Morphological Analysis of Nahal Zihor Handaxes: A Chronological Perspective

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ABSTRACT

Lower Paleolithic handaxe assemblages were collected during a geological and archaeological survey at Nahal Zihor in the Arava, southern Israel, where the existence of a paleo-lake was established. Later measurements date sediments associated with the Zihor lake to ~1.6 Ma. The present study focuses on two groups of handaxes from different locations—*Group A* consists of handaxes from the shoreline of the lake, while *Group B* originated from the terraces which surrounded the lake. By observing the two groups of handaxes, the surveyors suggested that *Group A* could be assigned to the early Acheulian, while *Group B* was assigned to the late Acheulian. The aim of the current study is to present a more quantitative chronological assessment of the Zihor assemblages, through closer study of their shape attributes. The new element that is introduced in the present analysis is the use of the digitized 3-D images of the handaxes, from which various quantitative measures of each individual item were extracted. Our results validate the existence of two distinct groups and link *Group A* to the early Acheulian. Accordingly, this study suggests that the finds of *Group A* from the Zihor are the most southern location in the Levant where evidence of early Pleistocene hominid occupation has been found. The importance of the study of these lithic assemblages is primarily due to the scarce evidence of Lower Paleolithic hominid presence in the Levant, in particular the earliest phase in the southern region of Israel. Hence, the information derived here may shed new light on early hominin migrations out of Africa.

INTRODUCTION

Direct evidence for Early Pleistocene hominin dispersal throughout the Levant is limited to a few sites in Israel—'Ubeidiya at ~1.4 Ma (Bar-Yosef and Goren-Inbar 1993, Martínez-Navarro et al. 2009), and Evron Quarry and Bizat Ruhama at about 1 Ma (Laukhin et al. 2001; Ron et al. 2003). Currently, 'Ubeidiya in the Jordan Valley, Israel, provides the most southerly evidence for early hominid presence out of Africa (Belmaker et al. 2002; Martínez-Navarro et al. 2009).

In 1996, a geological and prehistoric survey was conducted in the Zihor River valley by H. Ginat and I. Saragusti of the Hebrew University. The surveyors discovered an early sequence of Pleistocene fluvio-lacustrine deposits indicating the existence of a paleo-lake named "Lake Zihor." These deposits were assigned to the early Pleistocene using preliminary correlations with pollen and faunal assemblages from the 'Ubeidiya paleo-lake (Ginat 1997: 109–111). Recently, ^{10}Be exposure dates suggested a minimum date of ~1.6 Ma for the fluvio-lacustrine deposits (Guralnik et al. 2010). Tectonic uplifting of the southern Negev, post-dating Lake Zihor, caused changes in the main drainage systems, resulting in the gradual development of valleys and the formation of terraces. Four terraces were identified in the southern Negev (Ginat 1997: 188), however, unlike the lake deposits, the terraces were not dated geologically (for further elaboration on the geology see Ginat et al. 2003).

The survey also discovered a large collection of Lower Paleolithic handaxes concentrated in many find spots in an area of 12km^2 (Figure 1; Ginat 1997; 2003: 450). The find spots are located in two areas—near the suggested shoreline of Lake Zihor and on the neighboring terraces (see Figure 3). The handaxes were divided into two groups according to their find location (Ginat 1997: 176–178)—*Group A* includes handaxes found along the reconstructed shoreline of the paleo-lake (Ginat 1997) and *Group B* consists of handaxes, derived from the terraces.

Observing the handaxes, Ginat et al. (2003) noted a similarity of *Group A* with the 'Ubeidiya handaxes dated to 1.4 Ma. It also was suggested that items belonging to *Group B* are similar to handaxes found in upper Acheulian sites in northern Israel (Ginat 1997: 178), dated to the later part of the Lower Paleolithic (Ginat et al. 2003: 452). The handaxes of both groups were found on the surface, and therefore the geological dates might not correlate with the archeologically estimated dates, which were based on qualitative consideration.

The above considerations clearly underline the poten-

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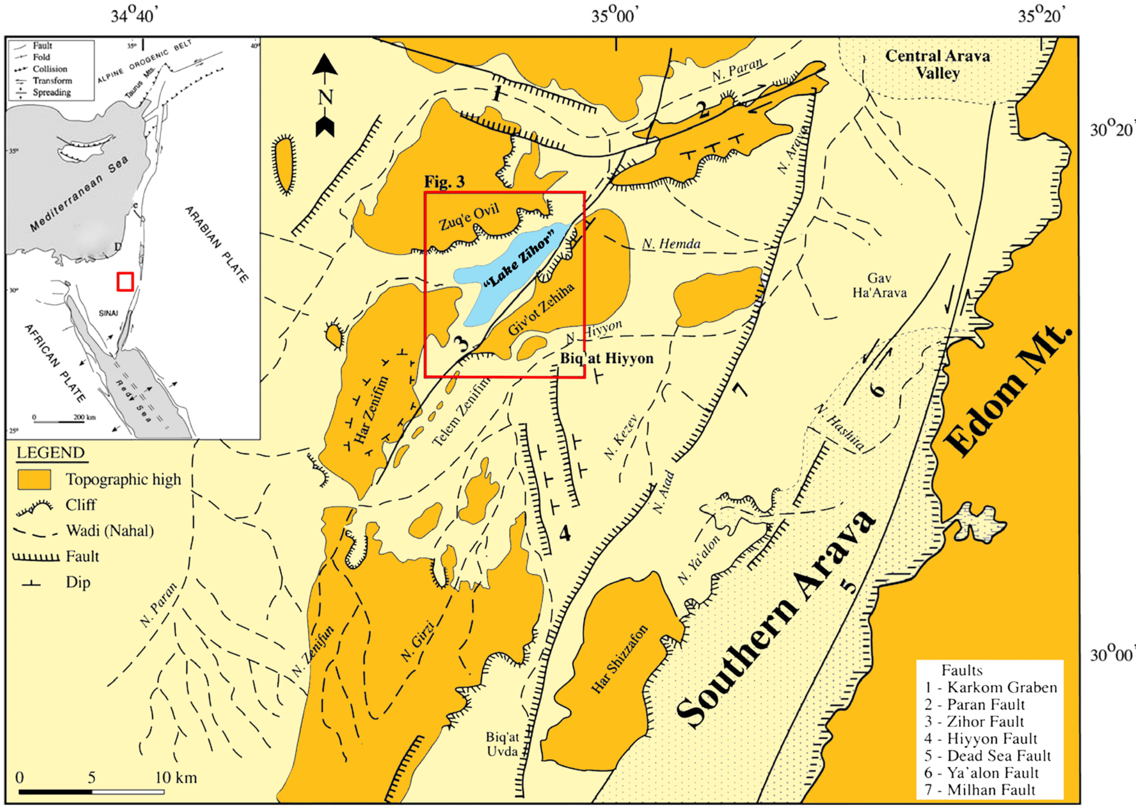

Figure 1. Location of the Pleistocene lake Zihor in the Arava region, Southern Israel (after Ginat et al. 2003).

tial importance of the Zihor finds for the understanding of the early migration of hominids out of Africa. They also motivated the present research.

We studied the Zihor finds in two complementary ways. Observing the individual handaxes, we registered variations in composition and in their surface properties. We then extracted metric and shape parameters from precise 3-D scans. Combining our data with the previously established chronology of the Lower Paleolithic handaxes in the Levant (Gilead 1970; Saragusti et al. 2005), we were able to provide further evidence for the approximate dates of the two Zihor groups. Our results support the previous assessments and provide further evidence in favor of positioning the Zihor as the southernmost Lower Paleolithic site out of Africa.

The morphometric approach to the study of handaxes is almost as old as prehistoric research. Various linear metrics (length, width etc.) and functions thereof were used to classify handaxes since the early days. During the last 20 years there has been ongoing research oriented to understanding the underlying concepts of handaxe variability. Crompton and Gowlett (1993; Gowlett and Crompton 1994) emphasized the importance of allometric measures to characterize variations of handaxe morphology. White (1995) claimed that the variety of the final morphology of handaxes is dictated by the raw material used for the production. McPherron (1999; 2006) hypothesized that this variety could be explained as a function of reduction intensity. Sharon (2007) in a paragraph headed "On comparing between apples and oranges in the study of Acheulian large cutting tools" showed that both White and McPherron's hypotheses do not apply to early Acheulian assemblages and large flake based Acheulian industries. Archer and Brown (2010) relate handaxe variability to specific reduction strategies, where the reduction strategy and intensity are mediated by raw material selection, yet Sharon (2008) argues for a radically different pattern. The framework outlined by these researchers must be taken into account when engaging in morphology-based questions of intra-variability assemblages, however, these works do not account for time-transgressive variations, especially when dealing with early Acheulian industries or with inter-assemblage variability. To the best of our knowledge, to this day the only quantitative morphometrics that distinguish between early and late Acheulian handaxes in the Levant are based on size (Gilead 1970) or symmetry (Saragusti et al. 1998; Saragusti 2002; Saragusti et al. 2005). In our study, we focus on these measures, at the same time bearing in mind the possibility of variation related to the reasons cited above.

METHODOLOGY

The survey of Nahal Zihor yielded over 100 find spots (localities with highly dense surface collections, primarily handaxes) in an area of 12km^2 (Ginat 2003: 450). Large concentrations of stone tools were observed at six find spots (find spots 40, 52, 61, 62, 86, 100). The entire assemblage, which consists of a few hundred artifacts, has not yet been analyzed. For the present study, 50 intact handaxes were chosen—*Group A* is represented by 25 handaxes, which comprises nearly all the handaxes retrieved from find-

Figure 2. Assemblage of handaxes from find-spot 62 (after Ginat et al. 2003).

points 52 and 62 (Lake shore, Figure 2). The 25 handaxes representing *Group B* were randomly selected from *ca*. 300 handaxes collected from the richest find spot (86) which is closely associated with the terraces overlaying the lake deposits (Figure 3).

The handaxes were examined in two independent ways. Each handaxe was examined visually and descriptive attributes including variations in raw material, patina, and pot lid distribution were recorded. Precise surface images of the handaxes were recorded by a 3-D camera. The resulting digitized triangulated surfaces were used to extract various metric parameters including the facial asymmetry parameter. Below, we describe these complementary tests separately and in detail.

3-D SCANNING AND DOCUMENTATION

The handaxes were scanned using a high precision 3-D camera (manufactured by Polygon Technology, Darmstadt, Germany), which projects structured light on the artifact and records the object with two digital cameras. The digitized surfaces were then analyzed using our recently developed algorithm. First, it determines the proper positioning of the artifacts (In brief, the algorithm computes the inertia tensor for the artifact. The inertia eigenvectors are then identified as the coordinate frame where the artifact is aligned, see details in Grosman et al. 2008). Second, the algorithm computes the linear measures—length, width, thickness, width at half length, width and thickness at 1/5 length, and width and thickness at 4/5 length, thus emulating the conventional method for measuring handaxes (Bordes 1961; Goren-Inbar and Saragusti 1996; Roe 1964). The digital image also enables the computation of additional parameters which are not accessible using traditional techniques, namely, volume and center of mass (Grosman et al. 2008). Finally, the program prepares detailed and accurate computerized views and sections, replacing the traditional hand drawn images. They are arranged in plates (e.g., Figure 4), which are automatically assembled once the page size, number of artifacts per page *etc*. are specified (e.g., Figure 5).

ASYMMETRY

The use of the degree of asymmetry (the asymmetry parameter) as a diagnostic tool in the study of early lithic artifacts has been advocated by several scholars (Hardaker and Dunn 2005; Lycett 2008; Machin et al. 2007; Nowell 2000; Saragusti et al. 1998; Saragusti 2002; Saragusti et al. 2005).

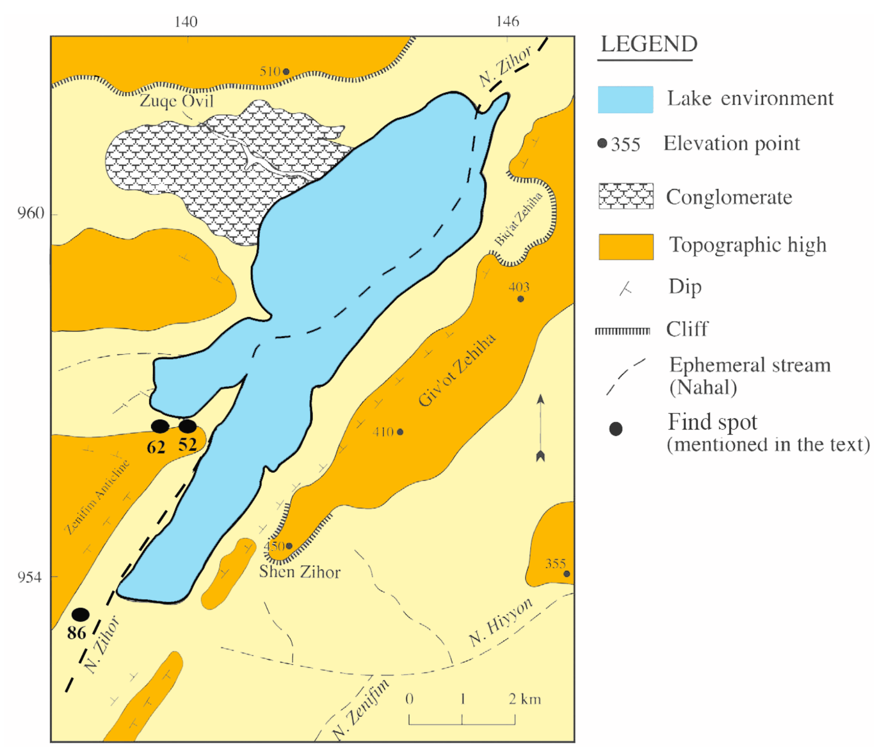

Figure 3. Paleo-lake Zihor and the location of the find-spots analyzed in present study (52, 62, and 86) (after Ginat et al. 2003).

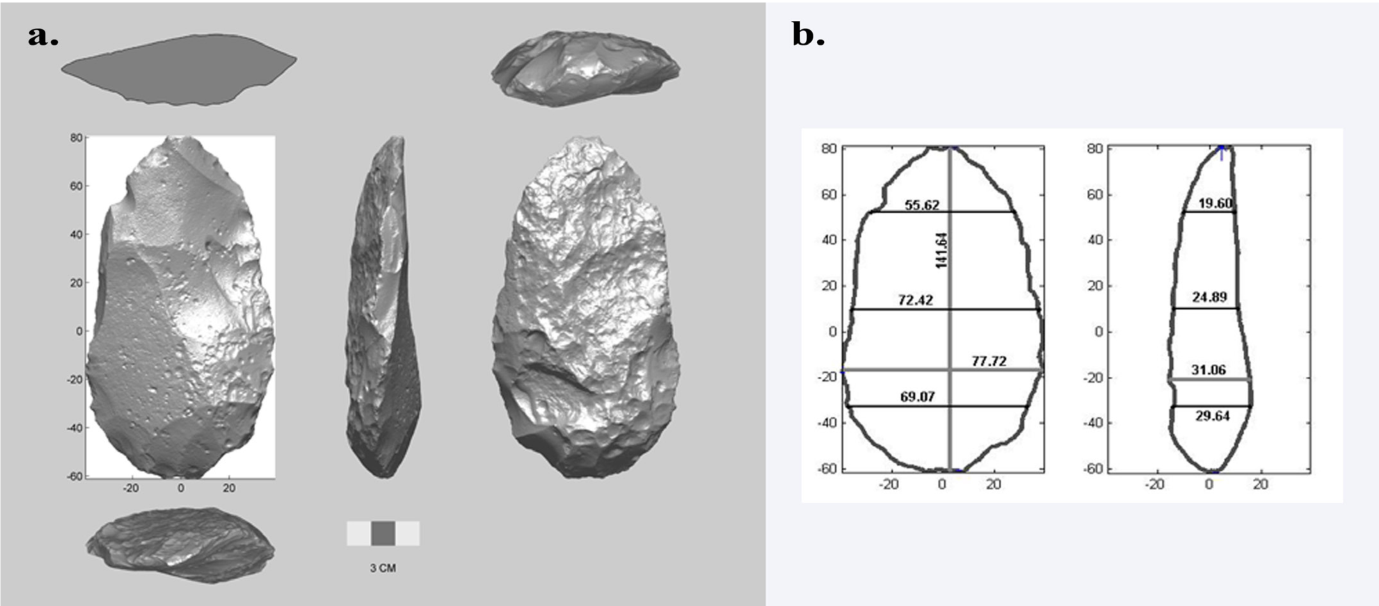

Figure 4. Handaxe documentation (Group B handaxe, note pot-lids on both surfaces): a) five views and section at maximum width; b) linear measures.

Here, we quantify the degree of facial asymmetry using the method proposed by Saragusti et al. (2005). This method is based on the following principles. The profile of the artifact is a closed curve, defined as the projection of the artifact on its ventral plane. A profile is symmetric if there is a line that divides the profile into two halves which are mirror symmetric. If the profile is not symmetric, such a line cannot be drawn. However, one can look for the line which provides the best partition of the profile, so that the two parts are the least asymmetric. The difference between the two sides provides a measure of the asymmetry. This process was formulated mathematically (Saragusti et al. 2005) to produce a numerical value that quantifies the degree of facial asymmetry (i.e., less symmetrical artifacts are attributed by higher asymmetric values). By using the methodology developed by Saragusti et al. 2005, we are able to place the asymmetry parameter of the Zihor assemblage on the scale derived in Saragusti et al. (2005) for other sites.

CONVENTIONAL DESCRIPTIVE ATTRIBUTES

Each handaxe was carefully observed and the following attributes were documented:

- *Patina*: the patina is a brown/black coating which evolves on rock surfaces in hot and slightly moist conditions. When moisture comes in contact with aeolian particles situated on the rock's surface, a chemical reaction occurs. The moisture evaporates and the residue (usually rich in iron or manganese) remains. The residue covers the rock with a very thin coating that is observable as a change in color (Howard 2002; Liu and Dorn 1996; Reneau et al. 1992). Observations concerning the extent of patina were made by recording the presence of two different colored varnishes (double patina) on one or both faces of the artifacts.
- *Pot lids*: pot lid removals are small, disk-shaped convex indentations which form on the artifact surface after a fragment is ejected in response to drastic temperature fluctuations that cause the surface of the rock to expand (Purdy 1975: 136; e.g., see Figure 4). The presence or absence of pot lid removals was recorded for each handaxe.
- *Post-depositional distal breakage scars*: these are large scars that change the shape of the handaxe tip, and usually exhibit a different color than the artifact surface. The number of distal breakage scars was recorded on both handaxe surfaces.
- *Raw Material*: the raw materials used to manufacture the handaxes were sorted by color, coarseness, and breakability, and were compared visually to known raw materials in the research area. These characteristics were used to identify three different raw materials for the handaxes.

RESULTS

COMPOSITION

The two handaxe groups from the Zihor Valley differ in the raw material types selected for their manufacture. *Group A* handaxes (see Figure 5) are produced from a variety of raw materials—flint (52%), silicified sandy phosphorite (32%), and silicified limestone (16%), while *Group B* handaxes were manufactured exclusively from flint. Previous studies of Levantine handaxes showed that, in the early Acheulian, handaxes were made from a variety of raw materials (Gilead 1970: 3), yet "At a certain point, postdating the times of Gesher Benot Ya'aqov (middle Acheulian), the diversity typical of raw material selection is replaced by a rather

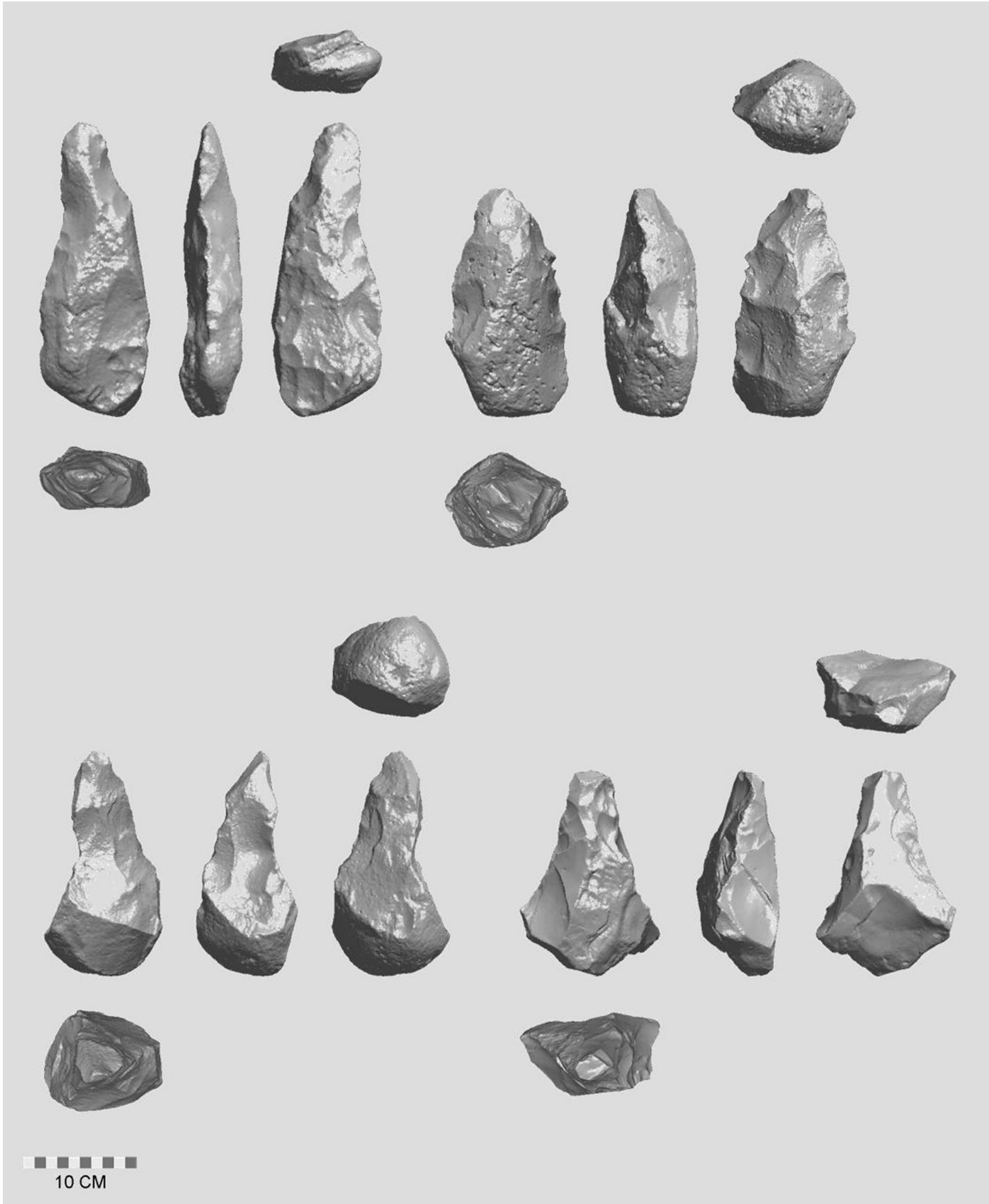

Figure 5. Plate presenting typical handaxes from Group A (find-spots 52 and 62).

simplified pattern, characterized by an exclusive use of flint" (Goren-Inbar 1995: 100). This difference enables the preliminary assignment of *Group A* handaxes to the early Acheulian and *Group B* to a later date.

BASIC LINEAR MEASURES

The linear measures were extracted from the 3-D models as described above. Figure 6 and Table 1 present the mean values and standard deviations of artifact width, thickness, length, thickness at the tip (4/5 length), width at the tip (4/5 length), thickness at the base (1/5 length), and width at the base (1/5 length).

The most conspicuous feature in these data is that on average, all the linear parameters (but one) for *Group A* handaxes are larger than those of *Group B* by a factor of 1.3±0.1. Thus, on average, the shapes of the two groups differ only by scaling with a constant factor. The only exception is the thickness at 1/5 length (thickness of the proximal edge), which shows some significant allometry. A plausible reason for this phenomenon will be suggested below. This is the only allometry we observed in the present assemblage.

Another view of the data is provided in Figure 7. Each handaxe is represented as a point in a scatter plot where the coordinate axes are the length (L) and the cubic root of the measured volume ($V^{1/3}$). The scaling property of the linear measures is confirmed because in this presentation, the points scatter along a straight line. Moreover, the points corresponding to *Group B* occupy a lower section of the two parameter space corresponding to the factor 1.3 dif-

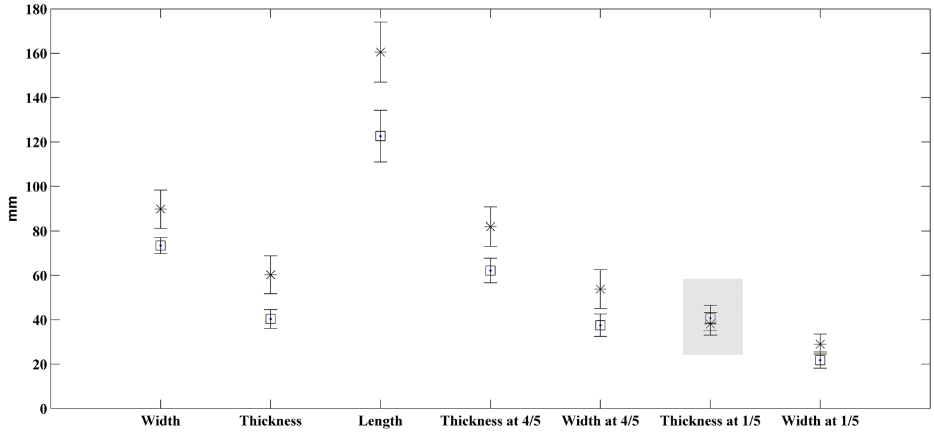

Figure 6. The metric parameters of Group A handaxes (*) vs. Group B (□) with standard deviations. The variable which is similar in both groups is emphasized by a gray box.

ference in their respective linear measures. This is demonstrated clearly in the positions of the mean values of the two groups.

Another clear difference between the two groups also is apparent from Figure 7—*Group B* handaxes are standardized and are tightly grouped within a relatively small range, which suggests a higher degree of homogeneity. *Group A* is more heterogeneous—its parameters are distributed over a significantly larger range.

Previous morphological studies of Lower Paleolithic handaxes suggested a chronological progression from more robust, heterogeneous handaxes in the early assemblages to the later, more homogenous ones during the Late Acheulian (Gilead 1970). An increase in homogeneity of handaxe shape and the reduction in size through time have been frequently described in other Acheulian handaxe studies from various geographic areas across the Old World (Sharon 2007). Gilead (1970) suggested that there is a gradual shortening of handaxes in the Levant through time (Figure 8). Indeed, the average length of the handaxes in *Group A* (166mm) is equivalent to those from 'Ubeidiya. The average size of the *Group B* handaxes (124mm) falls in the range of Ma'ayan Barukh and Umm Qatafa handaxes (late Acheulian, see Figure 8). We can thus conclude that the linear measures suggest the assignment of *Group A* to the early Acheulian and *Group B* to the late Acheulian.

ASYMMETRY

The mean value of *Group A*'s asymmetry is slightly higher than that of *Group B* (Figure 9). When the Zihor asymmetry values are plotted against those from the sites presented in Saragusti et al. (2005) both *Groups A* and *B* fall within the range of the earliest assemblages. *Group A's* mean value is even higher than that of the earliest assemblage in the Levant—'Ubeidiya. *Group B* is far less symmetrical than the Ma'ayan Baruch handaxes (see Figure 9), with an asymmetry similar to that of the 'Ubeidiya handaxes. The asymmetry values of both Zihor groups fall within the range of the early Acheulian. This is not consistent with our previous assessment which was based on clear differences in the linear dimensions and raw material selection of the two groups. *Group B* displays an asymmetry value which is far larger than expected, and thus it is placed in the same age range as *Group A*. In the following we shall explain this ap-

TABLE 1. MEAN AND STANDARD DEVIATIONS OF MEASUREMENTS BY HANDAXE GROUP.*

	Group B	SD	Group A	SD	A / B
Width	73.71	5.72	89.96	16.37	1.22
Thickness	40.66	6.95	58.33	18.28	1.43
Length	123.92	17.58	165.88	32.95	1.33
Thickness at upper fifth	63.19	8.55	80.64	18.05	1.27
Width at upper fifth	37.68	7.62	53.24	21.75	1.41
Thickness at lower fifth	**40.20**	**9.15**	**38.03**	**9.77**	0.94
Width at lower fifth	21.32	3.85	28.64	11.37	1.34

*The variable which is similar in both groups is emphasized by a gray box (see discussion).

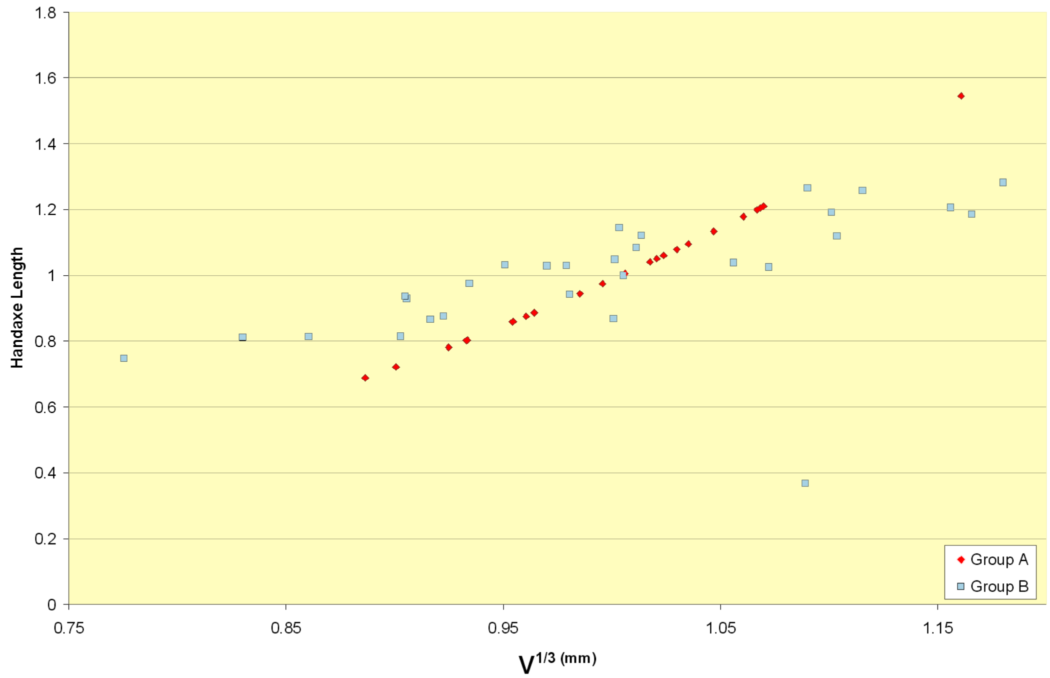

Figure 7. Handaxe length and volume derived from the 3-D analysis of the handaxe assemblages.

parent contradiction by showing that the two groups experienced very different post-depositional histories. Once this is established, we shall use the results of a recent study (Grosman et al 2010) to estimate the effect of post-depositional processes on the asymmetry values. Correcting for this effect brings the asymmetry data in agreement with the other date estimates.

SURFACE PROPERTIES— POST-DEPOSITIONAL PROCESSES

The Zihor handaxes were collected from the surface, suggesting that they might have been exposed to various natural processes after being discarded. Preliminary observations showed that such processes affected *Group B* far more extensively than *Group A*. This indicates that the *Group B*

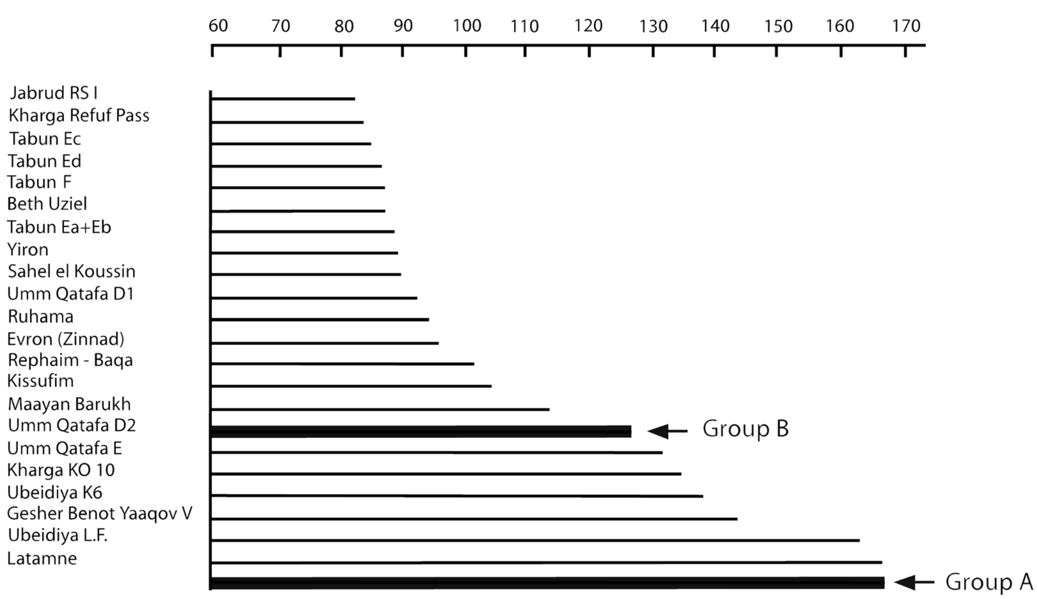

Figure 8. Mean length of handaxes (mm) (after Gilead 1970) plotting Group A and Group B mean values.

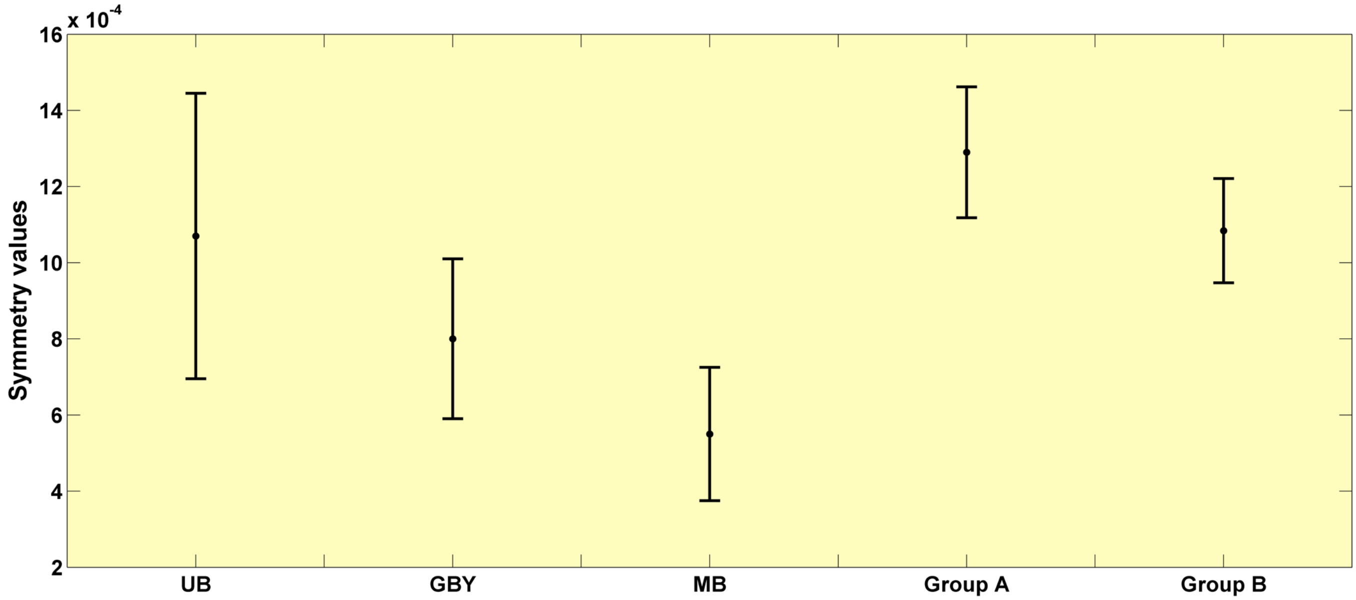

Figure 9. Comparison of asymmetry values: early sites – 'Ubeidiya (UB), Gesher Benot Ya'aqov (GBY), and Ma'ayan Barukh (MB) (Saragusti et al. 2005) and Zihor Groups A and B. Y axies should be asymmetry and not symmetry.

handaxes were more damaged, and that their original geometric parameters (linear metric dimensions as well as the asymmetry) were altered. In the following section we first substantiate the claim that the two groups underwent very different post-depositional histories. Second, we describe an experiment that allowed us to quantify the change in the geometric parameters as a function of the intensity of post-depositional damage. The experimental results are used to show that: 1) the linear metric parameters are not substantially affected by battering; 2) the asymmetry parameter is sensitive to battering; and, 3) a quantitative analysis of the experimental results offers a way to correct for post-depositional effects on the mean asymmetry parameter for the *Group B* artifacts.

In the following, we list the evidence collected by inspecting the artifacts, which suggest that *Group A* and *B* underwent substantially different post-depositional histories. Breakage scars on the distal edge provide direct evidence for the intensity of the post-depositional forces which acted on the object. Over 90% of *Group B* handaxes bear such scars, and 72% have more than two scars (Figure 10). In contrast, half of the *Group A* handaxes bear no distal breakage, and the other half shows only one scar. In addition, 72% of *Group B* handaxes display patina on both surfaces while only 4% of *Group A* handaxes display this degree of patina (Figure 11). The presence of patina on both surfaces suggests that the handaxes rolled over during two separate events and patina formed on the surface between the turning events. On the other hand, more than 50% of *Group A* handaxes have no patina at all. Finally, almost all *Group B* handaxes display pot lids which appear on both surfaces in about half of the cases (e.g., see Figure 4). Again, this differs from *Group A* handaxes which bear pot lids in only 64% of the cases, most of them only on one surface. Together, these observations suggest that *Group B* handaxes were exposed to harsher post-depositional conditions than those of *Group A*.

THE EFFECT OF POST-DEPOSITIONAL PROCESSES ON MORPHO-LOGICAL PARAMETERS

Recently, the effects of battering on the linear measures and the degree of asymmetry of handaxes were studied (Grosman et al. 2010). It was shown that asymmetry increases due to battering, and appreciable asymmetry is observed even when the net volume reduction is less than 5%. This was explained by showing that the battering removes small flakes from the sharper edges of the handaxes without significantly affecting its general shape or dimensions.

The surface properties of the two Zihor groups provide strong evidence to the assertion that *Group B* handaxes underwent substantial post-depositional damage, in contrast with items in *Group A* which do not show these marks. Moreover, the *Group A* handaxes were not associated with alluvial or colluvial pebbles (Ginat et al. 2003: 450), so that damage by battering was unlikely to occur.

Following Grosman et al. (2010), we can propose that the original or true mean asymmetry parameter for the *Group B* handaxes was substantially lower when the handaxes were originally deposited. It is not possible to provide a quantitative statement about the corrected asymmetry in the present case. The recent handaxes that were used in the experiment were not identical in material, shape, and size to the prehistoric ones. However, a rough estimate of the effect can be obtained by using the same increase in the asymmetry parameter as given by the mean experimental result. This is shown in Figure 12 where the mean asymmetry of *Group A* handaxes is the same as its measured value.

Saragusti et al. (2005) showed the asymmetry values

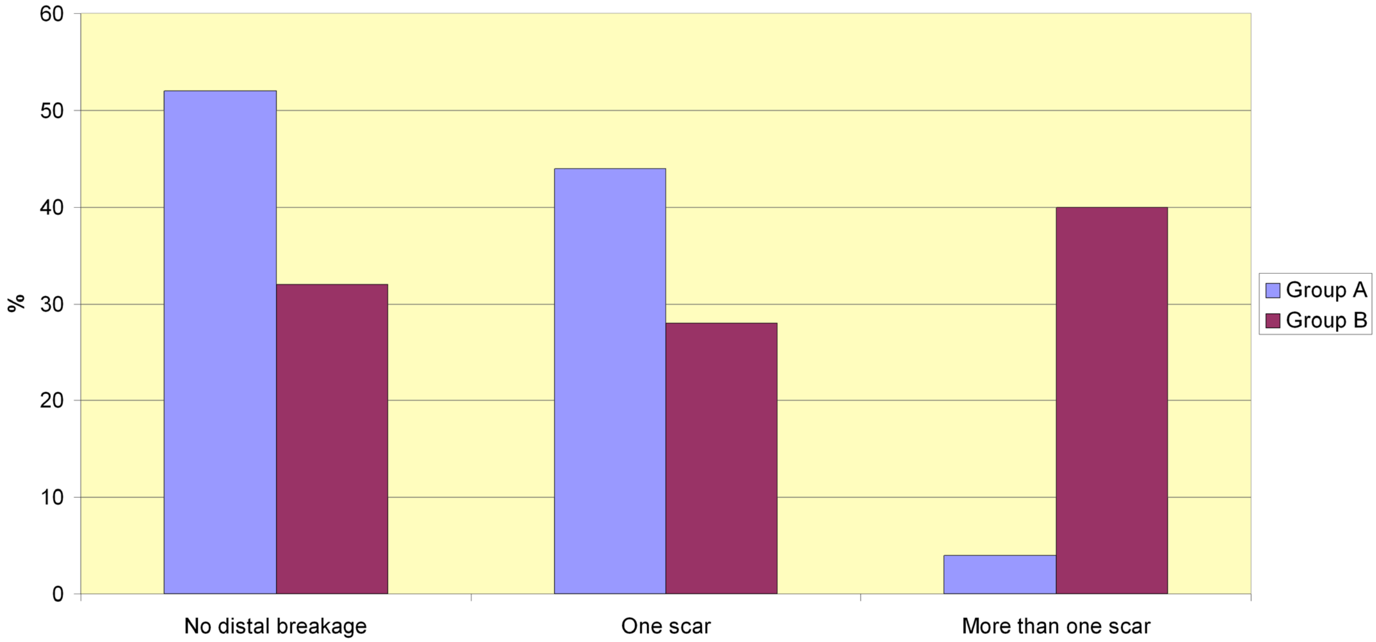

Figure 10. Distal breakage scars.

of handaxes generally decreases through time. Recently, however, Lycett (2008) suggested that temporal variability in handaxes does not progress linearly, but is the consequence of a more complex social, adaptive, or functional process. In his analysis, Lycett does not take into account the chronological sequence of the Levantine Lower Paleolithic established by Saragusti et al. (2005). We believe that the latter interpretation is relevant in the present study.

It is important to note that Saragusti's results are taken here at face value although she did not monitor post-depositional effects on the handaxes she measured; most of them originate from sites which are clearly *in situ*. Still, it appears that the Zihor *Group A* handaxes are at least as old as the Ubeidiya handaxes. The asymmetry values of the *Group B* handaxes is consistent with the value expected for the Late Lower Paleolithic handaxes.

STATISTICAL ANALYSIS

The results above identify major differences between the two groups of handaxes. Yet this analysis already assumed

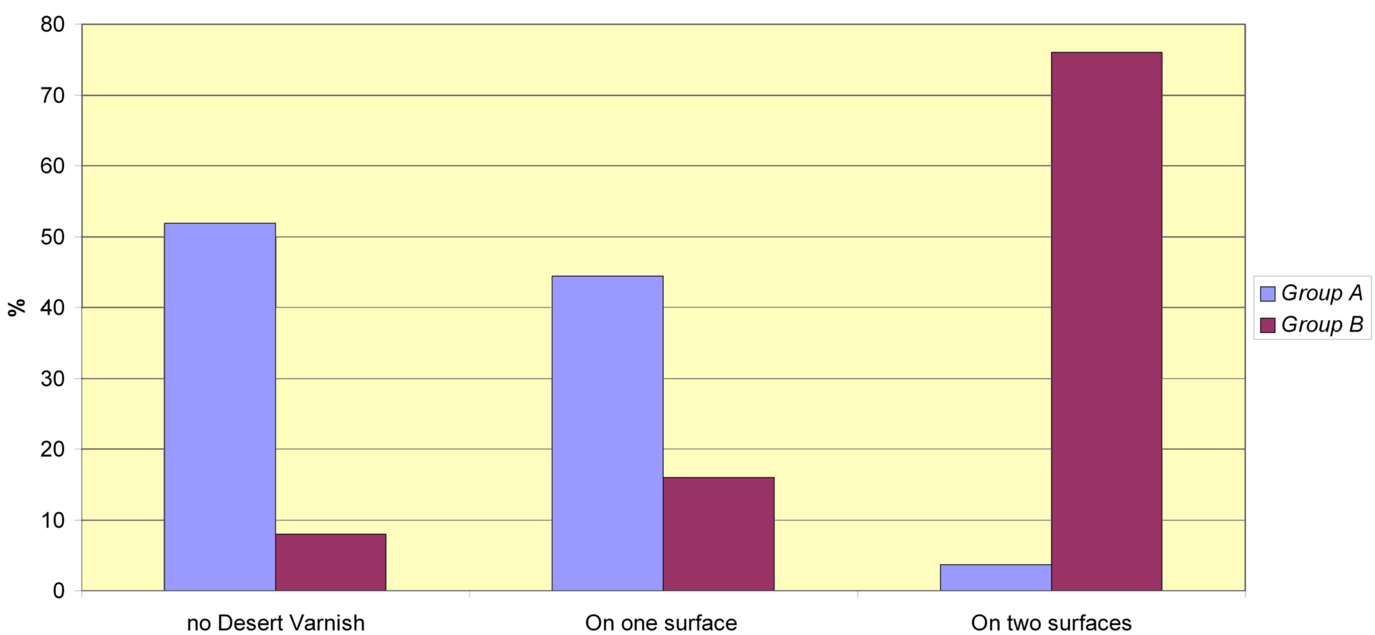

Figure 11. Patina on handaxe surfaces.

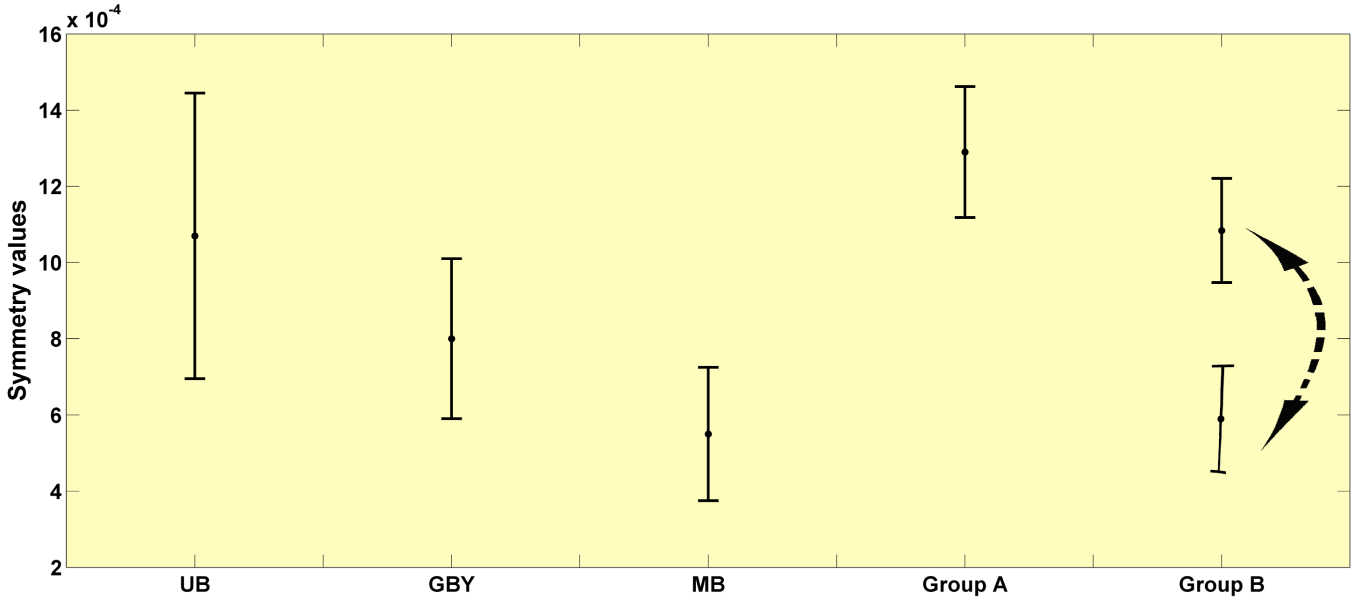

Figure 12. Asymmetric mean values of handaxe assemblages with the new estimated value of Group B. Same as Figure 9.

that they were two discrete groups based on their geographic location in the Zihor basin. In order to validate this assumption, we statistically tested all of the parameters extracted from the handaxes (from the 3-D image and manually) using Principle Component Analysis (PCA) and Discriminant Analysis.

PCA is the best way to avoid redundancies and to focus on the relevant variables which represent the true variability of an assemblage (Jackson 1991; Jolliffe 2002). This method transfers the original information from the distance matrix into a new matrix, with no loss of information. The columns of the new matrix are linear combinations of the original ones. They are defined in such a way that they are linearly independent and with descending magnitude of variability. The variability of a column is computed as the mean of squared distances of each value from the average of the column. PCA was applied to the data set after reducing it to a lower dimension. Since the parameters were measured on diverse scales, we normalized them according to each variable's mean value. The output of the PCA analysis is displayed in a coordinate system defined by the 1^{st} and 2^{nd} principal component (Figure 13).

The clear partition between the two sets of handaxes is achieved by the first component. The dominance of a single PCA is in complete accord with our previous assertion that allometry is not significant for this analysis—the scale is the feature which distinguishes between the two groups.

We next applied discriminant analysis, the purpose of which is an understanding of the data set. A careful examination of the prediction model that results from the procedure can give insight into the relationship between group membership and the variables used to predict group membership. Discriminant analysis (Figure 14) was conducted to determine the boundaries between the groups. Except for a few handaxes that were classified to the wrong group, the resulting function discriminates the handaxes into the two distinct groups used here.

These two statistical analyses show that the characteristics of each handaxe, independently, support the original division into two groups.

CONCLUSIONS

Handaxes are the '*guide fossils*' of Lower Paleolithic Acheulian industries and were studied intensively across the Levant during the last half-century (e.g., Gilead 1970; Goren-Inbar and Saragusti 1996; Sharn 2007). Handaxes are distributed in the Old World and provide prehistoric research with markers of early hominid occupations within and outside Africa (Sharon 2007; Soressi and Dibble 2003). Accordingly, the Nahal Zihor handaxes may have an important role in understanding the "out of Africa" route during the early Pleistocene.

The analyses of the handaxe assemblages from the Zihor valley are problematic primarily because of the rarity of finds from *Group A* (only 25 handaxes). Additional uncertainties include the post-depositional processes that differentially affected the two groups of handaxes, as well as the uncertainty of the landscape context in which they were found. Despite these limitations, we were able to obtain consistent relative dates for the handaxes based exclusively on their shape. Three attributes verified the relative chronological assignment—raw material selection, size parameters, and asymmetry values of each group.

The most striking result presented here is the association of the *Group A* handaxes with the early Acheulian. This result strengthens the claim that *Group A* is contemporaneous with Lake Zihor. The date suggested for the Lake Zihor deposits is 1.6 Ma (Guralnik et al. 2010). This is therefore the southern-most spot in Israel where evidence of early Pleistocene hominid occupation has been found. These findings support the idea that the Dead-Sea-Rift was one of the main routes of northward migration of hominids out of

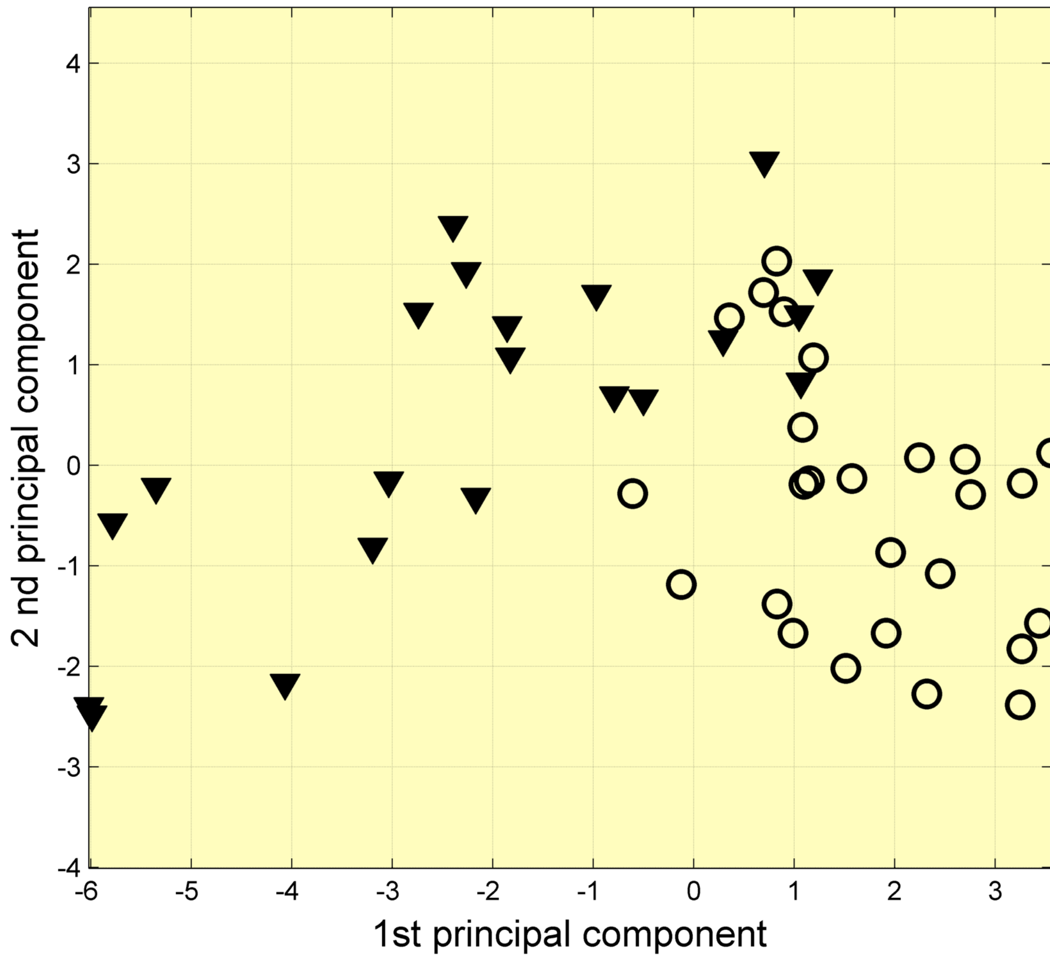

Figure 13. Principal component analysis.

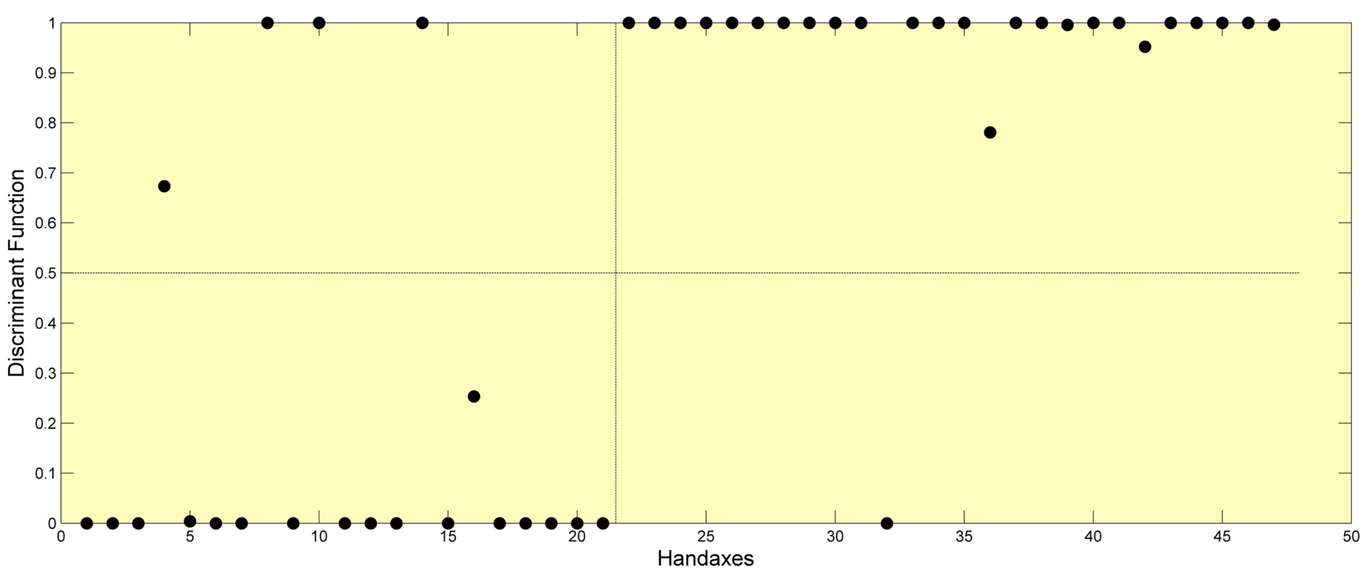

Figure 14. Discriminant analysis using all the parameters. At the x-axis, Group A is defined between 1–21 and Group B between 22–50.

Africa (Goren-Inbar et al. 2000).

The present study also shows that the only allometry present in the handaxes is the constancy of handaxe butt thickness through time at the Zihor region. The thickness at 1/5 length (thickness of the proximal edge) (see Figure 6) stands out as the only parameter which does not follow the almost uniform ratio of ~1.3 between the metric measures of the two groups. Thus, despite substantial differences in size, the handaxe butt was standardized (see Figure 6, see Table 1). Local raw material availability, namely pebble size, is ruled out as the cause of this homogeneity since different raw material sources were utilized over time. Instead, this character likely results from the fact that for at least 1.5 million years, handaxes were held by hand at the proximal edge of the tool (Jones 1980; McNabb et al. 2004; among others). Standardizing the size of the base assures a convenient grip for the tool. Recent ergonomic studies suggest that tool handles with diameters in the range 30–40mm are significantly more comfortable than other sizes (Kong and Lowe 2005: 499). Although the handaxe section is oval rather than circular at the base, like present-day handles, the average thickness of the gripping base of the handaxe is similar (40mm on average, see Table 1). These results reinforce previous observations that only minor changes occurred in power grip during the Paleolithic, indicating modest evolutionary changes of the human hand (Susman 1994). The base dimension reveals a functional constraint on size in favor of comfort gripping regardless of temporal, style, or cultural changes, as evident in the other dimensions.

The present study underscored the great influence of post-depositional effects on the asymmetry values of the Zihor artifacts, and therefore the importance of considering them in comparative analyses (see Nowell 2000 for similar results).

The archaeological analysis presented here demonstrates the effectiveness of combining descriptive and quantitative attributes for obtaining far-reaching conclusions; namely, that it is possible to establish a division between two temporal phases based solely on the properties of the lithic artifacts. Thus, within a larger scale of assemblages, the accenting of diachronic and synchronic trends is promising. Future research will increase the number of handaxes from the Southern Levant to enable a better fine-tuning of the evolutionary process of bifaces in the Lower Paleolithic of the Levant.

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