Morphometric and technological analysis of Acheulean Large Cutting Tools from Porzuna (Ciudad Real, Spain) and questions of African affinities

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Abstract

The Acheulean of central Spain is well known from a handful of sites. Rarely, however, are these assemblages subject to systematic technological and morphological analyses. Numerous years of surface collection within the Porzuna area (Ciudad Real) has yielded a substantial collection of Lower-Middle Palaeolithic lithic material (with over 8000 stone tools), now housed at the Museo Provincial of Ciudad Real. It has been suggested that the LCT technology of the Spanish Acheulean may have been directly influenced by ESA African technological traditions; however, others have suggested a European origin for the technology. Here we present a techno-typological and 3D morphometric analysis of the LCT's collected at Porzuna. We compare the Porzuna artefacts to other known local assemblages from Ciudad Real as well as Acheulean LCT's from north, east and South Africa, to investigate potential technological and morphological affinities. Results of our analysis show that despite sharing technological similarities, such as the use of large flakes as blanks, significant morphological differences exist between the African and Iberian LCTs.

Keywords: Large Flake Acheulean; Iberian Peninsula; handaxe; morphometric analysis; Early Stone Age

1) Introduction

The Acheulean emerged in East Africa in association with a new species, *Homo erectus s.l.*, and became the longest lasting human cultural tradition (~1.76-0.2 million-years-ago [Mya]). Characterised by the appearance of large flake technologies and bifacially flaked core tools (Isaac, 1969; de la Torre et al., 2008), collectively termed as large cutting tools (LCTs), the rapid diffusion of Acheulean technology between 1.76 and 1.7 Mya is evidenced at sites such as Kokiselei 4 at West Turkana (Kenya) (Lepre et al., 2011), KGA6-A1 at Konso (Ethiopia) (Beyene et al., 2013), FLK W at Olduvai Gorge (Tanzania) (Diez-Martín et al., 2015), and Gona (Quade et al, 2004; Semaw et al., 2018). Subsequently, Acheulean LCT's became widespread across Africa, Europe, the Levant and large swathes of Asia and Arabia (e.g. Isaac, 1977; de la Torre et al., 2008; Presnyakova et al., 2018; Mishra et al, 2010; Goren-Inbar and Saragusti, 1996; Zhang et al., 2010; Shipton et al., 2014; 2018).

The origin and dispersal of the Acheulean in Europe is an important and ongoing point of debate. This includes within the Iberian Peninsula, where the earliest evidence of hominin occupation comes from sites such as Barranco León and Fuente Nueva, dated to 1.4-1.2 Ma (Toro Moyano et al., 2011), and Sima del Elefante (Atapuerca) (Carbonell et al., 2008) dated to 1.2 Ma; although their lithic assemblages have been classified as Oldowan or Mode 1. The earliest Iberian Acheulean assemblages have been documented at Barranc de la Boella, dated to ca. 1 Ma (Valverdú et al., 2014), and Cueva Negra, dated to 0.9-0.78 Ma (Scott and Gibert, 2009). Middle Pleistocene sites are, however, common on river terraces across the Iberian Peninsula. This includes the central Spanish area of Porzuna and Campo de Calatrava, where several Acheulean sites have previously been identified along the Guadiana River and its tributaries (Santonja and Redondo, 1973; Santonja and Querol, 1976; Vallespí et al. 1979; 1980; Alañón Flox 1980; 1982; Ciudad Serrano et al., 1983a; Ciudad Serrano, 1986). Other large river basins in the Iberian Peninsula with documented Acheulean sites include the Tagus and its tributaries (Santonja et al., 1978; Querol and Santonja, 1979; Santonja and Pérez-González, 2002; Rodríguez de Tembleque et al. 2004; Santonja and Villa, 2006), and the Guadalquivir river basin (Vallespí, 1992; Caro Gómez, 2000; Fernández Caro, 2008) (Figure 1). The wide documentation of LCTs across the Iberian Peninsula has resulted in multiple analyses highlighting their importance to hominin populations in this region (Santonja and Villa, 1990; 2006; Arroyo and de la Torre, 2013; Méndez-Quintas et al, 2018).

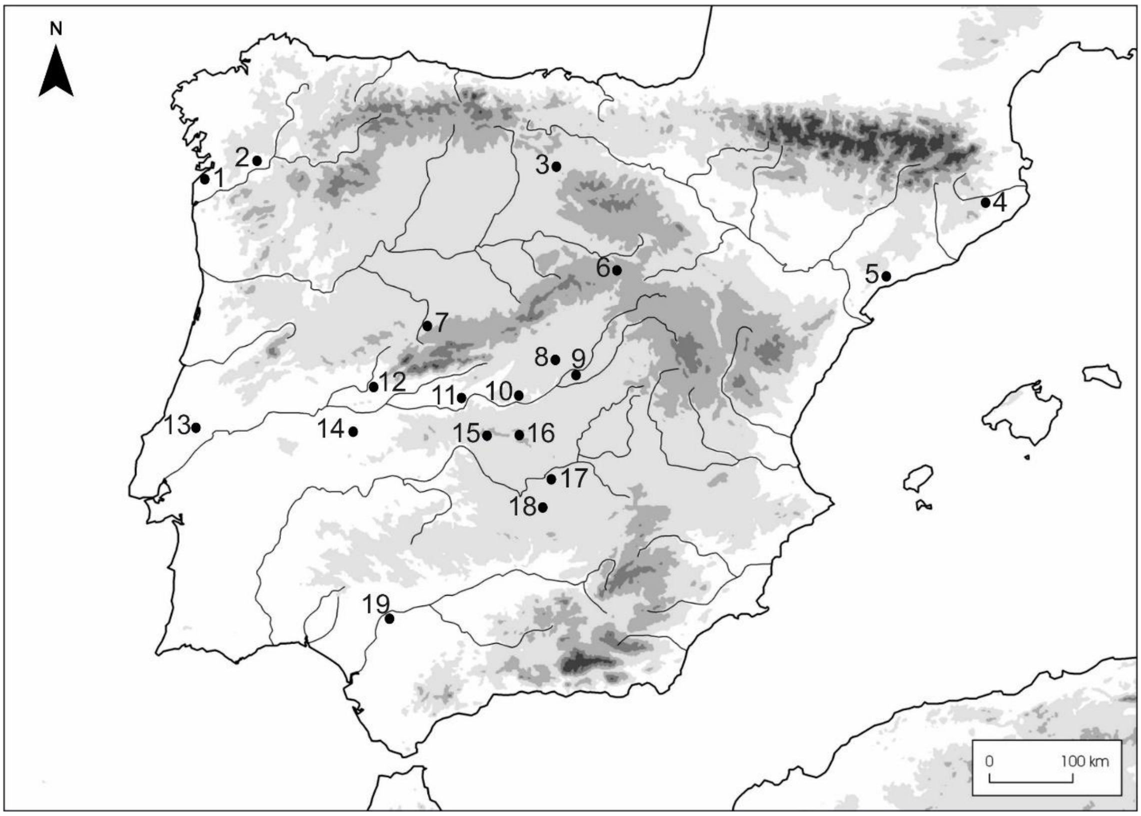

Figure 1. Location of a selection of Middle Pleistocene Acheulean sites from the Iberian Peninsula. Legend: 1. Budiño; 2. Porto Maior; 3. Galería (Atapuerca); 4. Puig d'Esclats; 5. La Cansaladeta; 6. Torralba and Ambrona; 7. La Maya; 8. San Isidro; 9. Áridos; 10. Pinedo; 11. Puente Pino; 12. El Sartalejo; 13. Gruta da Aroeira; 14. Santa Ana; 15 Porzuna; 16. El Sotillo; 17. Albalá; 18. El Chiquero; 19. Las Jarillas.

The earliest hominin migrations into Iberia, and in turn the appearance of the Acheulean, could have occurred through two routes. Individuals could either have colonised the peninsular from a North Africa route across the Strait of Gibraltar or spread through Western Europe. To date, both remain viable as potential dispersal routes of Acheulean technology into Iberia. Archaeological and faunal evidence has led O'Regan (2008) and Martínez and Garriga (2016), for example, to favour repeated episodes of Acheulean hominin population dispersals from Western European and the Levant into Iberia. Alternatively, Sharon (2011) has suggested a North African dispersal, based on the use of large flakes for biface manufacture, the high number of cleavers in assemblages, and the use of raw materials beside flint. To date, however, few studies have set out to formally test the hypothesised north African-Iberian dispersal routes as evidenced through lithic artefacts. Indeed, in a similar vein to hominin dispersal studies in other regions, there is a need for detailed typo-technological and morphometric comparisons of artefacts from both 'origin' and 'destination' localities (Goren-Inbar and Saragusti, 1996; Lycett and von Cramon-Taubedel, 2008; Lycett, 2009; Fleagle et al., 2010; Shipton and Petraglia, 2011; Wang et al., 2012).

Here, we present a technological and 3D shape analysis of a new Acheulean LCT assemblage collected from the Porzuna area of Ciudad Real, Spain. Our aim is to conduct a comparison of LCTs from this location with six other known Acheulean assemblages from Campo de Calatrava (El Sotillo and El Chiquero, Spain), north Africa (STIC and Cunnette), East Africa (HK, Olduvai Gorge) and South Africa (Elandsfontein). We assess techno-typological and 3D morphometric traits from Porzuna alongside these Spanish and African assemblages, contextualizing the Porzuna artefacts among other Central Spanish sites, while also contributing to our understanding of potential south-western dispersal routes into Europe by Middle Pleistocene hominins.

2) Materials and Methods

2.1 Materials

The archaeological locality of Porzuna

Porzuna lies in the north-west of Ciudad Real province (Spain), close to the foothills of the Montes de Toledo (in the north) and the volcanic area of Campo de Calatrava (to the south). Porzuna valley is crossed by the Bullaque River and filled with alluvial fan deposits. Multiple open-air artefact localities occur on its +5m river terrace. Our recent visits to the area confirmed the availability of high densities of raw material (mainly quartzite) and artefacts (Figure 2).

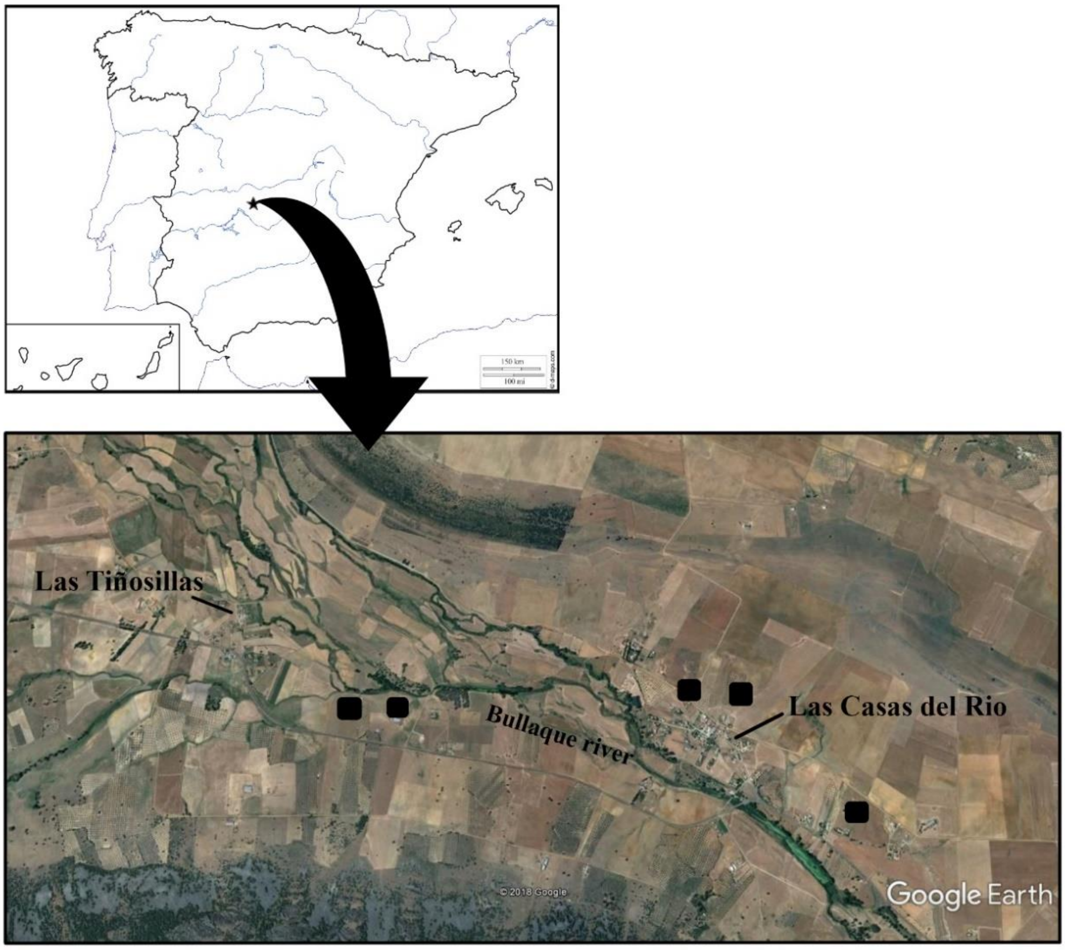

Figure 2. Location of Porzuna and general view of the area. Black squares refer to the points where lithics where collected (according to Vallespí et al., 1985).

The Porzuna assemblage currently contains over 8000 artefacts (including cores, débitage, retouched pieces and LCTs [bifaces, cleavers, picks and large flakes]) recovered by various prospectors from the 1950s onwards. First reported by Vallespí and colleagues (1979 and 1985), the assemblage was initially considered a mixture of Acheulean and Mousterian of Acheulean Tradition (MTA) artefacts, with very high densities of bifaces (>400), cleavers (>300) and picks (>130). Such occurrences were rarely documented outside of Africa at that time. Despite the lack of radiometric dates, Ciudad Serrano (1988) estimated the site to be included within the last glaciation (Würm I; ca 115 Kya). In a wider regional context, additional studies of the Guadiana and Jabalón rivers documented the presence of the Acheulean assemblages in +10/13 m and +8 m terraces (Santonja, 1996; Santonja, Pérez González, 2002, 2010), while the only radiometric chronology available to date was obtained from a +13/16 m terrace in the Guadiana river dated to 153.867 BP (López et al., 2005).

The lithic collection presented in this paper belongs to a previously unreported Porzuna assemblage deposited at the 'Museo Provincial of Ciudad Real' in 2015. Collected by a local prospector and subsequently donated, it consists of 216 artefacts separated into two localities: Las Casas del Rio (n= 58, 27%) and the larger assemblage of Las Tinosillas (n= 157, 73%) (Table 1). Within this assemblage there is a clear bias towards larger artefacts (cores and LCTs) compared to debitage which is underrepresented in the analysed assemblage. Due to this inherent bias we decided to focus our analysis exclusively on the LCTs (n= 130).

	Las Casas del Rio		**Las Tinosillas**	
	N	%	N	%
Natural base	0	0.0	2	1.3
Retouched piece	1	1.7	0	0.0
Flake	5	8.6	7	4.4
Flake fragment	0	0.0	1	0.6
Large cutting tool	21	36.2	109	69.0
Core	31	53.4	39	24.7

Total	**58**	**100**	**158**	**100**

Table 1. Breakdown of categories with all pieces included in the new assemblage accessed.

Comparative archaeological assemblages

Handaxes included in the 3D shape analysis were selected from sites in central Spain, and north, east and South Africa.

The Spanish assemblages include El Sotillo and El Chiquero; both are housed at the Museo Provincial of Ciudad Real (Spain). The lithic assemblage from El Sotillo, located ~20 km to the east of Porzuna, is formed of 115 bifaces, cleavers, knives and large flakes collected during the 1980's (see: Serrano et al., 1983; Arroyo and de la Torre, 2013). Located in a Pleistocene alluvial fan deposit in the Bullaque river valley (Portero et al., 1988), recent excavations at this locality have increased the assemblage size and will soon shed light on the absolute chronology of the assemblage. El Chiquero, located ~60 km south of Porzuna, is formed by a small group of surface collected handaxes (*n* = 8) from the left side of the Jabalón river valley. In this site, since the initial collection of surface material, no additional works were undertaken.

North African artefacts were selected from various localities from Sidi Abderrahman. Main sites include STIC, Cunnette and Grotte des Ours. Based on previous studies of these collections, STIC contains 'cruder' handaxes than Cunnette with a predominance of quartzite cobbles as blanks. Comparative analysis of human remains found in nearby localities support an estimated chronology between 0.6-0.4 Ma (Marshall et al., 2002).

From Olduvai, handaxes were selected from the Hopwood's Korongo (HK) site. Located on the north side of the gorge, this site was excavated during the 1931 expedition (Leakey and Roe, 1994). Despite uncertainties about its stratigraphic position, test trenches excavated in 1969 determined that HK is located in upper Bed IV or even the Masek Bed, and therefore has a chronology of < 0.6 Ma (Leakey and Roe, 1994). At HK, the majority of the handaxes are made of coarse grain quartzite and flake as blank (Marshall et al., 2002).

Finally, we selected bifaces from the South African site of Elandsfontein 8634 with an estimate age base of faunal remains between O.7-0.6 Ma (Marshall et al., 2002). The assemblage is predominantly formed of bifaces, but also contains low frequencies of cleavers. Raw materials include silcrete, Table Mountain sandstones, and quartz (Marshall et al., 2002).

2.2 Methods

All artefacts were initially technologically classified as Large Cutting Tools (LCTs), as proposed by Isaac (1977). Tools were subsequently classified into different categories (biface, uniface, cleaver, pick, knife, LCT blank, undifferentiated LCT) following definitions by Kleindienst (1962) and Isaac (1977). We used the term undifferentiated LCT to refer those large flake tools that cannot be included within the other categories. A technological analysis was performed for each tool, considering attributes such as raw material, type of blank, presence of cortex, number of *façonnage* removals, and point shape (i.e. McNabb et al., 2004; de la Torre and Mora, 2018). All artefacts had basic morphometric data taken from them using digital callipers, In each case the maximum dimension was taken.

Both parametric and non-parametric statistical tests were conducted depended on the type (categorical vs numerical) and distribution of data under study. A combination of Chi-square (Cramers V) (for categorical data) and Kruskal-Wallis and Mann Whitney U (for numerical data) tests were used to test for intra assemblage variation. The significant threshold was assessed at a 0.05 significance level, and post hoc analyses were employed where appropriate. Adjusted residuals were calculated for Chi-Square tests, with a value of 2.0 and -2.0 being taken to assess significant at a 0.05 confidence level. Pair-wise comparisons were undertaken for both Kruskal-Wallis and Mann-Whitney U tests. All statistical tests were computed using a combination of Microsoft Excel, SPSS and PAST (Hammer et al., 2001).

3D Shape Analysis

To facilitate shape comparisons between Porzuna, other Iberian, and African LCT assemblages, 3D morphometric data were collected from seven Acheulean handaxe assemblages. This included Porzuna (n = 57), El Sotillo (n = 34), El Chiquero (n = 8), STIC (n = 40), Cunnette (n = 40), Olduvai Gorge (n = 40), and Elandsfontein (n = 40) (Figure 3). The selection of African assemblages was chiefly based on matching their chronology and the estimated dates of the central Spanish sites.

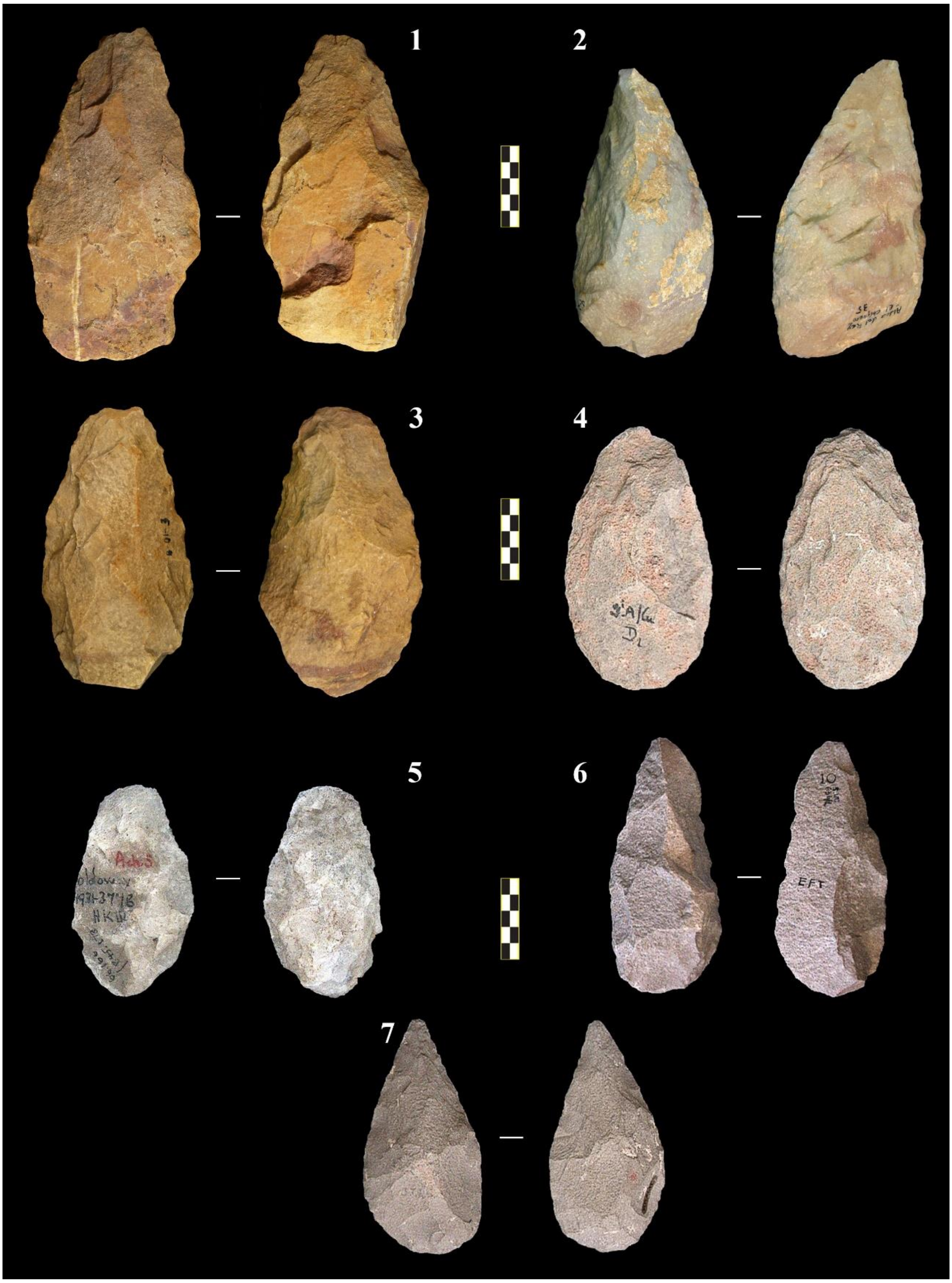

Figure 3. Examples of handaxes from Porzuna (1), El Chiquero (2), El Sotillo (3), Cunnette (4), HK (Olduvai Gorge, 5), Elandsfontein (6) and STIC (7).

The three Spanish sites (Porzuna, El Sotillo, and El Chiquero) had morphometric data collected from plan-view and side-view digital photos taken by the authors. Corresponding

STIC, Cunnette, Olduvai and Elandsfontein digital photos were downloaded from the freely available Biface Database (Marshall et al., 2002). The number of artefacts included in the Porzuna assemblage represents the total number of handaxes present in the assemblage deposited at the museum in 2015 (n = 57). The El Sotillo samples represent 29.6% of the LCT assemblage (following counts by Arroyo and Torre, 2013), while we used the whole assemblage of El Chiquero available. The Biface Database holds substantial numbers of handaxes from the other four assemblages. We chose a random selection of 40 from each to include as a representative sub-sample. In each instance plan-view and side view photos were chosen as the side displaying the most flake scars above 0.5 cm^2 in maximum dimension (Lycett et al. 2006). Each handaxe was scaled in mm using the scale-bar present in each image.

Within the variation of the LCTs categories existing within the Acheulean assemblages (i.e. picks, cleavers, etc) we selected only handaxes as they tend to display technological characteristics that facilitate their inclusion in morphometric analysis, allowing also to assess potential variations on the shape of the same type of artefact between populations.

Here, we use a 3D Cartesian co-ordinate shape analysis system outlined in detail elsewhere (Costa, 2010; Eren et al., 2014; Schillinger et al., 2015; Key and Lycett, 2017). Once each handaxe image was orientated by means of its line of maximum symmetry following Lycett et al. (2006), 29 metric variables were recorded in mm using the free image analysis software ImageJ (Figure 4). Variables recorded included the maximum length, width, and thickness of each tool. A further 26 metric variables were recorded from each tool; 13 plan-view width, and 13 side-view thickness, measurements. These additional variables were recorded at specific percentage points along the length of each artefact (Figure 4).

These 29 metric variables were size-adjusted using the geometric mean method, which has been shown to appropriately remove isometric size (scaling) differences between specimens, while retaining shape information (Jungers et al., 1995; Lycett et al., 2006).

Geometric mean can be calculated as $\sqrt[n]{a_1 \times a_2 \times a_3 \times \ldots \times a_n}$ where a series of variables (a_n) are computed as the nth root of their product. This was undertaken individually for the 29 metrics recorded from each handaxe, in turn producing 29 size-adjusted metrics describing shape for each tool. Principal component analysis (PCA) was used to examine shape variability among the 260 handaxes examined across all seven Acheulean assemblages. The size adjusted data from all tools were entered a PCA such that the major patterns of shape variation between artefacts could examined in a hierarchical fashion. The PCA was performed using PAST v.3.14 (Hammer et al., 2001).

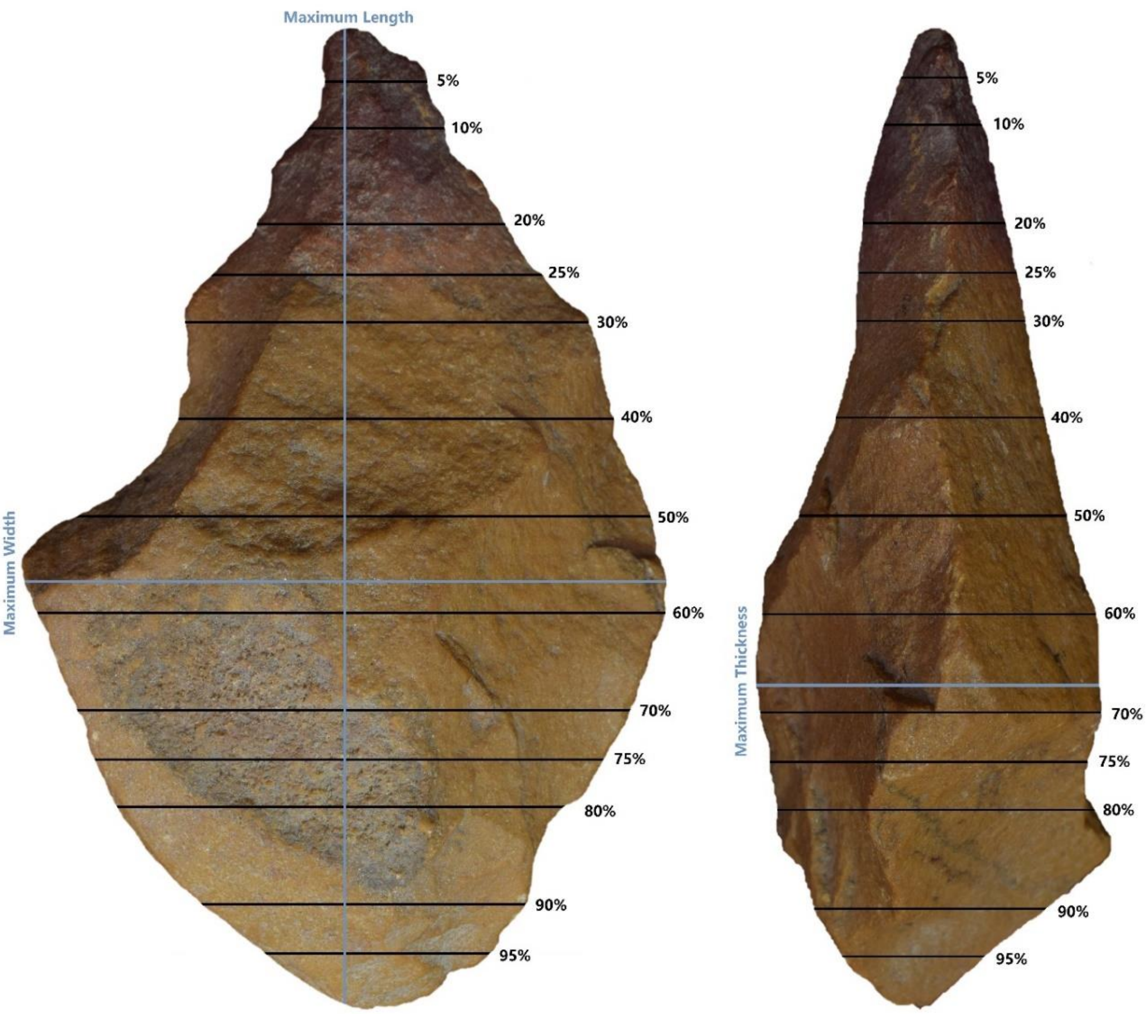

Figure 4. The 29 metric variables recorded form each artefact. The tool in this image has already be orientated by means of its maximum symmetry.

Shape differences between artefact assemblages were statistically examined using PC1 and PC2, which represent 43% and 24% of the observed variation (respectively). PC1 is most heavily loaded (i.e. influenced) by maximum length and the width measurements recorded at 50-80% of handaxe length. PC2 is principally loaded by maximum length measurements and width in the base of the tool (75-95% of handaxe length). Kruskal-Wallis tests were used to identify whether significant differences in median PC1 and PC2 values existed within four sets of artefact assemblages. The Porzuna artefacts were independently compared to the two Spanish (El Chiquero and El Sotillo), two Moroccan (STIC, Cunnette), and Olduvai and Elandsfontein Acheulean sites. Additionally, the four African sites were compared independently of the Porzuna material. Post-hoc Mann-Whitney U tests were used to identify the nature and direction of any significant differences. Significance was assumed in-line with the Bonferroni Correction in all instances.

3) Results

3.1 Technological characteristics of the Porzuna assemblage

The studied assemblage is dominated by bifaces (n = 57, 43.8%) and unifaces (n = 25, 19.2%), however, picks (n = 17, 19.2%), knives (n = 12, 9.2%), and cleavers (n = 11, 8.5%) are also represented, along with a small number of unmodified LCT blanks (n = 4, 3.1%) and four (3.1%) examples which cannot be assigned a typical typological classification (Figure 5). All were made on fine grain local quartzite; the same raw material as the rest of the Porzuna Assemblage.

Large flakes predominate within the assemblage (n = 63, 48.5%), however, cobbles have also been extensively used (n = 49, 37.7%). Split cobbles (n = 4, 3.1%) and tabular blocks (n = 2, 1.5%) contribute only a small proportion of the blank types. There is a significant difference in blank type between LCT categories, as indicated by a Chi-Square (Cramers V) test ($X^2 = 0.317$, $p = 0.001$). Adjusted residuals show that this difference is derived from an over representation of indeterminate blanks for bifaces, flake blanks for LCT blanks, cleavers, and knives, and cobbles blanks for picks.

Most LCT's fall between 100-160 mm in length with an average of 144.6 mm, however, some range in excess of 200 mm. On average LCT's are relatively thick (mean = 51.3 mm) and heavy, with a mean weight of 677.7 g and ranging from 100.4 g to 1919.3 g. A Mann-Whitney U test shows a significant difference in dimensions between LCT categories; however, a pair-wise comparison shows that this difference is due to a general heterogeneity in LCT length and weight between groups with no category being significantly longer, shorter or heavier. Knives, however, are significantly wider than bifaces, cleavers and picks, while picks are significantly thicker than cleavers and bifaces.

Ninety-six (73.8%) of the LCT's possess <50% dorsal cortex coverage, with this proportion increasing once examples with no remaining cortex are included (n = 107, 82.3%). There is a significant difference in cortex coverage between all LCT categories (Cramer's V ($X^2 = 0.297$, $p = 0.028$)) and blank types (Cramers V ($X^2 = 0.375$, $p = 0.019$)), with knives being significantly non-cortical, cobble blanks possessing significantly >50% cortex, and indeterminate blanks possess an over-representation of 0% cortex coverage.

The majority of the worked LCT's have been bifacially flaked (n = 99, 77.3%), with only 22.7% (n = 29) exhibiting unifacial *façonnage*. Most LCTs possess a convergent pointed tip (n = 102, 78.5%), however, convergent square, oblique and generalised tips are also present within the assemblage (n = 14, 10.8%), with an equal number of divergent tips (n = 14, 10.8%). Convex (n = 52, 40%), straight (n = 48, 36.9%) and pointed (n = 30, 23.1%) bases are all represented within the assemblage.

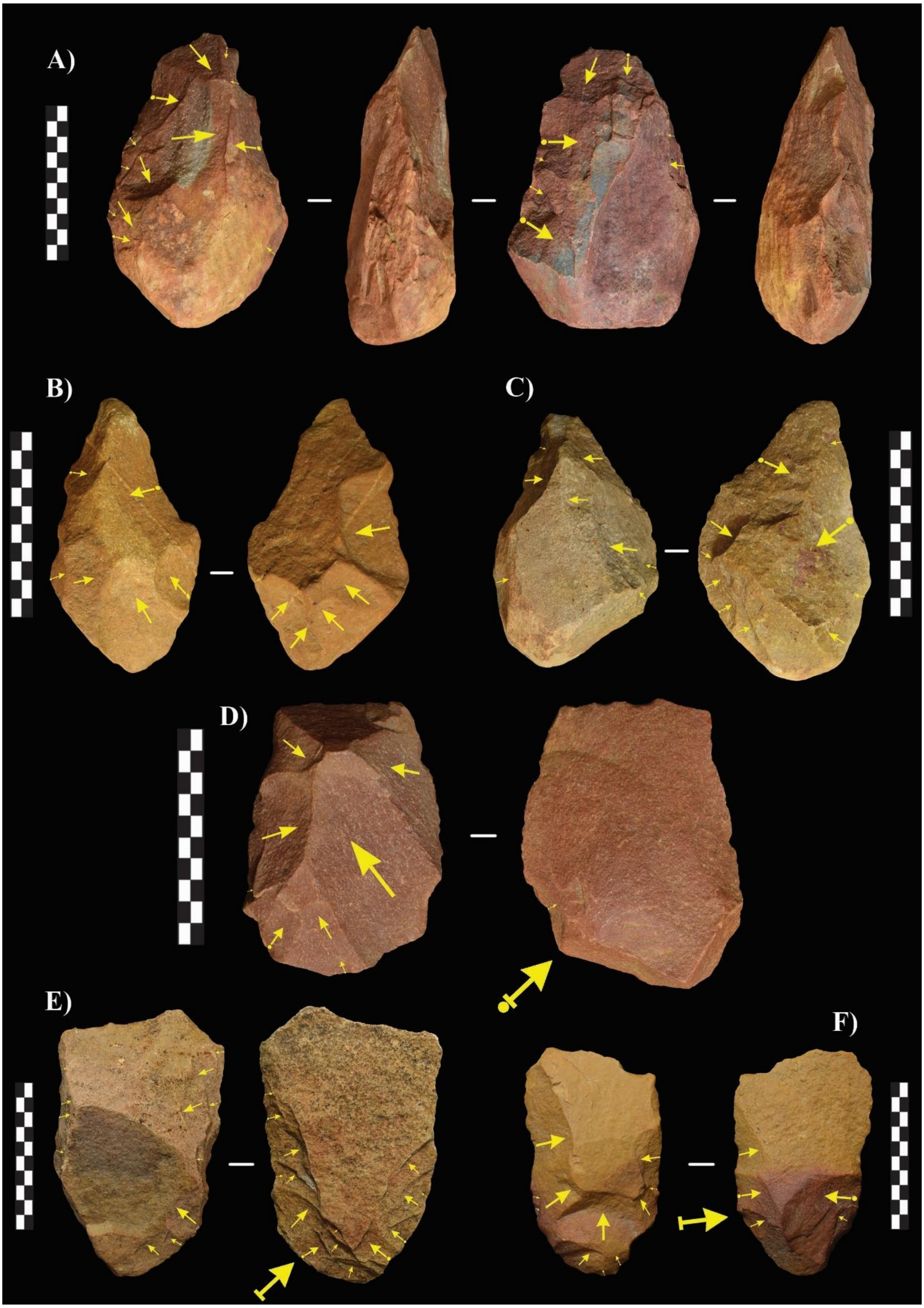
A)
B)
C)
D)
E)
F)

Figure 5. Examples of handaxes (A-C), LCT (D), and cleavers (E-F) from the analysed assemblage of Porzuna.

Of the LCTs produced on flakes, side struck flakes were primarily used as blanks (n = 35, 55.6%), however, end struck flakes are also present (n = 16, 25.4%). In a minority of cases, it is impossible to identify the flake type due to the degree of secondary shaping. The majority (n = 52, 82.6%) of flakes used as blanks retain evidence of the platform used to detach from the core; for half of these, an attempt to thin the platform and bulb is evident. This thinning is primarily through invasive direct flake removals using the dorsal surface of the flake as a platform.

Cobbles (n = 23, 40.4%) and flakes (n = 22, 38.6%) are the preferred blanks for biface (handaxe) production. Bifaces show a varying degree of secondary *façonnage*, with just over half possessing between 1-10 flake removals (n = 30, 52.7%) associated with shaping, whilst 47.3% (n = 27) are more heavily worked, with between 11-20 removals. 89.5% (n = 51) of them possess a pointed tip.

Three *chaine operatoires* have been identified during the manufacture of handaxes. One consists of blanks (mainly cobbles) with the medial-distal part bifacially shaped, while the proximal area of the blank is untouched and remains cortical (e.j. Figure 5A). The second group of artefacts include large flakes with minimum *façonnage* work to obtain a pointed shape (e.j. Figure 5b). Finally, there is a group of tools in which the natural morphology of the blank is used, leaving one of the surfaces unmodified and shaping the opposed ones using either a unifacial or centripetal exploitation.

Flakes (n= 10, 90.9%) are the preferred blank for cleaver production, with only a single example in which the flake blank could not be confirmed. Most of the secondary working on cleavers is associated with the removal of the bulb of percussion, the thinning of the original flake platform as well as the shaping of the base of the tool (Figure 5E). It is also interesting to highlight the identification of some cleavers with potential use wear traces represented by a series of scars located on their distal edge (*tranchant*), similar to the traces described in experimental studies (Claud et al., 2015) and cleavers from the Ethiopian site of Mieso (de la Torre et al., 2014).

Many of the picks in the Porzuna assemblage are produced on complete cobbles (n = 12, 70.6%) or split cobbles (n = 2, 11.8%), with a single example of a flake blank being used (5.9%). In general, picks were not subjected to substantial secondary working, with an average of 5.8 *façonnage* extractions each. The trihedral pick shape is often due to a steep intersection of two large removals on the dorsal surface, associated with the core preparation prior to the removal of the LCT blank.

On the manufacture of knives, flake blanks were used exclusively (n = 12). Both, large end struck (n = 4, 33.3%) and side struck (n = 8, 66.7%) flakes were used, with side struck flakes being more prevalent. The majority of knives possess between 0 – 50% dorsal cortex (n = 11, 91.6%), and are bifacially worked (n = 11, 78.6%) possessing an average of 9 *façonnage* removals being and relatively minimally shaped, possessing between 1-10 removals (n = 8, 66.6%).

Finally, unifaces show a similar blank selection to bifaces, in that both complete cobbles (n = 12, 48%) and flakes (n = 11, 44%) predominate; both end struck (n = 4) and side struck (n = 4) flakes were used in equal measure, whilst there are also single examples of split cobbles and tabular blocks being used as blanks. All unifaces possess pointed tips, with a small number having been shaped through the detachment of 1 (n = 3, 12%) or 2 (n = 3, 12%) notches towards the tip. The unifaces are minimally shaped, with the majority possessing fewer than 11 removals (n= 19, 76%), with only a small number exhibiting greater secondary reduction (n = 6, 24%).

3.2 Shape differences

Figure 6 plots PC1 against PC2 for all handaxe assemblages, separated according to the four Kruskal-Wallis tests. These principal component plots illustrate handaxe shape differences and overlap between assemblages. The three Spanish assemblages display a substantial amount of correspondence in their forms, with the variation observed in Porzuna subsuming all but eight of the other bifaces (Figure 6a). Kruskal-Wallis tests between the Spanish assemblages, for both PC1 and PC2, reveal significant differences in median PC score values (Table 2 and Table 3). Mann-Whitney U tests reveal mean rank shape values to be significantly different between the three assemblages in all instances, other than Porzuna and El Sotillo for PC2 (weighted by maximum tool length and base width).

Assemblage Set (PC1)	**Kruskal-Wallis (*p*)**
Porzuna, El Chiquero, El Sotillo	.0001
Porzuna, STIC, Cunnette	<.0001
Porzuna, Olduvai, Elandsfontein	<.0001
STIC, Cunnette, Olduvai, Elandsfontein	<.0001

Table 2. Kruskal-Wallis tests of median differences for PC1 between the four sets of Acheulean handaxe assemblages.

Assemblage Set (PC2)	**Kruskal-Wallis (*p*)**
Porzuna, El Chiquero, El Sotillo	.0012
Porzuna, STIC, Cunnette	<.0001
Porzuna, Olduvai, Elandsfontein	.0716
STIC, Cunnette, Olduvai, Elandsfontein	<.0001

Table 3. Kruskal-Wallis tests of median differences for PC2 between the four sets of Acheulean handaxe assemblages.

Figure 6b details the shape-space variation observed between Porzuna and the two Moroccan Acheulean sites (STIC and Cunnette). Differences in shape clearly exist between the three assemblages, with Porzuna displaying lower PC1 and PC2 values than the other two sites, while STIC has some of the highest PC2 values and Cunnette has the highest PC1 values. Kruskal-Wallis tests for PC1 and PC2, again, revealed significant median differences between the sites. In all but one instance Mann-Whitney U tests revealed the mean ranks of PC1 and PC2 to be significantly different between assemblages (Table 4 and Table 5). Porzuna and Cunnette, however, display similarly ranked PC2 values (Table 5).

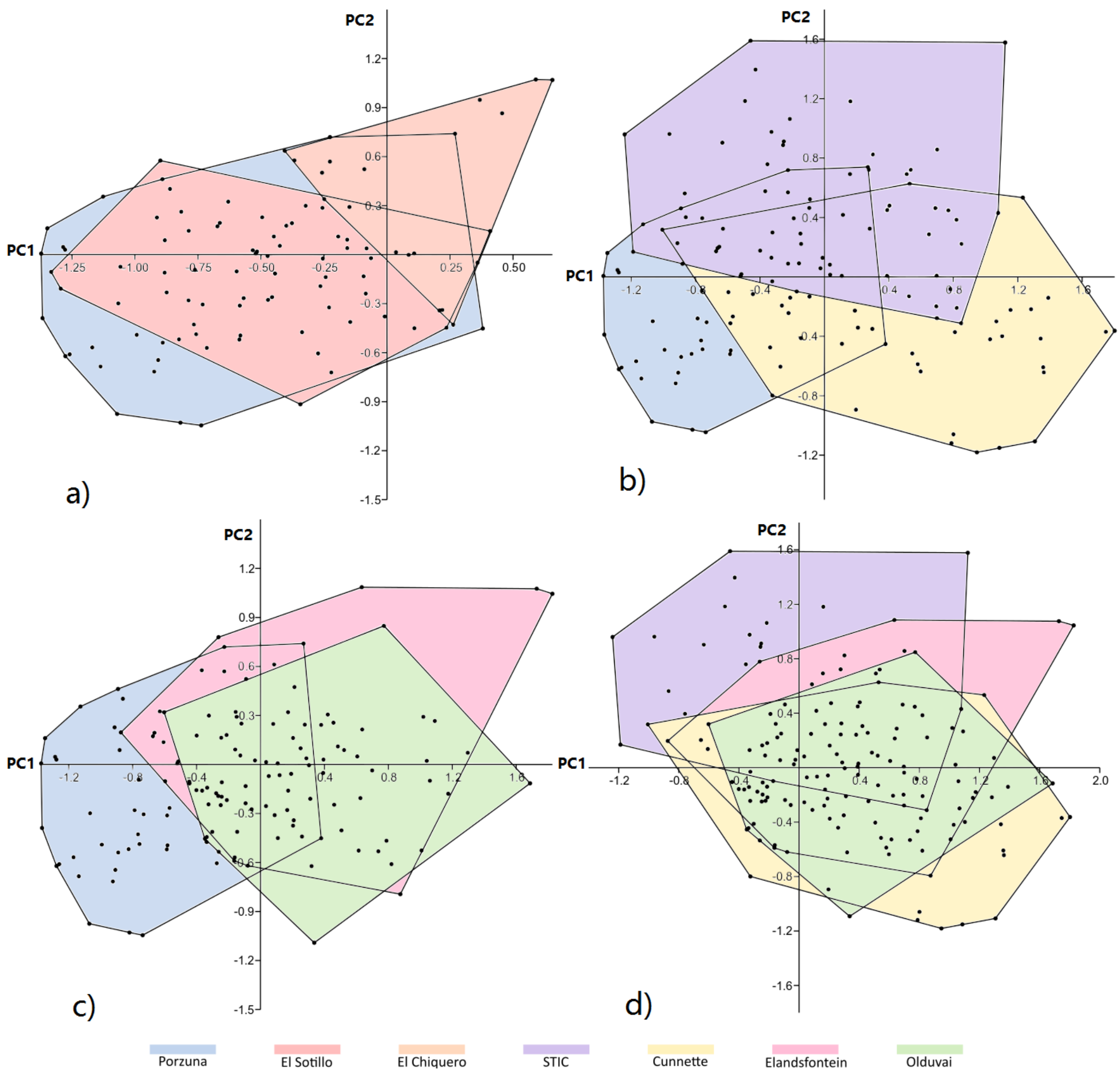

Figure 6. PC1 plotted against PC2 for the four primary intra-site comparisons of handaxe 3D shape. Figure 'a' depicts the shape space of the three Spanish sites, 'b' compares Porzuna and the two Moroccan sites, 'c' likewise compares Porzuna with Olduvai and Elandsfontein, while 'd' illustrates the four African sites.

Mann-Whitney U (PC1)			
	Porzuna	**El Chiquero**	
El Chiquero	.0003		
El Sotillo	.0112	.0067	
	Porzuna	**STIC**	
STIC	<.0001		
Cunnette	<.0001	<.0001	
	Porzuna	**Olduvai**	
Olduvai	<.0001		
Elandsfontein	<.0001	.4273	
	STIC	**Cunnette**	**Olduvai**
Cunnette	<.0001		
Olduvai	.1134	<.0001	
Elandsfontein	.0364	.0031	.4273

Table 4. Mann-Whitney U tests of mean rank for PC1 between the four sets of Acheulean handaxe assemblages.

Mann-Whitney U (PC2)			
	Porzuna	**El Chiquero**	
El Chiquero	.0005		
El Sotillo	.3801	.0009	
	Porzuna	**STIC**	
STIC	<.0001		
Cunnette	.1847	<.0001	
	Porzuna	**Olduvai**	
Olduvai	.8199		
Elandsfontein	.0404	.0497	
	STIC	**Cunnette**	**Olduvai**
Cunnette	<.0001		
Olduvai	<.0001	.0952	
Elandsfontein	<.0001	.0019	.0497

Table 5. Mann-Whitney U tests of mean rank for PC2 between the four sets of Acheulean handaxe assemblages.

There is some shared shape space between Porzuna handaxes and those from Olduvai Gorge and Elandsfontein, although there are also clear differences, with the two African assemblages displaying higher PC1 values. Olduvai and Elandsfontein share similar shape spaces. As with the Moroccan assemblage significant differences in median values were identified between Porzuna, Olduvai and Elandsfontein via a Kruskal-Wallis test. Although this was only for PC1(Table 2). Mann-Whitney U tests identified significant differences in PC1 mean ranks between Porzuna and the two African assemblages, but not between Olduvai Gorge and Elandsfontein. No PC2 tests returned significant differences.

The final plot, Figure 6d, details shape differences between the four African handaxe assemblages. Greater overlap between the assemblages is illustrated here, relative to the two African comparisons that include Porzuna. STIC appears to have a number of artefacts with a combination of low PC1 and high PC2 values, which the other sites do not display; but this only represents a third of the assemblage. Kruskal-Wallis tests for both PC1 and PC2 revealed significant median differences between the sites. As with above, Mann-Whitney U tests did not identify significant differences between Olduvai and Elandsfontein. This was similarly the case between STIC and Olduvai/Elandsfontein for PC1, and Cunnette and Olduvai for PC2 (Table 5). The other tests returned significant shape differences.

4) Discussion

4.1 Integrating Porzuna within the Acheulean at the Iberian Peninsula

Our analyses demonstrate this previously unreported assemblage of Acheulean artefacts from Porzuna to have similar metrics and technological characteristics to the rest of the collection hitherto studied (Vallespí et al 1979; 1985; Serrano Ciudad, 1985; Cabrera, 1986). Together, Porzuna can now be considered to contain one of the largest accumulations of Acheulean LCTs in the Iberian Peninsula, with over a thousand documented tools. Nearby, at El Sotillo, there is also a large assemblage of LCTs predominantly formed of large flakes (Ciudad Serrano, 1983b; Arroyo and Torre, 2013). Within this assemblage, indeterminate LCTs, cleavers and knives show low degree of shaping of the ventral faces, and flake blanks tend to be dominated by side-strike flakes as documented also at Porzuna. At El Chiquero, despite of the low frequency of handaxes deposited at the museum (n = 8), six are produced on flake blanks. These handaxes tend to be smaller (mean length of 152.5 mm [SD = 24.2 mm], and mean weigh of 424.1 g [SD 124.7 g]), with a higher degree of shaping and symmetry than the Porzuna ones. Thus, at a local scale seems to be technological similarities within the Acheulean assemblages in which there was a common use of large flakes during the Middle Pleistocene. Given this wider pattern we would suggest that other Acheulean localities in Campo de Calatrava (Santonja and Querol, 1976; Vallespí et al., 1980) yet to be reviewed may share similar technological traits.

Despite some shape central tendency differences between the three Spanish assemblages, the PCA plots reveal near complete overlap in their shape space. Moreover, relative to the African assemblages, the Spanish LCTs cluster closely. Thus, we are confident in assigning some uniformity in shape between the Porzuna, El Sotillo and El Chiquero assemblages. Arguably, therefore, there was transmission of stone tool related cultural information between populations enough to maintain a consistent Late Acheulean LCT shape in this region. Alternatively, limited cultural transmission distance may have been present between the hominins responsible for producing these three assemblages, in turn explaining their limited shape differences (Lycett et al., 2016). As far as is represented through the three assemblages analysed here, however, there is a unified expression of the Acheulean LCT culture in central Iberia during the Late Acheulean. This conclusion is supported by the technological analyses described above. Additional studies that include a greater number of Iberian sites may provide further evidence in support of this tentative conclusion.

Beyond Porzuna and Campo de Calatrava, other Spanish sites such as El Sartalejo (Cáceres) similarly display LCTs produced from large cobbles with a low degree of *façonnage* (Santonja 1986; Moloney, 1992). Moreover, sites including Gruta da Aroeira (Daura et al., 2018) and Santa Ana (Ollé et al., 2014), together with Galería (Atapuerca) (Garcia-Medrano et al., 2014), are known to display LCTs made on large flakes. Porzuna is, then, not alone in either respect. The later sites, Gruta da Aroeira and Atapuerca, display the only evidence in the Iberian Peninsula of an association between Acheulean technology and *H. heidelbergensis* remains. In addition, in the NW of Spain recent excavations at Portomaior (Galicia) have unearthed an LCT assemblage dated to 293-205 Kya dominated by handaxes and a low frequency of cleavers and picks (Méndez-Quintas et al., 2006; 2018), showing that LCTs have a wider distribution across the Iberian Peninsula.

In sum, archaeological sites such as Galería (Atapuerca), Porzuna, Santa Ana, El Sartalejo or Portomaior confirm that within a time span between 500-150 ka, across the Peninsula, an Acheulean culture existed in which there was a manufacture of large flakes coexisting with the manufacture of handaxes made from cobbles, something that is uncommon beyond the Pyrenees where large flakes within the Acheulean assemblages are rare (Sharon, 2011). All these sites share common characteristics, being mainly located on river terraces (with the exception of Galería (Atapuerca) and Santa Ana) and the primary raw material used to obtain large flakes being quartzite. In fact, as pointed by Santonja and Villa (2006), the presence of cleavers and large flakes is determined by the raw material as happened in the Iberian Peninsula where there is an abundance of large quartzite cobbles and blocks (but see Sharon, 2008). The concentration of Iberian Acheulean sites along river basins and their tributaries could be related to a high degree of mobility in hominin populations and the important of the fluvial networks (Santisteban and Schulte, 2007).

4.2 Determining African affinities in the Iberian Acheulean

Our second aim was to understand the nature of any overlap between Porzuna and Late Acheulean LCT artefacts from Africa, to better understand potential dispersal routes into Iberia from modern-day Morocco (Alimen, 1975). Technologically, Porzuna contains a large number of LCTs produced on large flakes, and as highlighted by Sharon (2010), the LFA displays wide chronological and spatial distributions in the Old World. Nonetheless, within France and other Western European countries the presence of this techno-complex is less dominant, with cobble blanks dominating relative to large flakes. Previously, the frequent presence of large flake LCTs in Iberia, but not other areas of Western Europe, has been used to support hypothesised hominin migration routes across the Strait of Gibraltar (Freeman, 1975; Santonja and Villa, 2006), as well as a North African origin of the Iberian Acheulean (Sharon, 2011).

Geological and faunal data confirms that North Africa and the Iberian Peninsula were never connected during the Pleistocene (O’Regan, 2008; Croitor, 2018), but the Straight could have been narrowed and more accessible during glacial periods (Straus, 2001). It is our view that the common presence of LCTs made on large flakes in Iberia cannot alone confirm frequent or sustained hominin migration from North Africa, nor an African origin for the Iberian Acheulean. Certainly, technological convergence appears as an alternative possibility. Equally, however, the technological similarities observed between Iberia (including Porzuna) and African Acheulean industries does suggest the potential of hominin dispersals and highlights the need to formally test the hypothesis through other means.

Here, we have taken a small step toward addressing the question of an African origin for the Iberian Acheulean by comparing the shape of handaxes from these two locations. Handaxes have potential to be highly variable in their shape (Wynn and Tierson, 1990; Lycett and Gowlett, 2008; Petraglia and Shipton, 2008), with differences in mean tendencies between assemblages often attributed to the influence of cultural evolutionary mechanisms (Lycett et al., 2016), among other factors. Low shape homogeneity between Acheulean LCT assemblages would in turn suggest the presence of substantive cultural transmission distances (and therefore limited contact) between populations. Our results indicated significant shape differences between Porzuna and all African assemblages when described using PC1 (significant PC2 differences were site-specific). Tests between the four African sites also revealed some significant differences for both PC1 and PC2, but generally these locations displayed greater similarity in shape with each other, than they did with Porzuna (Figure 6). We would contend, then, that as far as our results can demonstrate, the Porzuna material does not display a strong association with the African LCT assemblages examined here. Thus, there is no new evidence to support a proposed south-west dispersal route for Acheulean hominins into Europe. Reduced shape differences between the four African sites (Figure 6d), of which some display substantially greater geographic distances between them relative to Porzuna and the Moroccan sites, underlines the likely lack of cultural information flowing across the Gibraltar Straight. Insofar as our analyses demonstrate, the presence of large flakes on both sides of the Gibraltar Straight therefore appears to be the common point between these African and Iberian assemblages.

This does not rule out possible early dispersals into Iberia from North Africa, nor does it indicate there to be no dispersals during the Late Acheulean; rather, it suggests that if there were dispersals, they would have been limited enough to prevent the occurrence of a single, shared LCT cultural expression. As far as the origin and diffusion of LCT culture into Western Europe is concerned, our results do not provide support in favour of either a Western or Eastern route. Instead, they highlight the inherent difficulties of a Western water-bridging diffusion of hominin populations and culture during the Late Acheulean; a difficulty which also likely existed during earlier periods (O'Regan, 2008).

Technologically the Porzuna material is similar to the late Acheulean site of El Sotillo. Our shape analyses further indicate similarities between Porzuna and El Sotillo, as well as El Chiquero (all sites from the same region). An estimated age for the Porzuna material of between 400 and 200 Kya would not, therefore, be unreasonable. As discussed above, the shape distinctions observed between Porzuna and the African assemblages do not necessarily reflect deviation in age, but more likely represent a lack of contact and cultural exchange. The substantive Porzuna assemblage can tentatively be assigned to be of Late Acheulean origin, however, further dating of in situ sediments is needed to confirm this chronology.

By their very nature, Palaeolithic artefact shape analyses are limited by the sites sampled and the number of lithics examined. Here, we have taken a limited view of the Acheulean insofar as only seven sites have been considered. The inclusion of a greater number or alternative selection of Iberian and African sites could, certainly, alter our conclusions. Moreover, the inclusion of Levantine or Eastern European assemblages would provide a useful comparative sample and allow a hypothesised Eastern dispersal route for LCT technology to be tested. Nonetheless, our results are clear that the differences observed between Porzuna and Africa are generally greater than those observed between the four African sites. It is also true that the assemblages compared here have potential to not only be geographically disparate, but separated by tens, if not hundreds, of thousands of years.

5) Conclusions

Despite consisting of over 8000 artefacts, the Acheulean stone tool assemblage of Porzuna has received limited attention in the literature. Here, we have undertaken techno-typological and 3D morphometric analyses of the LCT material from Porzuna. Our aims were twofold. First, we wanted to contextualise Porzuna alongside other previously described Central Iberian material, to better understand any variation in LCT material, and the strength of any single Late Acheulean stone-tool culture in this region. Secondly, we investigated the hypothesised South-West European out-of-Africa dispersal route across the Gibraltar Straight by comparing Porzuna with multiple African Late Acheulean LCT assemblages.

Comparisons between Porzuna and two other nearby assemblages reveal a regional representation of LCT culture in Central Spain during the late Acheulean; as represented through their shape and technological character. Similarities between Porzuna and the African materials are limited to common *chaine operatoires* and technological classifications (on both cases, large flakes are used as blanks to manufacture LCTs), but significant shape differences and distinct central tendencies are observed between most assemblages, suggesting distinction handaxe 'end-goals' between these geographically diverse populations. Together, results highlight the commonality of Late Acheulean LCT production techniques across the Old World, and the strength of some regional stone tool cultural representations but provide no new evidence in support of a South-West dispersal route for hominins into Europe.

Porzuna represents a substantial collection of Acheulean artefacts that until now were 'hidden' from Palaeolithic literature. Given finite resources and the infrequent identification of new Lower Palaeolithic sites in Europe, we would argue that similar assemblages could, and indeed should, be better utilised for research purposes. Certainly, and as demonstrated here, collections such as Porzuna have considerable potential to shed light on the behaviour of European Middle Pleistocene hominins.

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