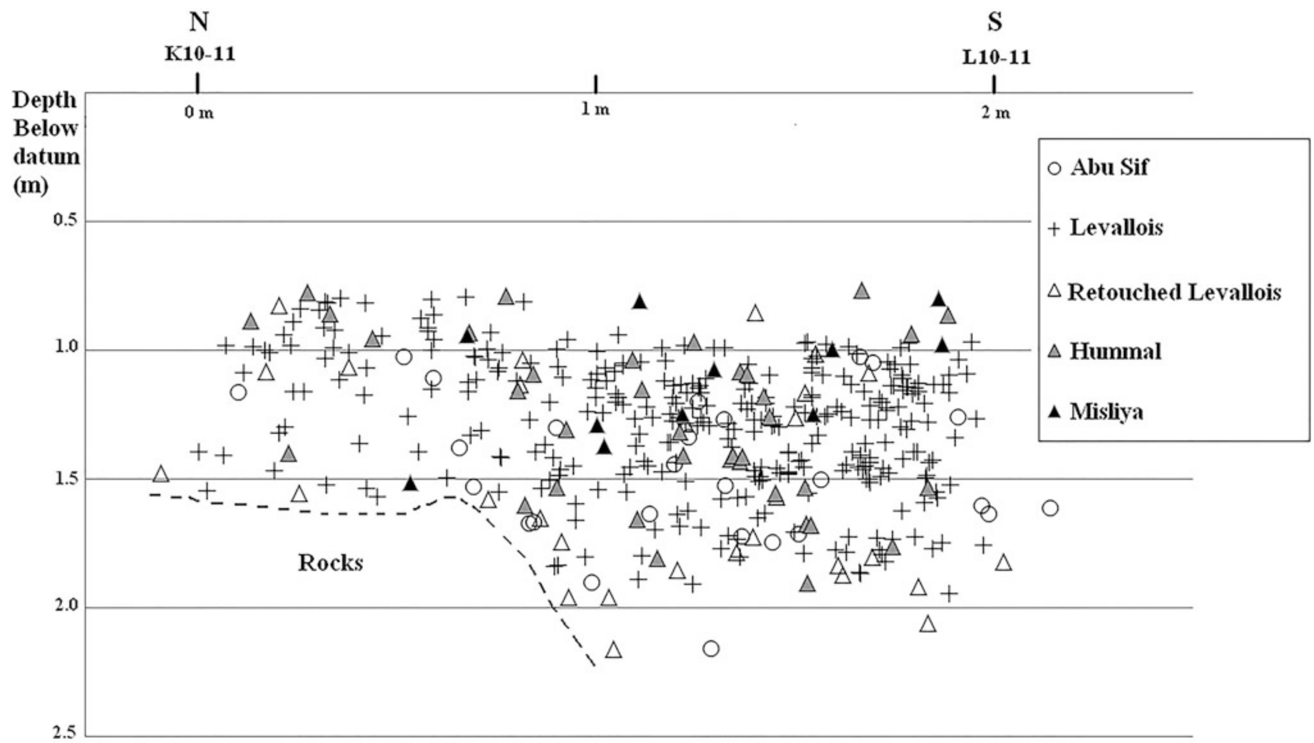

Fig. 8.4 Misliya Cave: vertical distribution of points from squares K10-11 and L10-11 in the EMP sequence, Upper Terrace (Fig. 8.2)

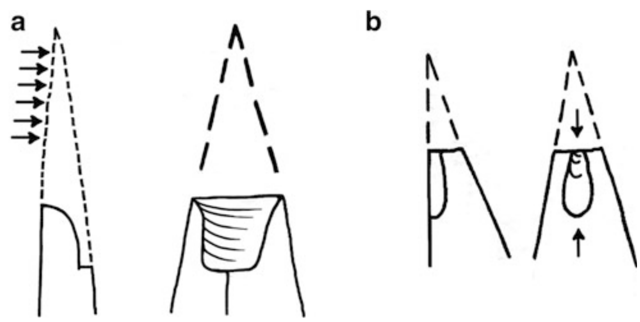

Fig. 8.5 Types of fractures diagnostic of impact. **a** Step terminating bending; **b** spin-off (after Fischer et al. 1984)

All points from the Misliya assemblage were observed for the presence of macro-DIF; their frequencies were recorded according to point type. Some points with macro-DIF were subsequently observed through Scanning Electron Microscopy (SEM) in an attempt to identify micro-DIF.

Morpho-metric Characteristics

All the points were measured in terms of their length, maximal width and maximal thickness (Fig. 8.6). Complete or nearly complete points were weighed. In order to evaluate the tip angle we outlined the distal part of the point (about 1.5–2.0 cm) and then measured the angle with a protractor. This method differs from that used in the study of Brooks et al. (2006). We believe that our approach (Fig. 8.7a, b) is more appropriate to the assemblage from Misliya Cave as many of the points at the site have either a curved lateral edge or truncation, as opposed to African points that appear to have roughly straight edges (Fig. 8.7c). Applying the method of Brooks and colleagues to points from Misliya Cave would reduce considerably the value of the tip angle and would not reliably convey the true variation in the assemblage. We also calculated the TCSP for all point types from Misliya Cave as follows: TCSP $= MaxWidth + 2\sqrt{(MaxWidth/2)^2 + MaxThickness^2}$ (Sisk and Shea 2009, 2011). For comparative purposes, data from the following assemblages were recorded: North American ethnographic dart tips, based on the collections published by Thomas (1978) and Shott (1997); archaeological points from the MSA sites of Aduma 5 and Porc Epic Cave, Ethiopia, suggested as possible tips of complex projectiles (Brooks et al. 2006; Sisk and Shea 2011). The assemblage of points from Misliya Cave and the North American ethnographic dart tips were compared through one-way analysis of variance (ANOVA) tests including Sheffé post hoc comparisons. ANOVA tests whether one or more sample means are significantly different from each other; Sheffé post hoc comparisons determine which or how many sample means are different.

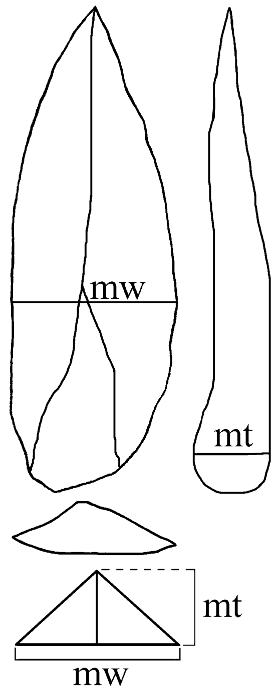

Fig. 8.6 Metric characteristics measurements based on the outline of Abu Sif points. mw Maximal width; mt Maximal thickness

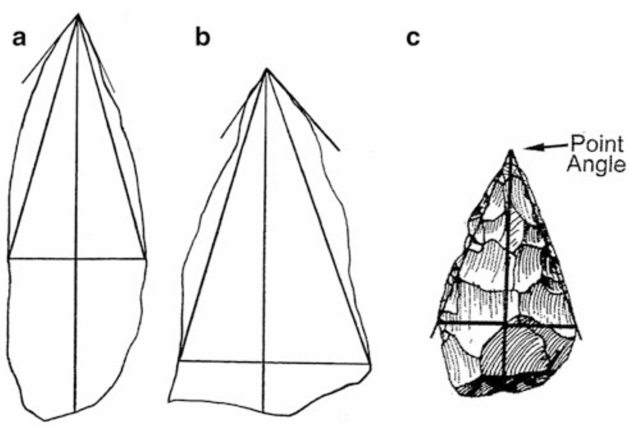

Fig. 8.7 Angle of distal tip measurements. **a**, **b** Applied in the present study, shown on the outlines of Abu Sif and Levallois points; **c** according to Brooks et al. (2006)

In terms of the distal tip, ANOVA analysis was applied only to points from Misliya Cave as there is no data for this characteristic for ethnographic dart tips. In addition, comparisons were made with Porc Epic points, previously suggested as possible tips of complex projectiles.

Results

Fractures Diagnostic of Projectile Impact

Table 8.1 shows the frequencies of DIF for various point types from Misliya Cave. The highest frequencies were observed among Levallois points (Figs. 8.8, 8.9 and 8.10) and Abu Sif points (Figs. 8.11, 8.12 and 8.13): 22.2 and 19.4%, respectively. Hummal points (Figs. 8.14 and 8.15) and Misliya points (Figs. 8.16 and 8.17) exhibit less than half the frequency compared to Levallois/Abu Sif points: 8.9 and 9.5%, respectively. Two retouched Levallois points with DIF comprise 6.3% of the group. Off-set points and points with bifacial or alternate retouch each have one representative with DIF, making up 11.1 and 14.3% of the group, respectively.

In the majority of the cases DIF were observed on the distal tip of the point. A few points were broken either at their proximal third or half their length with burin-like DIF (Fig. 8.13). Some exhibited DIF on both the distal tip and the breakage (Figs. 8.11 and 8.14). Fifteen points with macro-DIF on their distal tips were observed through SEM with linear striations occurring on five points (33%; e.g., Figures 8.8b, 8.11b and 8.16b). The relatively low frequency of micro-striations on the points from Misliya cave may be explained by the fact that observations were made only on the area of macro-fracture while striations may have been present on other areas of a point's surface. In previous works analyzing either experimental or archaeological assemblages of points the ratios of micro-striations vary. For example, Fischer et al. (1984) observed micro-striations on 60% of experimental points. Among eleven experimental microliths with macro-DIF observed through SEM only five exhibited micro-striations (Yaroshevich et al. 2010). For archaeological points, values of 40% (Crombe et al. 2001) and ca. 55% (16 of 29 segments, Lombard 2011) were reported.

Table 8.1 Misliya Cave: frequencies of DIF according to point type

Point type	With DIF		Total	
	N	%	N	%
Retouched Levallois	2	6.3	32	100
Levallois	20	22.2	90	100
Abu-Sif	7	19.4	36	100
Hummal	4	8.9	45	100
Misliya	2	9.5	21	100
Points with bifacial and/or alternate retouch	1	14.3	7	100
Off-set	1	11.1	9	100
Total	38	15.8	241	100

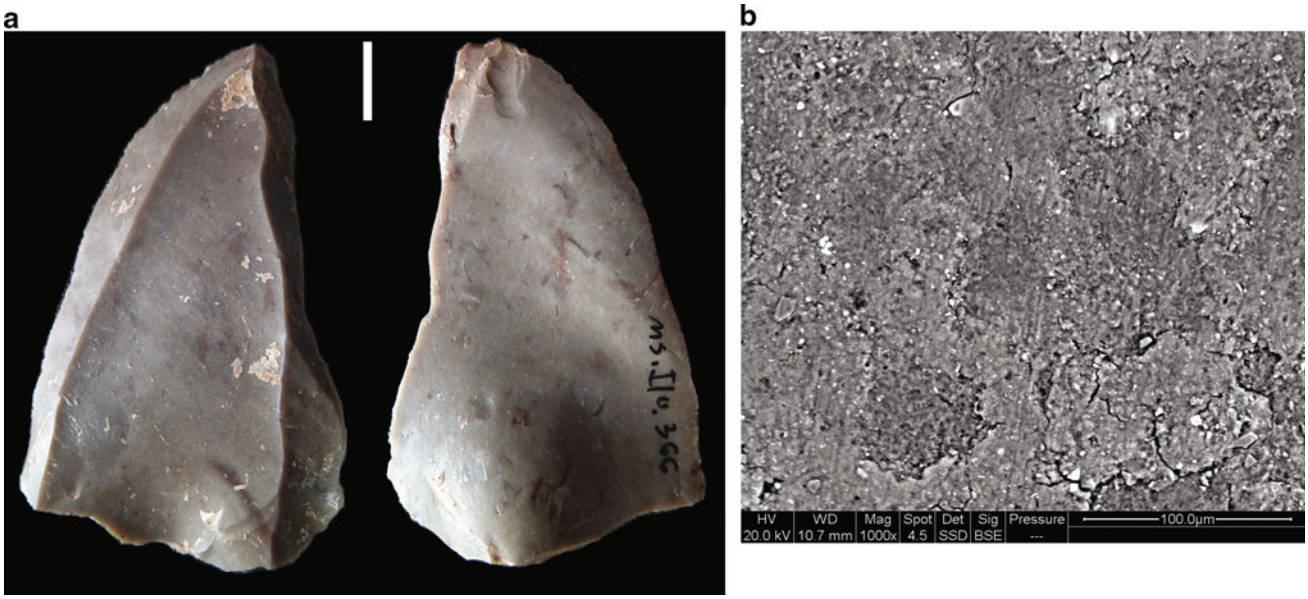

Fig. 8.8 Misliya Cave: DIF on Levallois point. **a** Macro-DIF. The scale is 5 mm; **b** micro-DIF

Fig. 8.9 Misliya Cave: Levallois point with macro-DIF. The scale is 5 mm

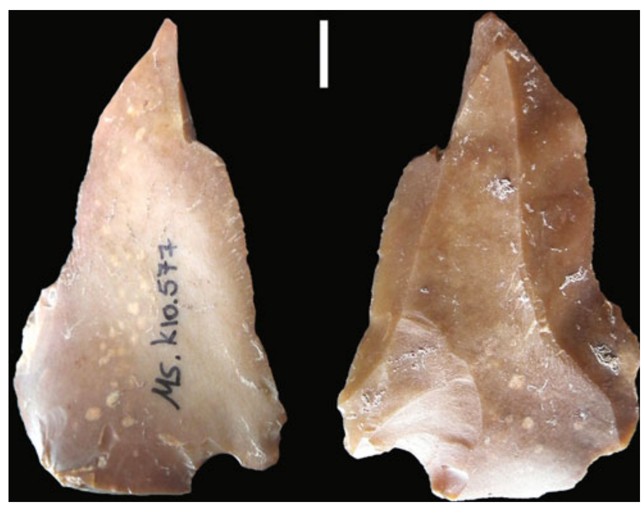

Fig. 8.10 Misliya Cave: Levallois point with macro-DIF. The scale is 5 mm

Morpho-metric Characteristics

The subsequent morpho-metric analyses we applied to the four types which are the most common and exhibit the highest frequencies of DIF, i.e., Levallois, Abu Sif, Hummal and Misliya points. Results of ANOVA analysis are shown for each metric characteristic separately. In addition, for each characteristic we present box plots where values for points with and without DIF are presented separately.

Maximal Width (Table 8.2, Fig. 8.18)

In terms of maximal width, the points create three distinctive groups: the first contains North American ethnographic dart tips, Misliya points and Hummal points with average values of 23.0, 21.5 and 25.7 mm, respectively. Abu Sif (30.5 mm) forms the second group whereas Levallois points (36.3 mm) belong to the third group. Hummal points bearing DIF appear at the lower end of the range for the type (Fig. 8.18) and their maximal width (19.1 mm, Table 8.3), is statistically similar

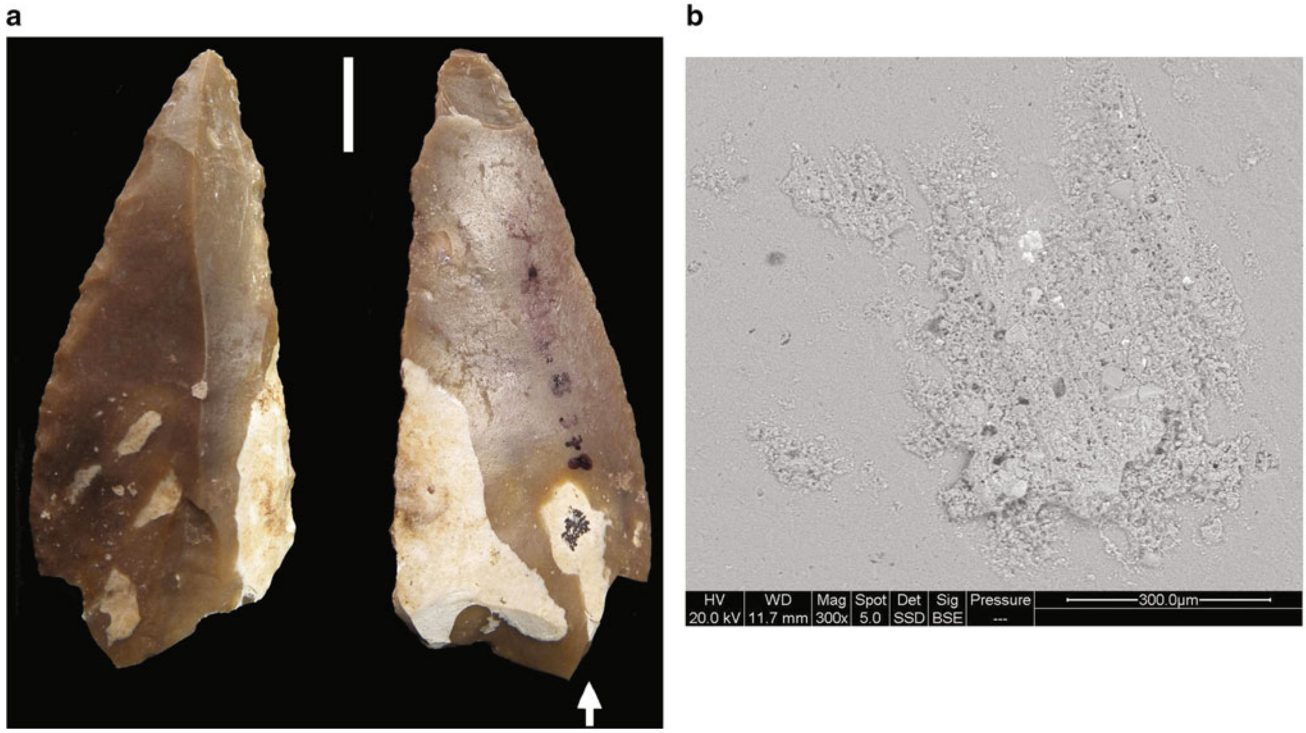

Fig. 8.11 Misliya Cave: DIF on Abu Sif point. **a** Macro-DIF. The scale is 5 mm; **b** micro-DIF

Fig. 8.12 Misliya Cave: Abu Sif point with macro-DIF. The scale is 5 mm

Fig. 8.13 Misliya Cave: Abu Sif point with macro-DIF. The scale is 5 mm

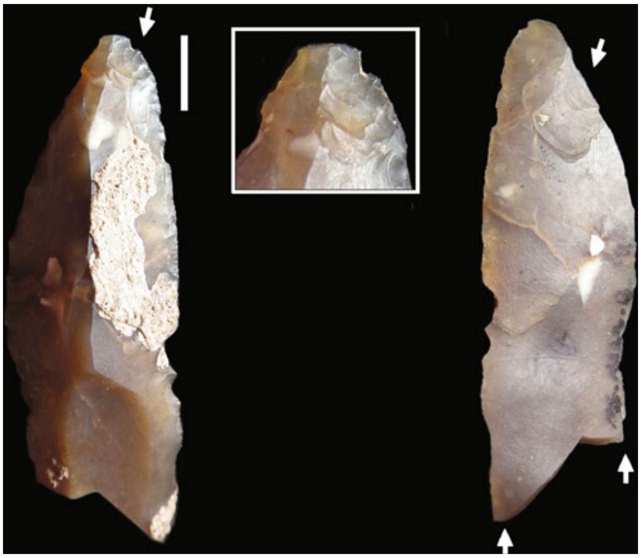

Fig. 8.14 Misliya Cave: Hummal point with macro-DIF. The scale is 5 mm

Fig. 8.15 Misliya Cave: Hummal point with macro-DIF. The scale is 5 mm

to North American ethnographic darts (Table 8.4). Also, in terms of maximal width Misliya and Hummal points with DIF are statistically similar (Table 8.4) to Porc Epic bifacial and unifacial points (23.61 and 23.15 mm, respectively, Sisk and Shea 2011) and have similar values with Aduma 5 points (about 23 mm, Brooks et al. 2006, Fig. 9).

Maximal Thickness (Table 8.5, Fig. 8.19)

In terms of mean maximal thickness North American dart tips (5.0 mm), Misliya (6.3 mm), Levallois (7.8 mm) and Abu Sif (9.3 mm) comprise four separate groups whereas Hummal (8.2 mm) belong to the third and in the fourth groups, meaning Hummal points are statistically similar to both, Levallois and Abu Sif points in terms of their maximal thickness.

Again, Hummal points with DIF have the lowest values within the type (6.2 mm). Misliya points and Hummal points with DIF are statistically similar (Table 8.4) to Porc Epic bifacial and unifacial points (8.36 and 7.45 mm, respectively, Sisk and Shea 2011) and are practically identical to Aduma 5 points (6.5 mm, Brooks et al. 2006, Fig. 9) in terms of their maximal thickness.

TCSP (Table 8.6, Fig. 8.20)

In terms of average TCSP the points create four distinct groups with Misliya (46.5 mm) and North American ethnographic dart tips (47.2 mm) comprising the first. Hummal (56.4 mm), Abu Sif (66.4 mm) and Levallois (76.0 mm) each represent separate groups. T-tests (Table 8.4) show that Hummal points with DIF are statistically similar to North American dart tips, as well as to Porc Epic bifacial and unifacial points (50.25 and 50.93 mm, respectively, Sisk and Shea 2011). Misliya points are statistically similar to Porc Epic bifacial points and even smaller than Porc Epic unifacial points in terms of TCSP (Table 8.4).

Weight (Table 8.7, Fig. 8.21)

In terms of mean weight, the points create three groups with a considerable overlap between them. North American ethnographic tips (4.4 gr.) belong to the first group; Misliya (10.6 gr.) belong to the first and to the second; Hummal (16.2 gr.) and Levallois (14.7 gr.) belong to the second and to the third; Abu Sif (22.7 gr.) belong solely to the third group. Misliya points have weights similar to Aduma 5 points (10 gr., Brooks et al. 2006, Fig. 11b).

Angle of the Distal Tip (Table 8.8, Fig. 8.22)

In terms of the average angle of the distal tip, the points create two distinctive groups with Abu Sif (58.9°), Misliya (62.0°) and Hummal (62.9°) belonging to the first and Levallois (73.1°) comprising the second. Abu Sif, Misliya and Hummal points with DIF show values lower than their type in general: 57.2°, 60° and 51°, respectively. These values are similar to Aduma points (55°–60°, Brooks et al. 2006).

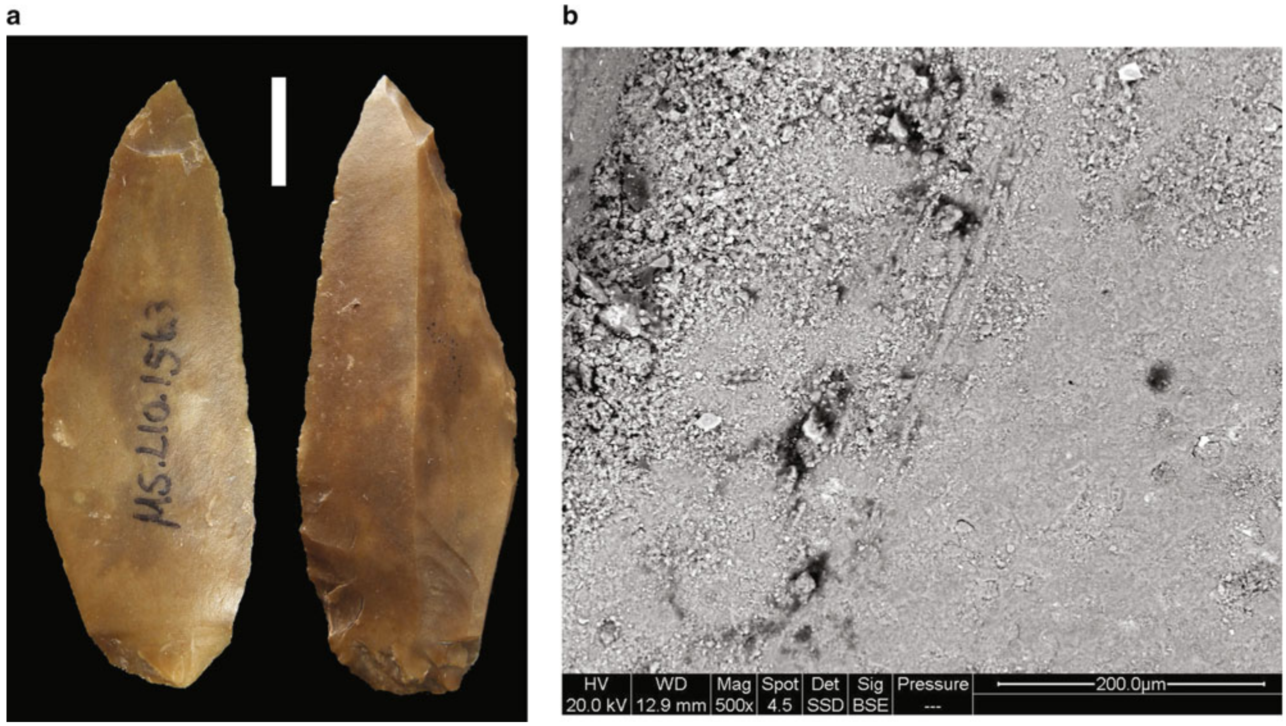

Fig. 8.16 Misliya Cave: DIF on Misliya point. **a** Macro-DIF. The scale is 5 mm; **b** micro-DIF

Fig. 8.17 Misliya Cave: Misliya point with macro-DIF. The scale is 5 mm

Table 8.2 Mean maximal widths for points from Misliya Cave and North American ethnographic dart tips: Scheffé homogeneous subsets based on one-way analysis of variance

Point type	N	Subset for alpha = 0.05		
		1	2	3
Misliya	18	21.5		
North American dart tips	40	23.0		
Hummal	45	25.7		
Abu-Sif	32		30.5	
Levallois	89			36.3
Significance		0.064	1.000	1.000

Discussion and Conclusions

While all point types present in the EMP layer of Misliya Cave seem to have been applied as tips of hunting weapons, there are four types, i.e., Levallois, Abu Sif, Hummal and Misliya which were most frequently used in this function. These four types differ in terms of their morpho-metric characteristics, as well as in terms of DIF ratios. Levallois

Table 8.3 Misliya Cave: morpho-metric characteristics of various types of points bearing DIF

Point type		Length	Maximal width	Maximal thickness	Angle	Weight	TCSP
Levallois	Mean	63.7	38.9	8.4	75.7	19.0	81.6
	N	14	19	19	11	12	19
	S.D.	10.6	7.0	1.8	13.0	8.0	13.9
Abu Sif	Mean	72.9	28.1	7.9	57.2	17.8	60.3
	N	2	5	5	4	4	5
	S.D.	13.4	2.5	1.5	6.9	6.2	5.5
Hummal	Mean	–	19.1	6.2	51.0	–	41.9
	N	–	4	4	4	–	4
	S.D.	–	4.4	1.5	5.2	–	9.6
Misliya	Mean	56.0	22.8	6.2	60.0	9.4	48.8
	N	2	2	2	2	2	2
	S.D.	0.9	3.2	1.4	14.14	2.0	7.5

Table 8.4 T-test probabilities comparing Misliya and Hummal points with North American ethnographic dart tips and Porc Epic bifacial and unifacial points. $p < 0.05$: the two samples differ with 95% confidence; $p > 0.05$: the two samples cannot be distinguished with 95% confidence. TCSP for Porc Epic points were compared to Misliya and Hummal points with DIF (http://in silico.net/statistics/ttest/two-sample) using standard deviation values provided by Sisk, personal communication, 2011

Point type	Versus North American dart tips			Versus Porc Epic unifacial points			Versus Porc Epic bifacial points		
	TCSP	Width	Thickness	TCSP	Width	Thickness	TCSP	Width	Thickness
Misliya	**0.79**	**0.21**	0.00	**0.12**	**0.15**	0.00	0.04	**0.10**	0.01
Hummal with DIF	**0.26**	**0.05**	0.03	**0.17**	**0.13**	**0.05**	**0.15**	**0.16**	**0.21**

and Abu Sif points, the two largest types, show relatively high frequencies of DIF, around 20%. Misliya and some Hummal points, specifically those bearing DIF are the smallest in the assemblage and statistically similar to North American ethnographic dart tips, as well as to MSA Porc Epic and Aduma 5 points in terms of metric characteristics. The frequencies of DIF for Misliya and Hummal points (ca. 10%), are only one-half of those occurring on Levallois and Abu Sif points.

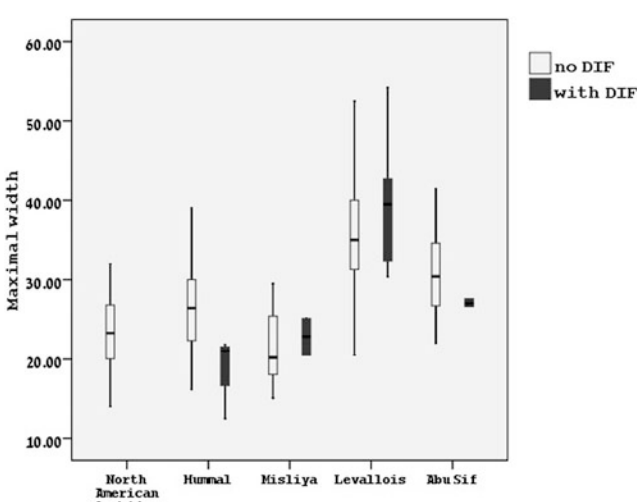

Fig. 8.18 Boxplots of maximal width values for various types of points from Misliya Cave and North American ethnographic dart tips

The largest types, Levallois and Abu Sif points differ statistically in terms of width, thickness, TCSP and the angle of the distal tip, with Levallois points being wider and thinner on average and having duller tips. Experiments with thrusting spears showed that greater width enhances penetrating ability of the point (Shea et al. 2001) while greater thickness makes the point more durable on impact, but reduces its penetrating capacity (Hughes 1998). Based on this evidence we suggest that Levallois points provided better penetration whereas Abu Sif points were designed to be more durable on impact. Abu Sif points show the lowest values of distal tip angle, a characteristic which increases

Table 8.5 Mean maximal thicknesses for points from Misliya Cave and North American ethnographic dart tips: Scheffé homogeneous subsets based on one-way analysis of variance

Point type	N	Subset for alpha = 0.05			
		1	2	3	4
North American ethnographic darts	40	5.0			
Misliya	18		6.3		
Levallois	89			7.8	
Hummal	45			8.2	8.2
Abu Sif	32				9.3
Significance		1.000	1.000	0.912	0.170

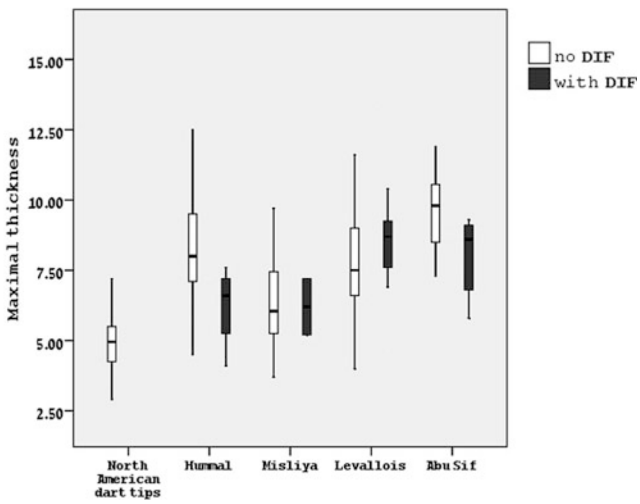

Fig. 8.19 Boxplots of maximal thickness values for various types of points from Misliya Cave and North American ethnographic dart tips

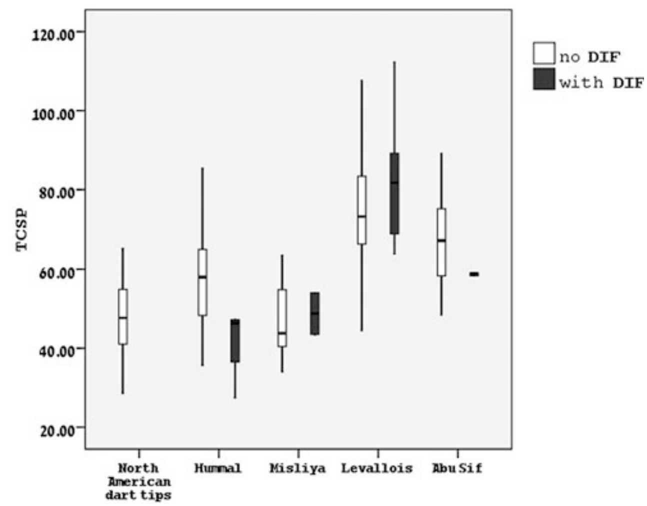

Fig. 8.20 Boxplots of TCSP values for various types of points from Misliya Cave and North American ethnographic dart tips

Table 8.6 Mean TCSPs for points from Misliya Cave and North American ethnographic dart tips: Scheffé homogeneous subsets based on one-way analysis of variance

Point type	N	Subset for alpha = 0.05			
		1	2	3	4
Misliya	18	46.5			
North American ethnographic darts	40	47.2			
Hummal	45		56.4		
Abu Sif	32			66.4	
Levallois	89				76.0
Significance		1.000	1.000	1.000	1.000

Table 8.7 Mean weights for points from Misliya Cave and North American ethnographic dart tips: Scheffé homogeneous subsets based on one-way analysis of variance

Point type	N	Subset for alpha = 0.05		
		1	2	3
North American ethnographic darts	10	4.4		
Misliya	18	10.6	10.6	
Levallois	76		14.7	14.7
Hummal	40		16.2	16.2
Abu Sif	28			22.7
Significance		0.408	0.515	0.156

penetrating abilities (Hughes 1998) thus reducing the influence of their relatively greater thickness.

There is a possibility that some DIF observed on the points from Misliya Cave occurred as a result of trampling as shown in experiments conducted by Pargeter (2011). However, the frequencies of DIF at Misliya Cave (between 6 and 22%) are considerably higher than those created in trampling experiments, up to 3%, depending on the type of the fracture (Pargeter 2011). The relatively high frequencies of DIF on Misliya Cave points precludes the possibility that these were created only as a result of trampling or post depositional processes. There are also parallels from other MP/MSA sites. For example, Shea (1988, 1993) reported relatively high frequencies of DIF for the Levantine MP, comprising about a third of all points bearing use-wear. In these analyses Shea included crushing and abrasion on tips in the criteria he used to infer projectile impact. If these are deducted, the frequency of DIF would comprise 10–20% (Shea, personal communication 2011). For the MSA Howiesons Poort segments the frequencies vary from 21 to 24% in different sites (Lombard and Pargeter 2008); MSA bifacial and unifacial point of various types exhibit DIF in frequencies varying from 5.3 to 13.4% (Villa and Lenoir 2006; Soriano et al. 2007; Villa et al. 2009a). For the European MP the values of DIF are somewhat lower, comprising 5.3% for the Bouheben site (Villa and Lenoir 2006) and 5.3 and 7.9% for units 1 and 2, respectively for Oscurusciuto rockshelter (Villa et al. 2009b).

The diversity in point sizes observed for the Misliya assemblage alongside the similarity of a particular group to North American ethnographic dart tips may reflect the presence of more than one kind of weapon during the EMP in the Levant. Thrusting or throwing spears, as well as darts may have been in use, presumably for different game or biotopes. Faunal evidence supports this possibility. The

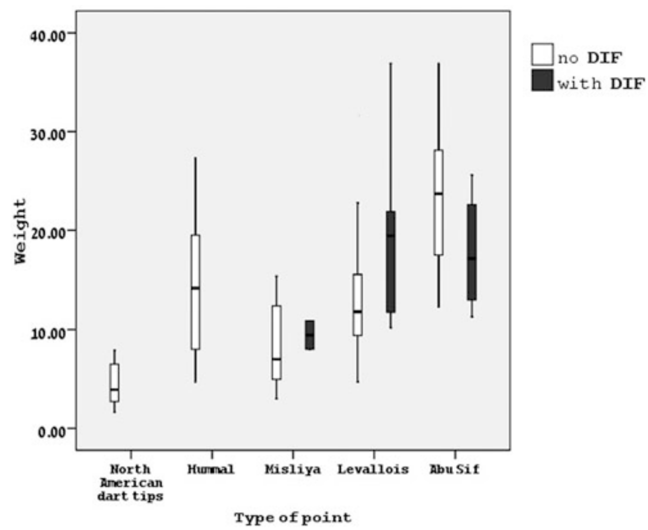

Fig. 8.21 Boxplots of weight values for various types of points from Misliya Cave and North American ethnographic dart tips

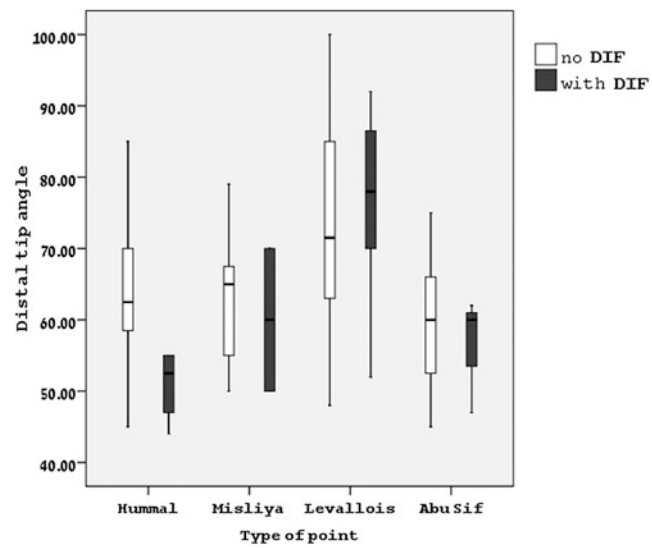

Fig. 8.22 Boxplots of the angle of the distal tip values for various types of points from Misliya Cave

Table 8.8 Mean distal angles for points from Misliya Cave: Scheffé homogeneous subsets based on one-way analysis of variance

Point type	N	Subset for alpha = 0.05	
		1	2
Abu Sif	27	58.9	
Misliya	17	62.0	
Hummal	44	62.9	
Levallois	75		73.1
Significance		0.703	1.000

emergence of the MP in the southern Levant was associated with hunting of mountain gazelle (*Gazella gazella*) in considerable numbers, a species extremely rare in the preceding Lower Paleolithic archaeofaunas. Moreover, this species, living in open terrain and hunted, according to ethnographic record (Churchill 1993) with complex projectiles was probably preferred by MP hunters in the Levant. The preference of gazelle is evident from the comparative analysis of faunal remains from a natural pitfall trap, Rantis Cave, and a number of anthropogenic cave sites (Yeshurun 2012). While in the natural trap Mesopotamian fallow deer (*Dama mesopotamica*) outnumber mountain gazelles, the anthropogenic caves, including Misliya (Yeshurun et al. 2007), show roughly equal presence of both species or an abundance of the latter. Whether this transformation in hunting behavior can be related to environmental changes i.e., prevalence of arid conditions during 285–255 or 240–230 ka BP (Vaks et al. 2010), close to the emergence of the MP, needs further research. The prevalence of aridity could have increased the population of gazelles who thrive in open, arid environments. This, in turn, could have led to the adoption of new hunting strategies and technologies, such as use of various stone tipped weapons, including long-distance projectiles.

The possibility of use of more than one kind of weapon during the EMP remains, however, theoretical. It is equally possible that the variability within Misliya Cave points actually reflects the range within one particular kind of weapon. Estimations of tip weight provided by Hughes (1998, Table IX) show that the range for Australian unfletched dart tips is 9–70 gr. Thus, dart tips seem not to be limited by weight or metric characteristics (see also Clarkson 2016) and theoretically all point types from Misliya Cave could have served as dart tips. Since there is no available data about dimensions of ethnographic (i.e., efficient) spearheads, we cannot exclude any archaeological type from being used as a tip for this kind of weapon, either. Experiments by Shea et al. (2001) showing that small and thin points are not efficient as tips of thrusting spears may be of relevance here. These provide further support for the possibility that Misliya points and Hummal points with DIF, the smallest points in our assemblage, served as tips of complex projectiles. Even so, at the present state we cannot rule out the option that these types represent the smallest efficient spearheads, probably for throwing by hand.

In sum, the diversity of Levantine EMP points in terms of their morpho-metric characteristics and the similarity of a particular group with North American dart tips support the possibility of the presence of a variety of weapons, including complex projectiles. In order to validate our observations, additional analyses should include considerations of the size of particular fracture types (e.g., Clarkson 2016; Sano et al. 2016) and calculations of fracture velocity (Hutchings 2011). Archery experiments and estimating performance characteristics can also provide insights on technological choices of prehistoric hunters (Yaroshevich 2010; Yaroshevich et al. 2010; Petillon et al. 2011). Such a study involving multiple lines of evidence will shed important new light on pertinent issues regarding technological transformations and subsistence strategies associated with the emergence of the MP in the Levant.

Acknowledgements In memory of Dan David, a dear friend and an enthusiastic supporter of the Misliya Cave Project. Misliya Cave is located in the Mount Carmel Nature Reserve, managed by the Israel Nature and Parks Authority. We thank Daniel Kaufman and Reuven Yeshurun for their comments and Reuven Kapul for preparing Fig. 8.4. Special thanks are given to Dr. Alex Berner and Larissa Popilevsky from the Electron Microscopy Centre at the Faculty of Materials Engineering, Technion, for the SEM analysis. The excavations at Misliya Cave are supported by the Dan David Foundation, the Leakey Foundation, the Irene Levi-Sala Care Archaeological Foundation and the Faculty of Humanities, University of Haifa. Israel Antiquities Authority permit numbers for the Misliya Cave excavations: G-16/2001, G-39/2002, G-14/2003, G-29/2004, G-12/2005, G-12/2006, G-4/2007, G-54/2008, G-52/2009, G-50/2010.

References

Barton, R. N. E., & Bergman, C. A. (1982). Hunters at Hengistbury: Some evidence from experimental archaeology. *World Archaeology, 14*, 236–248.

Bar-Yosef, O. (1998). The chronology of the Middle Paleolithic of the Levant. In T. Akazawa, K. Aoki & O. Bar-Yosef (Eds.), *Neandertals and modern humans in western Asia* (pp. 39–56). New York: Plenum Press.

Bergman, C. A., & Newcomer, M. H. (1983). Flint arrowhead breakage, examples from Ksar Akil. *Journal of Field Archaeology, 10*, 238–243.

Boëda, E., Geneste, J.-M., Griggo, C., Mercier, N., Muhesen, S., Reyss, et al. (1999). A Levallois point embedded in the vertebra of a wild ass (*Equus africanus*): Hafting, projectiles and Mousterian hunting weapons. *Antiquity, 73*, 394–402.

Brooks, A. S., Yellen, J. E., Nevell, L., & Hartman, G. (2006). Projectile technologies of the African MSA: Implications for modern human origins. In E. Hovers & S. L. Kuhn (Eds.), *Transitions before the Transition* (pp. 233–256). NewYork: Plenum/Kluwer.

Churchill, S. E. (1993). Weapon technology, prey size selections, and hunting methods in modern hunter-gatheres: Implications for hunting in the Paleolithic and Mesolithic. In G. L. Peterkin., H. Bricker & P. A. Mellars (Eds.), *Hunting and animal exploitation in the Later Palaeolithic and Mesolithic of Eurasia* (pp. 11–24). Washington, DC: American Anthropological Association.

Clarkson, C. (2016). Testing archaeological approaches to determining past projectile delivery systems using ethnographic and experimental data. In R. Iovita & K. Sano (Eds.), *Multidisciplinary approaches to the study of Stone Age weaponry* (pp. 189−201). Dordrecht: Springer.

Copeland, L. (1975). The Middle and Upper Paleolithic in Lebanon and Syria in the light of recent research. In F. Wendorf & A. Close (Eds.), *Problems in prehistory: North Africa and the Levant* (pp. 317–350). Dallas: Southern Methodist University Press.

Copeland L. (1983). The Paleolithic industries at Adlun. Section III: The Levalloiso-Mousterian of Bezez cave level B. In D. Roe (Ed.), *Adlun in the Stone Age: The excavations of D.A.E. Garrod in the Lebanon, 1958–1963* (pp. 261–366). Oxford: BAR International Series, 159.

Copeland, L. (1985). The pointed tools of hummal Ia (El-Kowm, Syria). *Cahiers de l'Euphrate, 4*, 177–189.

Crombe, P., Perdaen, Y., Sergant, J., & Caspar, J.-P. (2001). Wear analysis on early Mesolithic microliths from the Verrebroek site, East Flanders Belgium. *Journal of Field Archaeology, 28*, 253–269.

Dennel, R. (1997). The world's oldest spears. *Nature, 385*, 767–768.

Fischer, A., Hansen, P. V., & Rassmussen, P. (1984). Macro- and micro-wear traces on lithic projectile points. Experimental results and prehistoric examples. *Journal of Danish Archaeology, 3*, 19–46.

Garrod, D. A. E. (1955). Palaeolithic spear-throwers. *Proceedings of Prehistoric Society, 21*, 21–35.

Garrod, D. A. E., & Bate, D. M. A. (1937). *The Stone Age of Mount Carmel* (Vol. I). Excavations at the Wadi Mughara. Oxford: Clarendon Press.

Gordon, D. (1993). Mousterian tool selection, reduction, and discard at Ghar, Israel. *Journal of Field Archaeology, 20*, 205–218.

Hayden, B. (1979). Ho-Ho nomenclature committee. The Ho-Ho classification and nomenclature committee report. In B. Hayden (Ed.), *Lithic use-wear analysis* (pp. 133–135), New-York: Academic Press.

Hughes, S. S. (1998). Getting to the point: Evolutionary change in prehistoric weaponry. *Journal of Archaeological Method and Theory, 5*, 345–408.

Hutchings, K. (2011). Measuring use-related fracture velocity in lithic armatures to identify spears, javelins, darts, and arrows. *Journal of Archaeological Science, 38*, 1737–1746.

Jelinek, A. J. (1982a). The Tabun Cave and Paleolithic man in the Levant. *Science, 216*, 1369–1375.

Jelinek, A. J. (1982b). The middle Paleolithic in the Southern Levant, with comments on the appearance of modern *Homo sapiens*. In A. Ronen (Ed.), *The transition from Lower and Middle Paleolithic and the origin of modern man* (pp. 57–104). Oxford: BAR International Series, 151.

Jelinek, A. J., Farrand, W. R., Hass, G., Horowitz, A., & Goldberg, P. (1973). New excavations at the Tabun Cave, Mount Carmel, Israel: A preliminary report. *Paléorient, 1*, 151–183.

Lombard, M. (2005). Evidence of hunting and hafting during the Middle Stone Age at Sibudu Cave, KwaZulu-Natal: A multianalytical approach. *Journal of Human Evolution, 48*, 279–300.

Lombard, M. (2007). Evidence for change in Middle Stone Age hunting behaviour at Blombos Cave: Results of a macro-fracture analysis. *South African Archaeological Bulletin, 62*, 62–67.

Lombard, M. (2008). Finding resolution for the Howiesons Poort through the microscope: Micro-residue analysis of segments from Sibudu Cave, South Africa. *Journal of Archaeological Science, 35*, 26–41.

Lombard, M. (2011). Quartz-tipped arrows older than 60 ka: Further use-trace evidence from Sibudu, KwaZulu-Natal, South Africa. *Journal of Archaeological Science, 38*, 1918–1930.

Lombard, M., Parsons, I., & van der Ryst, M. M. (2004). Middle Stone Age lithic experimentation for macro-fracture and residue analyses: the process and preliminary results with reference to the Sibudu Cave points. *South African Journal of Science, 100*, 159–166.

Lombard, M., & Pargeter, J. (2008). Hunting with Howiesons Poort segments: Pilot experimental study and the functional interpretation of archaeological tools. *Journal of Archaeological Science, 35*, 2523–2531.

Lombard, M., & Philipson, L. (2010). Indications of bow and stone-tipped arrow use 64 000 years ago in KwaZulu-Natal, South Africa. *Antiquity, 84*, 635–648.

McCown, T. D. (1937). Mugharet es-Skhul: Description and Excavations. In D. A. E. Garrod & D. M. A. Bate (Eds.), *The Stone Age of Mount Carmel: Excavations at the Wady el-Mughara* (Vol. I, pp. 91–112). Chapter VI Oxford: Clarendon Press.

Meignen, L. (1998). Hayonim Cave lithic assemblage in the context of the near eastern Middle Paleolithic. In T. Akazawa, K. Aoki & O. Bar-Yosef (Eds.), *Neandertals and modern humans in Western Asia* (pp. 165–180). New York: Plenum Press.

Meignen L, (2011). The contribution of Hayonim cave assemblages to the understanding of the so-called early Levantine Mousterian. In J.-M. Le Tensorer, R. Jagher & M. Otte (Eds.), *The Lower and Middle Paleolithic in the middle east and neighbouring regions* (pp. 85–100). ERAUL 126.

Mercier, N., & Valladas, H. (2003). Reassessment of TL age estimates of burnt flints from the Palaeolithic site of Tabun Cave, Israel. *Journal of Human Evolution, 45*, 401–409.

Mercier, N., Valladas, H., Frojet, L., Joron, J.-L., Ryess, J.-L., Weiner, S., et al. (2007). Hayonim Cave: A TL-based chronology for this Levantine Mousterian sequence. *Journal of Archaeological Science, 34*, 1064–1077.

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.

Morales, M. R. G., & Straus, L. G. (2009). Extraordinary early Magdalenian finds from El Mirón Cave, Cantabria (Spain). *Antiquity, 83*, 267–281.

Neuville, R. (1951). *Le Paleolithique et le Mesolithique du desert du Judee*. Archives de Musee de Paleontologie Humaine memoire 24. Paris: Masson et Cie.

Nuzhnyy, D. (1989). L'utilisation des microlithes geometriques et non geometriques comme armatures de projectiles. *Bulletin de la Societe Prehistorique Francaise, 86*, 88–96.

Nuzhnyy, D. (1990). Projectile damage on Upper Paleolithic microliths and the use of bow and arrow among Pleistocene hunters in the Ukraine. In *The interpretative possibilities of microwear studies. Proceedings of the International Conference of Lithic Use-Wear Analysis, 15–17th February 1989 in Uppsala, Sweden* (pp. 113–124). Uppsala: AUN 14.

Nuzhnyy, D. (1999). Microlithic projectile weapons of the Late Palaeolithic and Mesolithic hunters of the Crimea. *Archeologija, 1*, 5–24 (Ukrainian).

Nuzhnyy, D. (2008). *Development of microlithic technology during the Stone Age: Projectile weapons of prehistoric hunters*. Kiev: KNT. (Ukrainian).

Odell, G. H., & Cowan, F. (1986). Experiments with spears and arrows on animal targets. *Journal of Field Archaeology, 13*, 195–212.

Pargeter, J. (2011). Assessing the macrofracture method for identifying Stone Age hunting weaponry. *Journal of Archaeological Science, 38*, 2882–2888.

Pétillon, J.-M., Bignon, O., Bodu, P., Cattelain, P., Debout, G., Langlais, M., et al. (2011). Hard core and cutting edge: Experimental manufacture and use of Magdalenian composite projectile tips. *Journal of Archaeological Science, 38*, 1266–1283.

Plisson, H., & Beyries, S. (1998). Pointes ou outils triangulaires? Données fonctionnelles dans le Moustérien levantin. *Paléorient, 24*, 5–24.

Rausing, G. (1967). *The Bow: Some notes on its origin and development*. Lund: C. W. K. Gleerups.

Rust, A. (1943). *Die Alt-und Mittelsteinzeitlishe Funde von Stellmoor*. Neumünster: Washholtz.

Sano, K., Denda, Y., & Oba, M. (2016). Experiments in fracture patterns and impact velocity with replica hunting weapons from Japan. In R. Iovita & K. Sano (Eds.), *Multidisciplinary approaches to the study of Stone Age weaponry* (pp. 29−46). Dordrecht: Springer.

Shea, J. J. (1988). Spear points from the Middle Palaeolithic of the Levant. *Journal of Field Archaeology, 15*, 441–450.

Shea, J. J. (1989a). A functional study of the lithic industries associated with hominid fossils in the Kebara and Qafzeh Caves, Israel. In P. Mellars & C. Stringer (Eds.), *The human revolution* (pp. 611–625). Edinburgh, Edinburgh University Press.

Shea, J. J. (1989b). Tool use in the Levantine Mousterian of Kebara Cave, Mount Carmel. *Mitekufat HaEven* (*Journal of the Israel prehistoric society*), *22*, 15–30.

Shea, J. J. (1991). *The behavioral significance of Levantine Mousterian industrial variability*. PhD dissertation, Harvard University.

Shea, J. J. (1993). Lithic use-wear evidence for hunting by Neandertals and early modern humans from the Levantine Mousterian. In G. L. Peterkin, H. Bricker & P. A. Mellars (Eds.), *Hunting and animal exploitation in the later Paleolithic and Mesolithic of Eurasia* (pp. 11–24). Washington DC: American Anthropological Association.

Shea, J., Davis, Z., & Brown, K. (2001). Experimental tests of middle palaeolithic spear points using a calibrated crossbow. *Journal of Archaeological Science, 28*, 807–816.

Shott, M. J. (1997). Stones and shafts redux: The metric discrimination of chipped stone dart and arrow points. *American Antiquity, 62*, 86–101.

Sisk, M. L., & Shea, J. J. (2009). Experimental use and quantitative performance analysis of triangular flakes (Levallois points) used as arrowheads. *Journal of Archaeological Science, 36*, 2039–2047.

Sisk, M. L., & Shea, J. J. (2011). The African origin of complex projectile technology: An analysis using tip cross-sectional area and perimeter. *International Journal of Evolutionary Biology, 2011*, 1–8.

Soriano, S., Villa, P., & Wadley, L. (2007). Blade technology and tool forms in the middle Stone Age of South Africa: The Howiesons Poort and post-Howiesons Poort at Rose Cottage Cave. *Journal of Archaeological Science, 34*, 681–703.

Stodiek, U. (1992). A propos de l'emmanchement des propulseurs au Paléolithique Supérieur. In J. P. Rigaud, H. Laville, & B. Vandermeersch (Eds.), *Le peuplement Magdalenien: Paléogeographie physique et humaine* (pp. 317–331). Paris: Comité des Travaux Historiques et Scientifiques.

Stodiek, U. (1993). *Zur Technologie der jungpalaolithischen Speerschleuder: Eine Studie auf der Basis archaologischer, ethnologischer, und experimenteller Erkenntnisse*. Tubingen: Verlag Archaeologica Venatoria.

Theime, H. (1997). Lower Paleolithic hunting spears from Germany. *Nature, 385*, 807–810.

Thomas, D. H. (1978). Arrowheads and Atl-atl Darts – How stones got shaft. *American Antiquity, 43*, 461–472.

Vaks, A., Bar-Matthews, M., Matthews, A., Ayalon, A., & Frumkin, A. (2010). Middle-Late Quaternary paleoclimate of northern margins of the Saharan-Arabian Desert: Reconstruction from speleothems of Negev Desert, Israel. *Quaternary Science Reviews, 29*, 2647–2662.

Valladas, H., Mercier, N., Hershkovitz, I., Zaidner, I., Tsatskin, A., Yeshurun, R., et al. (2013). Dating the Lower to Middle Paleolithic transition in the Levant: A view from Misliya Cave, Mount Carmel, Israel. *Journal of Human Evolution*, *65*, 585–593.

Villa, P., & Lenoir, M. (2006). Hunting weapons of the Middle Stone Age and the Middle Palaeolithic: Spear points from Sibudu, Rose Cottage and Bouheben. *South African Humanities, 18*, 89–122.

Villa, P., Boscato, P., Ranaldo, F., & Ronchitelli, A. (2009a). Stone tools for the hunt: Points with impact scars from a Middle Paleolithic site in southern Italy. *Journal of Archaeological Science, 36*, 850–859.

Villa, P., Soressi, M., Henshilwood, C. S., & Mourre, V. (2009b). The still bay points of Blombos Cave (South Africa). *Journal of Archaeological Science, 36*, 441–460.

Villa, P., & Soriano, S. (2010). Hunting weapons of Neandertals and early modern humans in South Africa. *Journal of Anthropological Research, 66*, 5–39.

Weinstein-Evron, M., Bar-Oz, G., Zaidner, Y., Tsatskin, A., Druck, D., Porat, N., & Hershkovitz, I. (2003). Introducing Misliya cave, Mount Carmel, Israel: A new continuous lower/middle Paleolithic sequence in the Levant. *Eurasian Prehistory, 1*, 31–55.

Wojtczak, D. (2011). Hummal (Central Syria) and its eponymous industry. In J.-M. Le Tensorer, R. Jagher & M. Otte (Eds.), *The Lower and Middle Paleolithic in the Middle East and neighboring regions* (pp. 289–308). ERAUL 126.

Yaroshevich, A. (2010). *Microlithic variability and design and performance of projectile weapons during the Levantine Epipaleolithic: Experimental and archaeological evidence*. PhD dissertation, University of Haifa.

Yaroshevich, A., Kaufman, D., Nuzhnyy, D., Bar-Yosef, O., & Weinstein-Evron, M. (2010). Design and performance of microlith implemented projectiles during the middle and late epipalaeolithic of the Levant: Experimental and archaeological evidence. *Journal of Archaeological Science, 37*, 368–388.

Yeshurun, R. (2012). Middle Paleolithic prey-choice inferred from a natural pitfall trap: Rantis Cave, Israel. In J. L. Clark & J. D. Speth (Eds.), *Zooarchaeology and modern human origins: Human hunting behavior during the later pleistocene* (pp. 45–75). Dordrecht: Springer.

Yeshurun, R., Bar-Oz, G., & Weinstein-Evron, M. (2007). Modern hunting behavior in the early middle Paleolithic: Faunal remains from Misliya Cave, Mount Carmel, Israel. *Journal of Human Evolution, 53*, 656–677.

Zaidner, Y., & Weinstein-Evron, M. (2012). Making a point: The Early Middle Palaeolithic tool assemblage of Misliya Cave, Mount Carmel, Israel. *Before Farming*, *4*, 1–23.