Journal of Paleolithic Archaeology (2024) 7:8
https://doi.org/10.1007/s41982-024-00172-4

RESEARCH

Not Just Scraping By: Experimental Evidence for Large Cutting Tools in the High Lodge Non-handaxe Industry

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Accepted: 28 February 2024

Abstract

The presence or absence of handaxes endures as the major criterion of Lower Palaeolithic classification, with contemporaneous core-and-flake industries modelled as simpler counterparts to Acheulean technology. This is based on the supposed absence of formal tools, particularly of large cutting tools (LCTs) which are understood to be important within Acheulean lifeways, functioning as butchery knives among other uses. Scrapers from the core-and-flake industry of High Lodge (MIS 13) evidence formalised flake-tool production techniques, geared towards large tools with long cutting edges and acute angles, comparable in many respects to Acheulean handaxes. A holistic set of experiments was designed to test the production, efficiency, and practical utility of these scrapers. The experiments compared these scraper forms against handaxes and Quina scrapers. Their use in roe deer butchery indicates functional differences but demonstrates the appropriacy of both large, refined scrapers, and handaxes for processing carcasses of this size. The results support the inclusion of High Lodge scraper forms within the standard definition of LCTs. This interpretation challenges perceived discrepancies between handaxe and non-handaxe industries and deterministic explanations for Acheulean material culture. The feasibility of alternative LCTs supports the argument that the Acheulean represents socially inherited behaviours rather than latent reinventions.

Keywords Large cutting tools · Lower palaeolithic · Acheulean · Handaxe · Scraper · MIS 13

Introduction

The handaxe has become an emblem of continuity through the Lower Palaeolithic, defining the Acheulean techno-complex over a period of more than 1.5 million years across Africa and Eurasia. Other large cutting tools (LCTs) attributed to the Acheulean include cleavers, picks, and knives, which are grouped typologically as retouched tools > 100 mm (Bordes, 1961; Leakey, 1971; Roe, 1964; Toth & Schick, 2019). Continuity in Acheulean LCTs is often read as a cultural phenomenon upheld through high-fidelity social transmission and restricted innovation (Finkel & Barkai, 2018; Isaac, 1977; Lycett & Gowlett, 2008; Shipton & Nielsen, 2015). Alternatively, the handaxe has been posed as a latent technology, achieved individually from genetic foundations (Corbey et al., 2016; Tennie et al., 2016, 2017). Genetic arguments are deemed inconsistent with localised standardisation of divergent technological traits, resembling patterns of cultural variation (Hosfield et al., 2018; Wynn & Gowlett, 2018; McNabb, 2020a; Shipton and Nielsen, 2015). Late Acheulean flake assemblages also evidence complex variation, including prepared core technology (Shipton, 2022; White & Ashton, 2003), laminar blade production (Gallotti et al., 2020; Hérisson et al., 2016; Wilkins & Chazan, 2012) and refined scraper forms (Hérisson et al., 2016; Singer et al., 1993). While the slow pace of innovation during the Acheulean is discordant with the rapid cultural developments and turnovers of modern populations, it is argued that social learning and conformity had a crucial role in maintaining Middle Pleistocene technological strategies (Shipton & Nielsen, 2015; Shipton & White, 2020).

A more cogent challenge to the Acheulean technocomplex is whether the handaxe was ever locally reinvented through functional convergence; a question most frequently posed for east Asian Pleistocene assemblages (Corvinus,

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Published online: 06 April 2024

2004; Li et al., 2021; Lin, 1994; Lycett & Norton, 2010; Norton et al., 2006; Petraglia & Shipton, 2008). Specific similarities in production methods and products across Africa and Eurasia are taken as evidence for shared cultural histories, such as the 'Large Flake Acheulean', which evidence consistent, highly structured operational chains (Méndez-Quintas et al., 2020; Sharon, 2010, 2019). Dispersal of a unified technological tradition—originating in east Africa—is the most parsimonious explanation of the available chronological data (Key, 2022; Mussi et al., 2023; Shipton, 2020). However, the chrono-technological sequence of core-and-flake assemblages, followed by simple ('early Acheulean') bifacial tools, and eventually more refined LCT types is observed broadly outside of Africa (Dennell, 2008; Moncel et al., 2015), making it difficult to rule-out paralleling evolutionary events. This ambiguity is conflated by a scarce hominin fossil record; the spread of handaxe technology through Europe in the early Middle Pleistocene has often been linked to the arrival of *Homo heidelbergensis* (Ashton, 2015; Moncel et al., 2013, 2020). Given the continuation of core-and-flake assemblages throughout the Middle Pleistocene in Europe (Davis & Ashton, 2019), localised reinventions of handaxe technology must also be considered during the late Acheulean period.

Core-and-flake assemblages provide less evidence than Acheulean industries of formalised knapping strategies and they are sometimes viewed as ad hoc technologies. Assemblages include the following: Ficoncella in Italy (MIS 13) (Aureli et al., 2016); Korolevo in Ukraine (MIS 13) (Koulakovska et al., 2010); Swanscombe (Phase I), Clacton and Barnham (Unit 5), UK (MIS 11) (Ashton et al., 2016; Conway et al., 1996; McNabb, 2020b; Wenban-Smith et al., 2006); and the 'Colombanien industry' in north-western France (MIS 11–9) (Guibert et al., 2022; Ravon, 2017). 'Choppers'—informal LCTs—have been described from core-and-flake assemblages, but these artefacts are ambiguously differentiated from cores, and there is no clear evidence for standardised or recurrent production (Ashton et al., 1992a, 1992b; Guibert et al., 2022). The absence of standardised LCTs within core-and-flake industries has been explained partly through exogenous factors—including the low accessibility of appropriate knapping materials (Ashton & Davis, 2021; McNabb, 1992; Rocca et al., 2016)—and endogenous factors, in particular group size, which is understood to affect the extent of individual learning and intergenerational skill transmission (Lycett & von Cramon-Taubadel, 2008; Mithen, 1994; White, 2000). These assemblages were once generalised as the 'Clactonian tradition' but this nomenclature has been largely abandoned due to the lack of positive evidence for cultural links across these geographically and temporally diverse assemblages. However, core-and-flake industries remain as outliers to the Acheulean, maintaining this basic dichotomy.

It remains unclear whether the presence and absence of handaxe technology are symptomatic of broader behavioural differences in the subsistence strategies and social dynamics of hominin groups. The archaeological evidence of core-and-flake industries across large regions during discrete time periods—including the Breckland region and Thames Valley during MIS 11c (Ashton et al., 2016; Davis et al., 2021)—indicates that at least some of these groups represent established populations. Core-and-flake assemblages are also found in association with the butchered remains of large mammals (Aureli et al., 2015; Pawłowska et al., 2014; Wenban-Smith et al., 2006), and the Clacton spear evidences formalised tools beyond the lithic record (Allington-Jones, 2015; Milks, 2022). These indications of primary access to large carcasses—including signs of specialised hunting practices—are congruent with those of Acheulean sites (Barroso Ruíz et al., 2011; Parfitt & Roberts, 1999; Pope et al., 2020; Rodríguez-Hidalgo et al., 2015). Ashton and Davis (2021) propose the 'Cultural Mosaic Model' whereby, in Europe, there is a complex of small-scale population groups with locally adapted toolkits, with or without handaxes, with population shifts, accentuated during climate change, helping to maintain social networks with knowledge and gene exchange.

The High Lodge Archaeological Contexts

High Lodge is a former clay, sand and gravel pit located in the Breckland region of Suffolk, East Anglia, UK, and is one of several archaeological sites associated with the extinct Bytham river network that pre-date the Anglian glaciation (MIS 12) (Davis et al., 2021; Lewis et al., 2021). The main stratigraphic units are overbank deposits formed in a low-energy watercourse during MIS 13, glacially tectonised in MIS 12 (Lewis, 1992). Although West et al. (2014) propose a different site formation theory, interpreting the clayey-silts as MIS 7 doline deposits, an MIS 13 age is supported by litho-stratigraphy (Lewis et al., 2019, 2021), as well as the mammalian taxa, *Stephanorhinus hundsheimensis* and *Trogontherium* sp., known to be extinct after MIS 12 and MIS 11, respectively (Preece & Parfitt, 2012; Stuart, 1992). Shear-planes within the High Lodge series are also symptomatic of englacial rafting (Lewis, 1992).

The Bed C2 clayey-silts contain the richest archaeological assemblage, with a total of 1097 lithic artefacts recovered through excavation between 1962 and 1968 (Table 1) (Ashton, 1992). This assemblage is characterised by simple core reduction strategies (*e.g.* alternating and opposing platforms), ad hoc flake-tools (*i.e.* notches, denticulates, 'flaked-flakes' and scrapers) as well as more formal, invasively-retouched scrapers. Handaxes and manufacturing flakes are not present in this assemblage, parsimoniously

Table 1 Lithic artefact frequencies by bed allocations from the High Lodge excavations (from Ashton, 1992: 125)

Artefact type	Bed B	Bed C1	Bed C2	Bed D	Bed E
Flakes	25	59	900	254	384
Chips	1	-	56	7	20
Knapping fragments	2	8	37	16	16
Flake tools	2	7	60	16	15
Bifaces	-	-	-	1	14
Cores	1	7	44	15	13
Total	31	81	1097	309	462

explained as a technological absence within this industry. This conclusion is supported by the vertical distribution of artefacts through 2 m of sediment, indicating a considerable timeframe; if bifaces were ever used by local groups during this formation period, it is highly unlikely that no evidence would be encountered (Ashton et al., 1992a, 1992b; Davis et al., 2021).

Bed E—stratigraphically above Bed C2—contains another important assemblage, with 462 lithic artefacts recovered during excavations. This technology is typical for European MIS 13 sites, including refined handaxes comparable to those from Boxgrove (Parfitt & Roberts, 1999), Waverley Wood (Keen et al., 2006), and the 'fresh' assemblage from Warren Hill (Davis et al., 2021). Bed E is a sandy unit, showing faster river flow during sediment formation than the underlying clayey-silts; however, rolling abrasion is limited on the artefacts from this bed, indicating that they are not heavily reworked from their depositional context (Davis et al., 2021). Low frequencies of lithic artefacts were also recovered from Beds B, C1, and D.

The High Lodge Scrapers

In the first published description of the High Lodge scrapers, Evans (1872: 549) remarked on their unusual character for 'river drift implements' as intensively retouched scrapers, 'remarkably similar to some of those found in the cave of Le Moustier'. As with Mousterian tools, the High Lodge scrapers often exhibit continuous, invasive, scalar retouch, distributed around the perimeter in forms consistent with Bordes' (1968) typological framework (Fig. 1). The British Museum houses 181 of these artefacts; 151 of which were collected while the pit was still active up to the 1920s—the 'Old Collection'—and another 30 that were recovered through excavations between 1962 and 1968 (Ashton, 1992; Davis et al., 2021). Comparisons between these two groups suggest recovery biases in the Old Collection favouring larger tools with more extensive retouch (Table 2), which were more diagnostic and attractive to collectors. Scrapers only comprise a minor component of the excavated sample from Bed C2, as 20% of all the flake tools and 1.1% of the whole assemblage (Ashton, 1992). However, the presence of 'classic' High Lodge scrapers in the excavated sample confirms that these flake-tools are a genuine facet of the Bed C2 industry.

An attribute analysis of the scrapers available for study from Bed C2 ($n = 12$) and the Old Collection ($n = 149$) demonstrates their unusually large proportions for flake-tools, with an average length of 97 ± 23 mm, width of 68 ± 20 mm, thickness of 23 ± 7 mm and retouched circumference of 117 ± 62 mm (Fig. 2). Length was taken in this study as the maximum dimension, given that the tool axis was often discordant with the original flake blank. Maximum width was recorded orthogonally to the tool axis. The scraper retouch is relatively acute for unifacial tools, with a mean edge angle of $48 \pm 9°$ (Fig. 3), taken as five equidistant points on the retouched edge of each tool via the 'calliper method' (Dibble & Bernard, 1980). Brumm and McLaren (2011) found that edge angles at High Lodge were only weakly correlated with the g eometric index of unifacial reduction (GIUR), indicating that acute edge angles were maintained over resharpening events. This is another unusual feature for scraper retouch, which normally becomes steeper as the working edge progresses into thicker portions of the flake blank (Clarkson, 2005; Dibble, 1995). Invasive retouch applied to the High Lodge scrapers appears to have minimised edge-steepening over recurrent retouch episodes. GIUR values were generally higher on scrapers with more extensive perimeter retouch, interpreted by Brumm and McLaren (2011) as evidence for Dibble's (1987, 1995) scraper reduction continuum, modelling convergent forms as heavily curated tools rather than predetermined designs. For simplicity, the High Lodge scraper forms are described hereafter as 'refined' scrapers, a term chosen because it is also used to distinguish bifaces that are more invasively retouched and extensively shaped. This distinction from other scraper forms is superficial and is not an assessment of functional hierarchy.

Refined scrapers like the High Lodge tools are atypical but not unique from Lower Palaeolithic assemblages. Comparable flake-tools have been found nearby at Warren Hill ($n = 29$), Lakenheath ($n = 2$), and Brandon Fields ($n = 1$), which may represent a regional presence of this industry in MIS 13 (Davis et al., 2021). Of particular note, the deposits at Warren Hill lie c. 1 km south of High Lodge and consist of deltaic sediments that formed in a proglacial lake during MIS 12. The sediments include armoured clay-balls, which have particle size and colour characteristics similar to the High Lodge clayey-silts, and probably derive from those deposits. The associated refined scrapers at Warren Hill are also likely to derive from High Lodge (Lewis et al., 2021). Refined scrapers

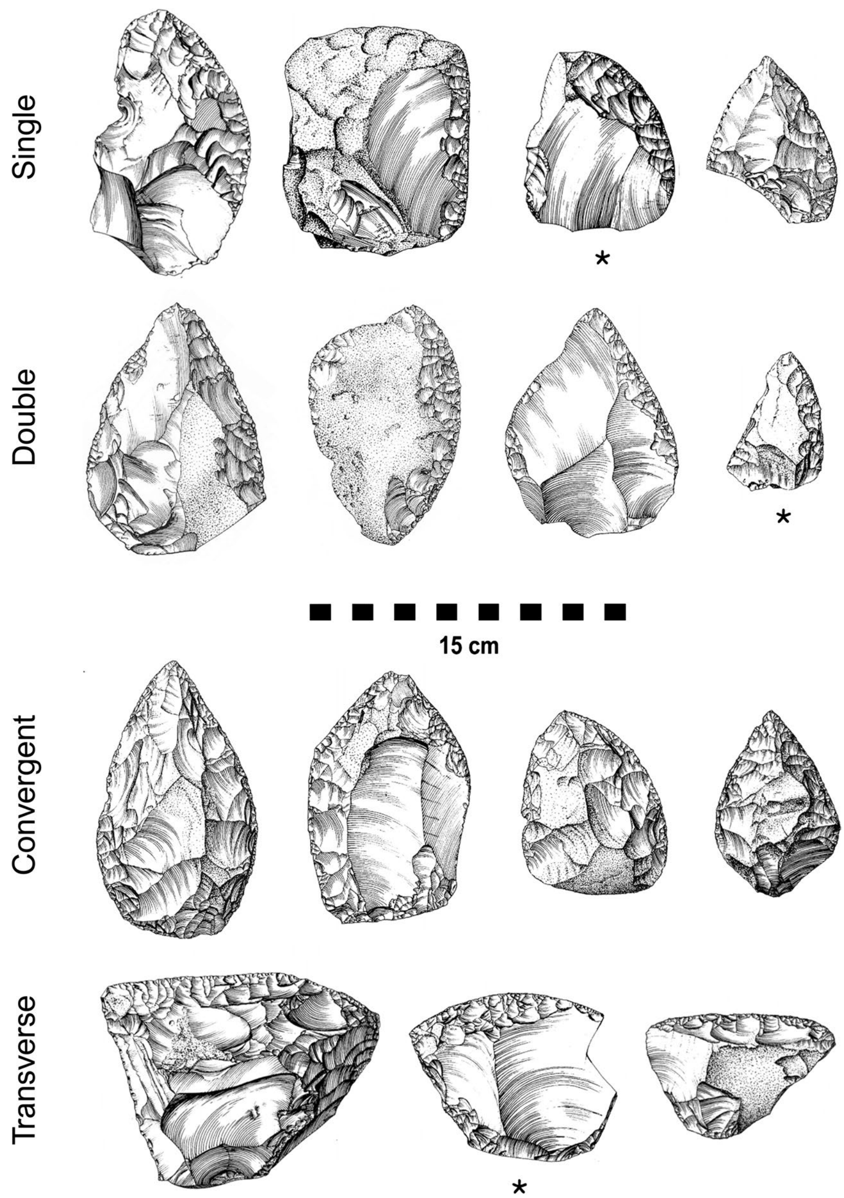

Fig. 1 Single, double, convergent, and transverse scrapers from the High Lodge excavated (*) and 'old' collections exampling variation in tool sizes, shapes, and retouch invasiveness (from Ashton et al., 1992a, 1992b, pages 153–155 and plates 1–40)

Table 2 Scraper measurements from the Old Collection ($n = 149$) and the excavated assemblage from Bed C2 ($n = 12$)

Measurement	Old	Excavated
Length (mm)	98.5 ± 23.9	83.8 ± 13
Width (mm)	67.8 ± 20.3	67.65 ± 14.7
Thickness (mm)	23.6 ± 7.7	23.1 ± 4
Angle (°)	48.8 ± 8.3	42.1 ± 10
Circumference (mm)	265.8 ± 62.8	231.4 ± 39.1
Perimeter retouch (%)	46.4 ± 21.7	34.8 ± 12
Weight (g)	157.1 ± 120.3	115.7 ± 71.8

are found in some European handaxe assemblages, most clearly from La Grande Vallée (MIS 13 and MIS 11) in the Poitou region of France (Hérisson et al., 2016), and the Hoxne upper Industry (MIS 11) from Suffolk (Singer et al., 1993). Refined scrapers become more common in later industries, including Acheuo-Yabrudian assemblages in the Levant (MIS 9) (Lemorini et al., 2016) and the Quina Mousterian in France (MIS 4) (Lhomme et al., 2011). A commonality across these industries is evidence for soft hammer technology (Blasco et al., 2013; Francesca Martellotta et al., 2021; Hérisson et al., 2016); a tool which facilitates invasive retouch via tangential percussion. Large retouched flakes (> 100 mm) that do not fit formal LCT categories are common within Acheulean assemblages, including level OC2 of Arbo, Spain, where these outnumber handaxes, cleavers, and picks (Méndez-Quintas et al., 2019).

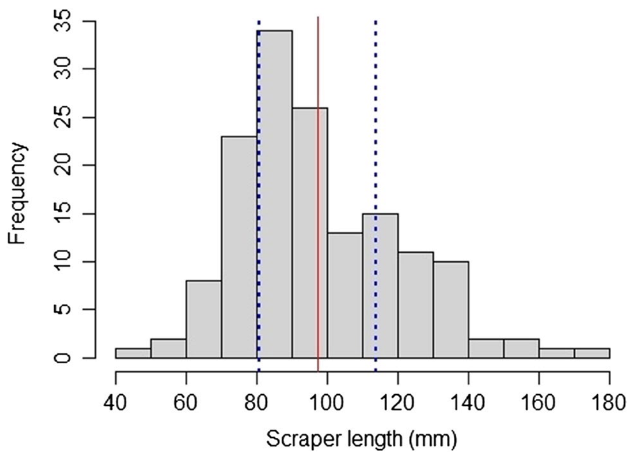

Fig. 2 Histogram of scraper length (complete artefacts) from the High Lodge collection ($n=149$). Red line, mean; blue dotted lines, interquartile range

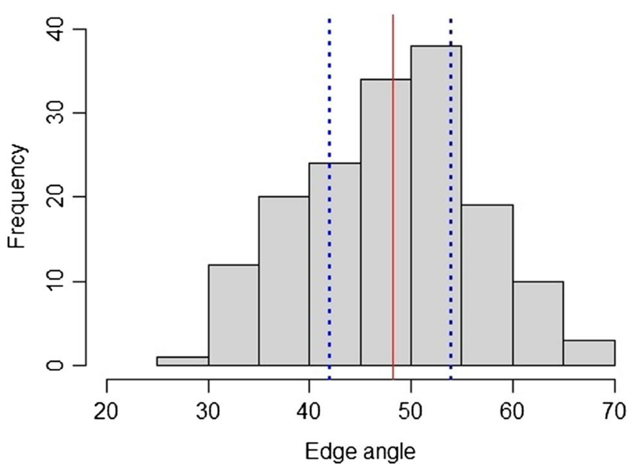

Fig. 3 Histogram of scraper edge angles from the High Lodge collection ($n=151$). Red line, mean; blue dotted lines, interquartile range

Scraper Production

The large flake blanks selected for scraper production at High Lodge are diagnostic hard hammer products, but the percussor technology used to retouch the refined flake tools is more ambiguous (Ashton, 1992). While relatively few Acheulean soft hammers have been identified in comparison to Middle Palaeolithic industries (Bello et al., 2016; Hutson et al., 2018), bone and antler percussors are interpreted as important components of late Acheulean technology on the basis of experimental replication, with purported advantages in late-stage handaxe refinement (Callahan, 1979; Wenban-Smith, 1989; Sharon & Goren-Inbar, 1999; García-Medrano et al., 2019). Soft hammer technology is not inferred from the Bed C2 industry, with no characteristic debitage—*i.e.* thin feather removals with diffuse bulbs of percussion and platform lipping—described from the excavated assemblage (Ashton, 1992). The criteria used to identify soft hammer products may be too dependent on data from biface reduction; this is demonstrated by the recent identification of bone percussors from the core-and-flake Clacton-on-Sea assemblages (MIS 11), interpreted as evidence for the habitual use of flake-tool 'retouchers' (Parfitt et al., 2022). This was previously assumed to be an exclusive hard hammer industry, based on the relatively simple retouched tools and the absence of recognisable soft hammer debitage (McNabb, 2020b). However, percussor type is notoriously difficult to determine from lithic products (Driscoll & García-Rojas, 2014; Pelcin, 1997; Sharon & Goren-Inbar, 1999).

To better understand the impact of percussor type on scraper morphology, FS (5 years of prior knapping experience) undertook a small-scale scraper reduction experiment, to track the progressive relationship between edge angle and GIUR on medium-to-large East Anglian flint flakes (275 ± 120 g). For this, FS applied three episodes of retouch to 30 flake blanks, half using a quartzite hammer (375 g) and the other half with an antler hammer (212 g).

The results of this experiment indicate that percussor type is an influential factor in the morphology and development of unifacial retouch. The most significant observed difference was edge angle, with soft hammer scrapers exhibiting more acute edges (mean $= 47 \pm 3°$) compared to hard hammer scrapers (mean $= 61 \pm 7°$); this discrepancy was significant in a two-tailed *T*-test, with a *p*-value < 0.0001 ($t = 11.2$). Edge angle was relatively stable over soft hammer reduction episodes, only increasing from 47° to 48° over the retouch episodes, which was insignificant in a one-way ANOVA test ($f = 0.24$, $p = 0.79$). Incremental steepening did occur during hard hammer reduction, increasing from an average edge angle of 56 to 64° ($f = 7.45$, $p = 0.002$). Edge angle was positively correlated with GIUR; particularly for hard hammer scrapers, which had a linear regression of $R^2 = 0.33$ and a strong statistical result in Spearman's rank correlation coefficient (RHO) test ($r_s = 0.53$, $p = 0.0002$). The correlation between edge angle and GIUR was weaker in the soft hammer scrapers, with a regression line of $R^2 = 0.095$ and lower statistical significance ($r_s = 0.36$, $p = 0.017$). Brumm and McLaren (2011) recorded a relatively weak relationship between edge angle and GIUR from the High Lodge scrapers ($R^2 = 0.039$), which is more compatible with the soft hammer scrapers analysed in this experiment (Figs. 4 and 5). Superficially, the acute and invasive flake removals characterising many of the High Lodge Bed C2 scrapers most resemble the scrapers retouched with soft hammers in this sample (Fig. 6) and, in addition, those made with soft hammers (deer bone) in an experimental study by Baena et al. (2017).

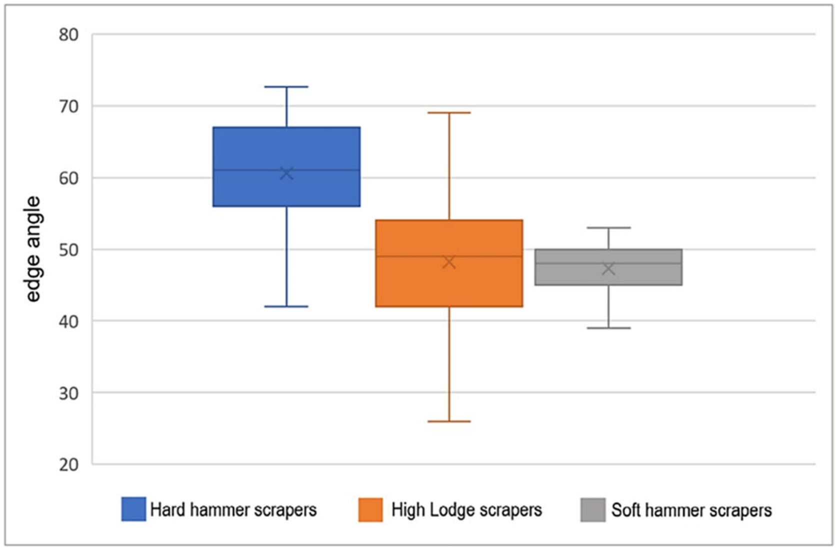

Fig. 4 Box-and-whisker plots for edge angle recordings from the experimental hard hammer scrapers ($n=45$), soft hammer scrapers ($n=45$), and High Lodge scrapers ($n=149$)

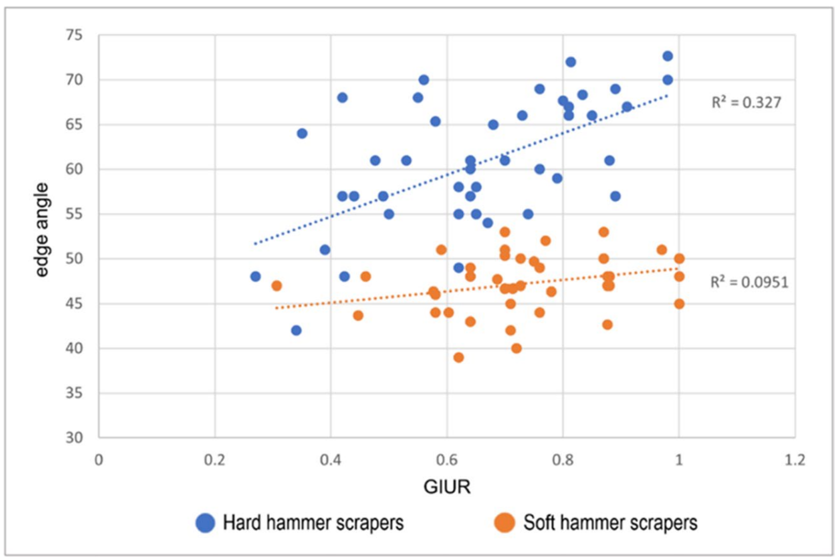

Fig. 5 Scatter graph with linear regressions showing the positive relationships between GIUR and edge angle from the hard hammer scrapers and soft hammer scrapers measured by FS during the scraper reduction experiment

A larger scheme of investigation is important to establishing repeatability of these results; however, the current findings demonstrate that there are observable differences in the morphology and development of scraper retouch depending on percussor technology. The results support the inference that soft hammers were regularly used for scraper retouch in the Bed C2 industry, with similar edge angles and reduction trajectories to those from the experimental sample.

Tool Forms and Functions

Unifacially retouched flake-tools with straight or convex perimeters and plano-convex profiles are frequently categorised as 'scrapers', a term inherited from early typological schemes (Odell, 1981). Use-wear studies of Lower and Middle Palaeolithic scrapers have demonstrated functional variation within and between sites, including applications in both cutting and scraping tasks, on hard and soft materials (Agam & Zupancich, 2020; Berruti et al., 2020; Pedergnana & Ollé, 2020; Rots et al., 2015). Scrapers from Acheulo-Yabrudian levels of Qesem Cave, Israel, appear to show patterns of use related to scraper retouch morphology, with acutely retouched demi-Quina scrapers (< 60°) showing predominant use as cutting tools, and Quina scrapers (> 60°) associated more often with hard scraping tasks (Lemorini et al., 2016). A functional relationship of this kind is supported by Baena and Santafé (2010), who found that flint scrapers with relatively acute working edges (< 60°) were more versatile across cutting and scraping tasks, while tools above this threshold were more limited to oblique scraping tasks.

Fig. 6 Comparison of retouch morphology on a scraper produced by FS with an antler soft hammer (left) and a scraper excavated from Bed C2 of High Lodge (HLC1232) (right), 1 cm scale

While sharpness is conventionally defined by the extent of rounding at the apex of the cutting edge (Gao et al., 2009; Key et al., 2022; Rahman et al., 2018), edge angle has been shown to covary with sharpness in flint flakes, with greater force required to complete cutting exercises in both participant and mechanised experiments (Key & Lycett, 2015; Key et al., 2018a). Edge angle is also linked to tool thickness, which will create more resistance during penetration, as is shown for metal knives (Hainsworth et al., 2008) and projectiles (Mahesh et al., 2021). Edge angle appears to be less consequential to larger flakes due to increased loading power (Key & Lycett, 2015); this was also supported in a study with handaxes, which were efficient at cutting through cardboard, rope, and neoprene strips below a critical edge angle threshold of ~70° (Key et al., 2016). However, edge angle and thickness may be more influential in tasks requiring penetration through thicker materials, including large meat packages during butchery.

Loading power may partly explain the lower efficiency of small flakes in rope cutting (Key & Lycett, 2014) and butchery exercises (Merritt & Peters, 2019), particularly if tool proportions necessitate an insecure pinch grip between thumb and fingers (Jones, 1980). However, smaller tools may offer more precision and dexterity for tasks requiring careful execution. Use-wear and animal residues on small flakes (<5 cm long) from late Acheulean contexts of Revadim, Israel, demonstrate habitual use alongside LCTs in butchery (Venditti et al., 2019). This is interpreted as a complimentary toolkit, facilitating precise butchery subtasks including skinning, cutting tendons and ligaments, defleshing bones, and removing the periosteum to assist bone breakage (Venditti et al., 2019). Tool efficiencies are also specific to user biometrics including hand size and manipulative strength (Key & Lycett, 2018), particularly for larger and heavier tools which can pose issues of reduced control and rapid user fatigue (Key & Lycett, 2018; Khaksar & Modarres, 2024). Some tool attributes appear to be non-consequential to function, including variation in handaxe planform (Key & Lycett, 2017b; Machin et al., 2007).

Table 3 Mean and standard deviations of length, width, thickness, and edge angle, measured from the scraper and handaxe reproductions used in the experiment

Tool	Length	Width	Thickness	Edge angle
Scrapers	111 ± 10.1 mm	78 ± 10.8 mm	28 ± 6.5 mm	52 ± 4.9°
Handaxes	111 ± 12.5 mm	79 ± 8.2 mm	31 ± 5 mm	55 ± 3.5°

In regard to the High Lodge scrapers, there is a weak theoretical basis to suggest that the tools primarily functioned in scraping tasks. In fact, these unusually large and acutely retouched flake-tools are arguably closer to expectations of handheld cutting tools. However, ergonomic studies have demonstrated the complex interaction between tool features, user biometrics and activity type in overall efficiency, as well as zones of 'free play' where there is low selection for task-specific traits (Key & Lycett, 2017a). Therefore, functional inferences must be tested through carefully designed experiments; ideally, a combination of controlled and actualistic parameters providing 'internal' and 'external' validity, respectively (Eren et al., 2016).

Rope Cutting and Clay Carving Experiment (Pilot Study)

An initial experimental investigation was organised in 2019 to test the cutting efficiency of scrapers and handaxes in a participant-focused study. Ten young adults (male and female, aged 19–23) were instructed to carve a panel of fresh potter's clay (620 × 200 × 20 mm) and cut a series of jute twine segments (4 mm) set within a steel-frame apparatus designed by Dr Alastair Key (University of Cambridge) (see Supplementary Information). Twine and clay were chosen as standardised materials with deformative properties similar in particular ways to plant fibres or animal tendons and meat respectively. While neither materials are perfect proxies for butchery or plant processing, stone tools have been differentiated by cutting efficiency using similar apparatus in previous experiments (Key & Lycett, 2014, 2017a, 2017b; 2020; Key et al., 2021; Mika et al., 2022). Each participant was randomly assigned a scraper and a handaxe produced from East Anglian flint (Table 3), emulating forms from the High Lodge collection, and was asked to do two run-throughs with each tool on both the twine and clay cutting tasks, totalling 80 individual activities. A stopwatch was used to record time to finish the exercises, and a tally counter was used to record the number of strokes used to cut the rope.

In both the clay and the rope cutting tasks, the main cause of variation was the participants, likely reflecting differences in strength, technique and their interpretation of the guidelines of 'fast but controlled' cutting (Figs. 7 and 8). The results show a large range of times (4 to 21 s in clay and 8.2 to 54 s with the rope). Learning bias does seem to have had some influence, particularly in using the handaxe to carve clay, with 80% of participants faster in their second attempt. An unusual result came from 'participant 9' during the rope task; while they finished the exercise in fewer strokes with the handaxe, the task took 22 s longer than with the scraper. As their final task of the experiment, it is likely that this reflects the participant's fatigue. Excluding the anomalous rope results from 'participant 9', the outcomes for handaxes and scrapers are very close; the clay took an average of 8.2 s to carve with the scraper and 7.7 s with the handaxe; the twine took an average of 15.4 s for scrapers to cut and 16.4 s for handaxes; and the twine was cut in an average of 22.8 strokes for scrapers and 23.1 for handaxes.

The task durations and frequency of cutting strokes were compared across the two tool groups through paired *T*-tests (two-tailed), which found all the results statistically insignificant ($p \geq 0.25$). While this pilot study was limited by a small dataset, this result indicates that there are only small discrepancies in cutting efficiency between refined scrapers and handaxes under these parameters. FS was encouraged by these results to explore actualistic butchery experiments to better understand tool efficiency in a more realistic simulation of tool use and selection.

Deer Butchery Experiments

Methods

An experimental investigation was devised to test whether the High Lodge scrapers could have functioned as LCTs, particularly as butchery knives like handaxes. As a specific question, this was approached through a series of actualistic

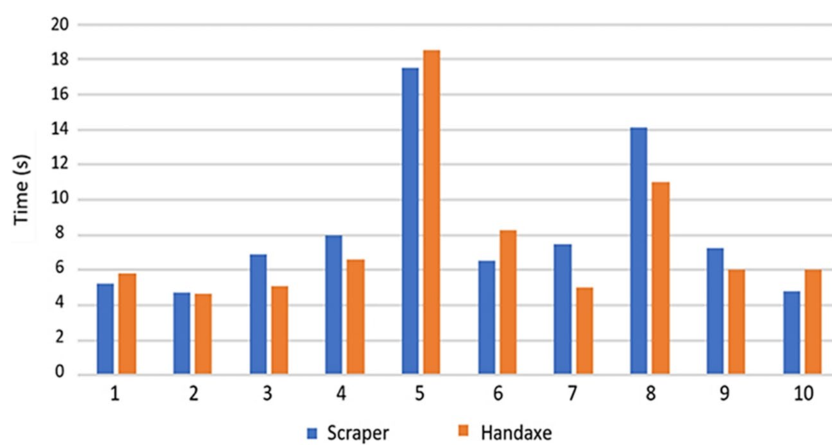

Fig. 7 Bar plot of average time taken for each participant (1–10) to carve the clay panel with a scraper (blue) and a handaxe (orange)

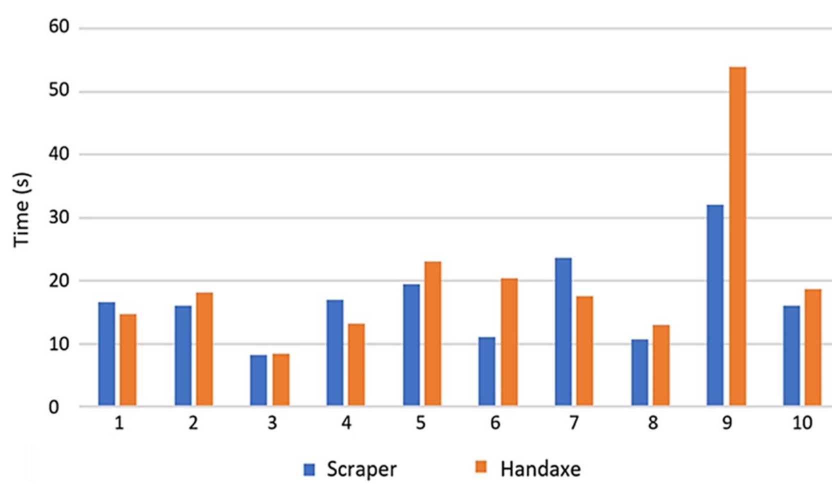

Fig. 8 Bar plot of time taken for each participant (1–10) to cut the rope segments with a scraper (blue) and a handaxe (orange)

butchery experiments using roe deer (*Capreolus capreolus*) carcasses procured ethically as part of population control culling. The huntsman also performed the experiment due to his prior expertise in butchery and hide-scraping and his impartiality to the outcome of the experiment. The methodology was approved in advance by the UCL ethics committee (project ID: 19331/001).

FS knapped a series of tools using East Anglian flint to match those of archaeological assemblages. As well as refined scrapers imitating High Lodge forms, other tools were tested to facilitate comparisons; handaxes based on artefacts from Bed E of High Lodge served as benchmarks for LCTs, and replicas of Qesem Cave Quina scrapers represented known hide-scraping tools (Fig. 9, Table 4, supplementary information). Quartzite hammers were used to produce flake blanks for scrapers and for the initial stage of handaxe reduction, while antler hammers were used for late-stage handaxe reduction and scraper retouch. FS tried to reproduce typical features from the archaeological assemblages, including the fine edge trimming on the High Lodge scrapers (Fig. 6) and the stepped scalar retouch characteristic of Acheulo-Yabrudian Quina scrapers. The distribution of scraper retouch is variable, including single, double, convergent, and transverse forms, whereas the handaxe perimeters were fully retouched, representing ovate and cordate forms. Each tool was labelled with a letter to reflect their tool group ('H' for handaxe, 'S' for refined scraper, and 'Q' for Quina scraper) and a unique number corresponding to their relative size, with one being the largest tool of each category. Images of the experimental tools and their respective code can be found in the Supplementary Information.

The three roebucks used in this experiment weighed 14, 15, and 18 kg following the removal of their heads, guts, and feet in the field. The butcher estimated that these deer would have weighed 20–25 kg as complete carcasses, placing them in the upper limits of Bunn's (1982) carcass size 1 category. While this is smaller than the preferred prey of Middle Pleistocene hominins in northern Europe (Smith, 2010), butchery marks—including striations specifically attributable to handaxes—have been identified on roe deer bones recovered from Boxgrove (Bello et al., 2009) and Happisburgh Site 1 (Lewis et al., 2019).

The butchery tasks followed normal UK butchery practise, other than the use of stone tools; skinning was performed from a mechanical hoist, butchery was conducted on a table, and the hide was fleshed over a plastic barrel. While this is not a true simulation of Middle Pleistocene butchery, it was advantageous to follow methods that were already

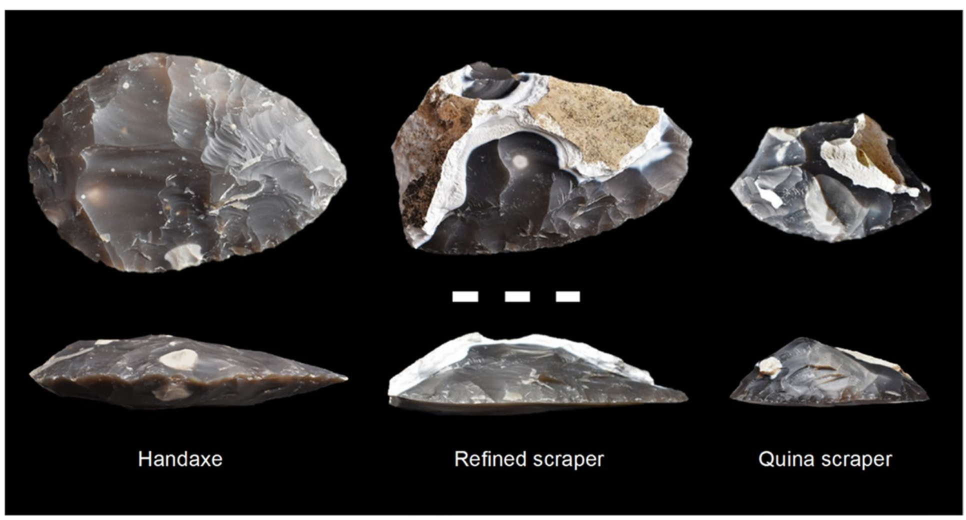

Fig. 9 Examples of a handaxe (H3), refined scraper (S7), and Quina scraper (Q1) produced for the experiment, 5 cm scale

Table 4 Mean and standard deviation scores of key measurements taken from the experimental handaxe, refined scraper, and Quina scraper assemblages, alongside equivalent data from the High Lodge handaxes ($n=70$) from Davis et al. (2021); High Lodge scrapers ($n=163$); and the Qesem Cave Quina scrapers ($n=88$) from Zupancich (2019)

	High Lodge handaxes	Experiment handaxes	High Lodge scrapers	Experiment scrapers (refined)	Qesem Cave Quina scrapers	Experiment Quina scrapers
Length	113 ± 31	120 ± 11	97 ± 23	111 ± 10	59 ± 17	74 ± 8
Width	71 ± 13	80 ± 8	68 ± 20	75 ± 11	45 ± 17	51 ± 7
Thickness	31 ± 10	27 ± 5	23 ± 7	26 ± 6	19 ± 8	26 ± 7
Weight	273 ± 199	271 ± 88	157 ± 120	223 ± 73	-	105 ± 45
Edge angle	-	36 ± 6	48 ± 9	46 ± 4	69 ± 14	66 ± 4

practiced by the subject, minimising learning bias during the experiments. The butcher was encouraged to swap between tools (of the same type) as he thought appropriate, either due to edge exhaustion or preferred tool morphologies. By random selection, the largest of the three carcasses was processed with elaborate scrapers and the smallest with handaxes. The experiment was filmed so that the results could be reviewed and recorded accurately; the duration and number of cutting strokes were recorded for the different subtasks, as well as tool change intervals, omitting any pauses in the experiment. The butcher was also asked to narrate his experience during the tasks, including a grading of each tool from one (completely impractical) to seven (ideal); an approach used by Machin et al. (2007) as a simple way to standardise qualitative comments.

Results

Butchery was quickest with the refined scrapers, taking 42 min and 31 s in total to skin (14 min 3 s) and deflesh (28 min 28 s) the carcass, omitting pauses during the experiment. The handaxes were marginally slower, taking 44 min and 22 s for skinning (15 min 33 s) and defleshing (29 min 9 s). The experiment using Quina scrapers was the slowest at 55 min 29 s, taking more than 3 min longer for skinning (18 min 40 s), and an additional 8 min to deflesh the carcass (37 min 9 s). The carcass butchered with Quina scrapers visibly had the most residual flesh, and the carcass butchered with refined scrapers had the least. These results corroborate the butcher's narrated experience, who preferred the refined scrapers overall for butchery (mean rating 6/7), performing marginally better than the handaxes (rated 5/7) and clearly superior to the Quina scrapers (rated 3/7). In total, 8 handaxes, 11 refined scrapers, and 11 Quina scrapers were used over the course of the experiments (Fig. 10).

Handaxes

Unprompted, the butcher adopted a 'five-jaw buttressed pad-to-pad' grip on the handaxes (Key et al., 2018b) and employed an arced cutting motion, with contact initiating midway along the tool and finishing at the tip. Similar methods are described in previous butchery experiments (Jones, 1980; Mitchell, 1995) and use-wear attributed to butchery is primarily distributed around this top portion of some Middle Pleistocene handaxes (Claud, 2015; Zupancich et al., 2021). The butcher consciously selected thinner handaxes for cutting, finding them sharper and easier to guide through the flesh. The largest handaxe in the sample (H1) had a maximum length of 143 mm and a thickness of 38 mm, but this was avoided in favour of smaller tools. The favourite handaxe from this experiment (H8) is analogous to refined examples from High Lodge, with a length of 120 mm, thickness of 24 mm, weight of 226 g, and a tip edge angle of 33°. In total, eight handaxes were used, with an average time of 5 min 33 s per tool. However, tools were regularly swapped to test different forms, rather than a response to blunt cutting edges. H8 was used until the cutting perimeter was deemed blunt, which took 12 min 41 s in total.

The handaxes were effective at the initial stages of skinning the carcass, benefitting from sinuous edges, which facilitated a firmer grip at the cutting edge to make incisions through the elastic skin. However, the large dimensions of the handaxes were inconvenient when separating the hide around the limbs. The two tools used were both rated 5/7 for the skinning. The butcher found handaxes particularly effective in cutting through large portions of flesh in the butchery phase, but less suitable for precision work such as cutting through tendons. This may be reflected in the timings of butchery subtasks; the handaxes were the fastest tools in cutting activities unencumbered by large bones (*i.e.* removing the forelimbs, fillets, and tenderloins), but they were relatively slow in disjointing and defleshing limbs (Table 4). The handaxes were rated 5/7 on average as butchery knives.

Refined Scrapers

The long and convex perimeter of the High Lodge type scrapers allowed for a similar grip and arced cutting motion to the handaxes, with the additional support of steep cortical margins on some of the sidescrapers, facilitating a 'backed' grip against the palm. However, the smaller retouched circumferences of sidescrapers likely contributed to the shorter intervals between tool changes, with each tool used for an average of 3 min 52 s. The butcher's favourite scraper (S3) was retouched on one side and was employed for a total of 7 min 26 s before it was deemed too blunt and abandoned. As with the handaxes, the pointed tips on convergent scrapers were advantageous for making deep incisions through the flesh (*e.g.* filleting), presumably benefitting from a narrower cross-section and greater loading power. There were also functional differences between larger and smaller scrapers, with the smaller tools selected for executing precise tasks (*e.g.* cutting tendons), before being swapped for larger tools to cut through meat.

The butcher removed the deer skin 1 min and 30 s quicker with the refined scrapers than with the handaxes. However, the butcher considered these to be less effective tools for penetrating skin due to their lower sinuosity; the scrapers used at this early stage of skinning were rated 2/7. Once beneath the skin, the scrapers were efficient at separating the skin from the muscle, rated between 4/7 and 6/7. The scrapers were most effective in the main stages of butchery with an average rating of 6/7. While the butcher found some serration useful to grip onto the meat, the straighter cutting

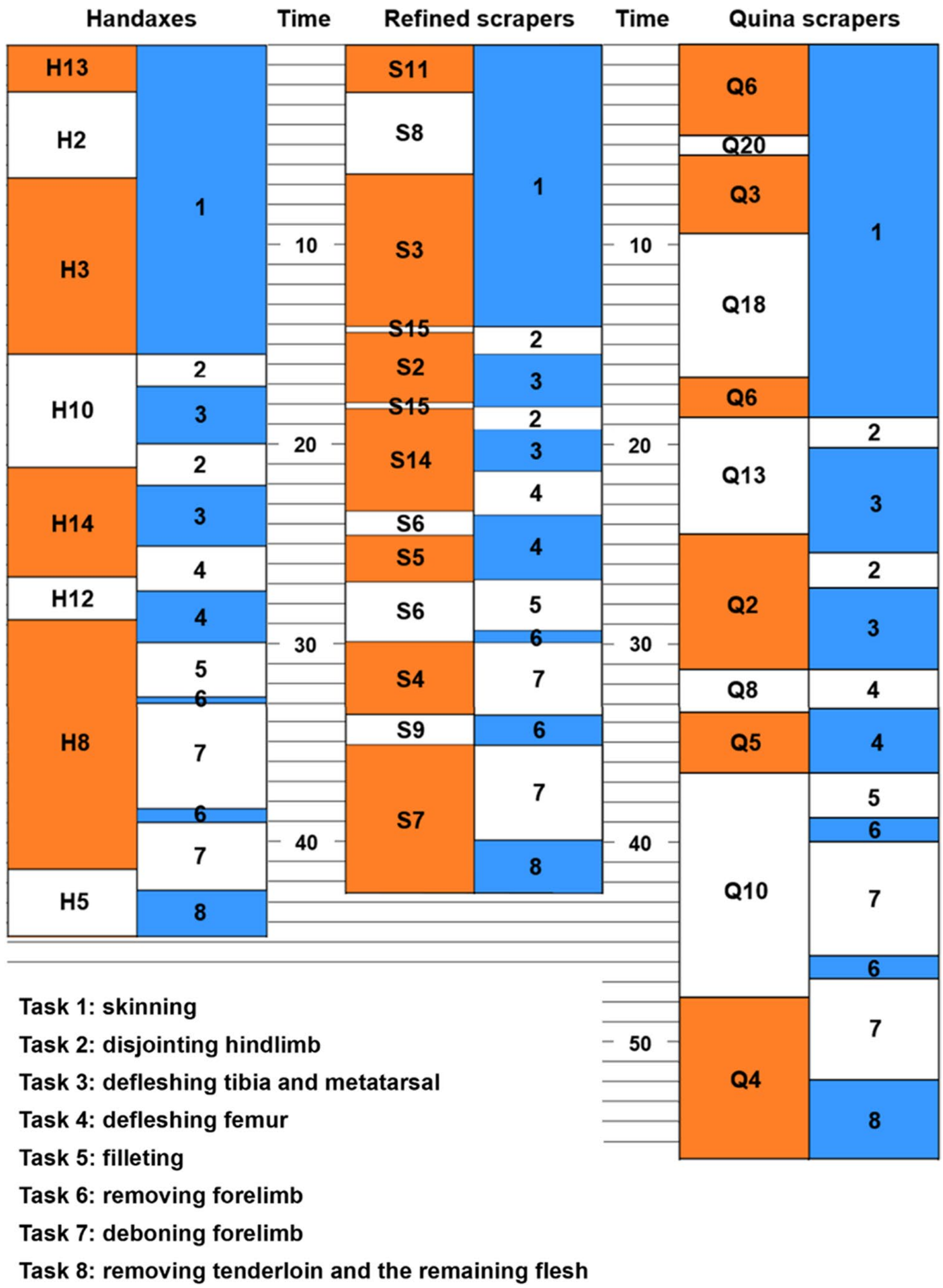

Fig. 10 Summary of the butchery experiments showing the time taken (shown in minutes) for eight key subtasks (alternating white/orange) and tool changes (alternating blue/white). Tool labels for handaxes (H), refined scrapers (S), and Quina scrapers (Q) correspond with images in the supplementary information

edges characterising the scrapers were perceived as a key advantage in creating neater cuts with less resistance and energy investment (Fig. 11).

Quina Scrapers

The butcher took longest to complete the exercise using the Quina scrapers, and these were his least favourite tool group to use. The main issue he found was their small size, necessitating an insecure grip between the thumb, index finger, and middle finger; a similar limitation was reported by Jones (1980) in his butchery experiments using small flakes. This grip also meant that the cutting edge was close to the user's fingers, thus blocking sight of the task and limiting dexterity—this was commented on as 'working blind'. While Baena and Santafé (2010) discuss the many ways that Quina scrapers could have been hafted or wrapped, use-wear analysis from Qesem Cave and experimentation by Zupancich et al. (2016) supports free-hand manipulation. The abrupt edge of these scrapers (60–70°) was deemed to be less sharp than the other tools, requiring more energy to cut—or more often tear—through soft tissue.

More cutting strokes were necessary to complete tasks using the Quina scrapers. The removal of forelimbs is the best

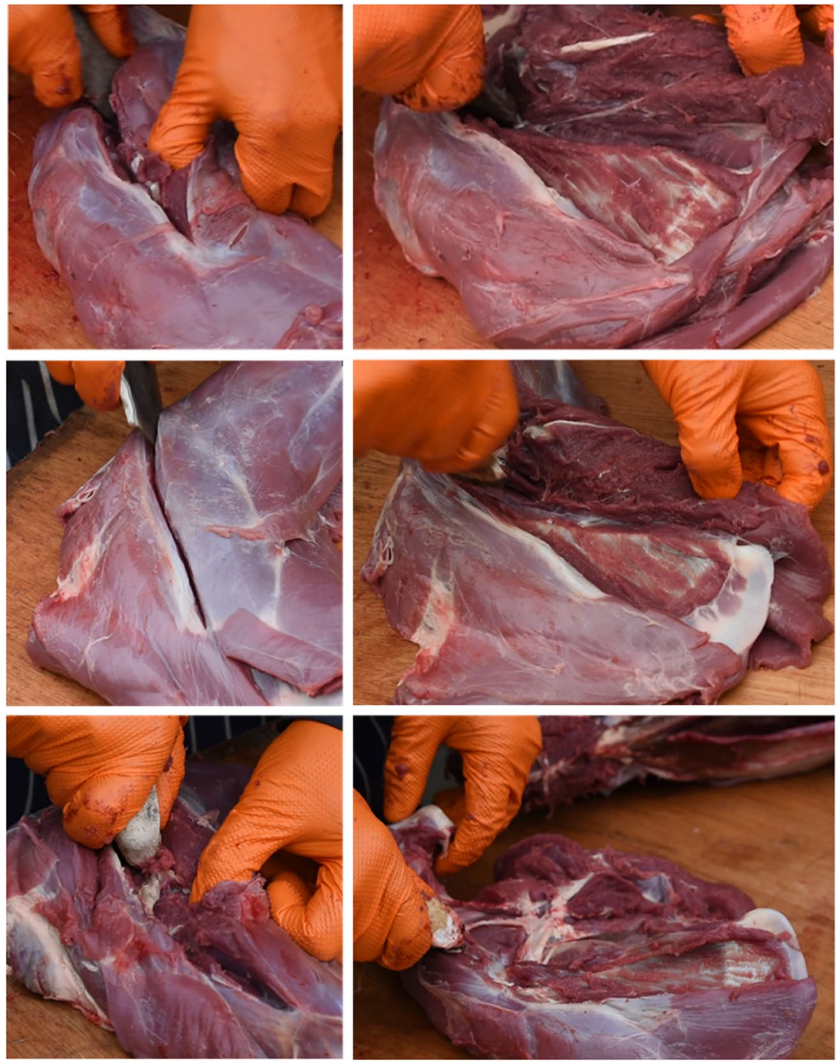

Fig. 11 Images from the experiment footage showing the initial cut (left) and defleshing (right) of the left scapula with a handaxe (top), refined scraper (centre), and Quina scraper (bottom)—note cleaner butchery of the scapula blade using the refined scraper

subtask to compare cutting efficiencies as this is a simple cut through muscle, with no joint between the scapula and axial skeleton. The first forelimb using handaxes took 42 strokes and the second took 46 (average = 44); the refined scrapers took 44 and 50 strokes (average = 47); but the Quina scrapers took 86 and then 84 strokes (average = 85). This discrepancy of the Quina scrapers is likely due to abrupt edge angles, less secure grips, shorter cutting edges, or a combination of these factors. For both the skinning and butchery the most common tool rating was three. The butcher remarked that it was difficult to feel the tools blunting as they were ineffective from the start of use—this likely explains why Q10 was used for 11 min and 13 s despite its short, retouched edge length (72 mm).

Hide Scraping Experiment

Wet hide scraping ('fleshing') to separate adipose fat from the skin membrane was attempted by the butcher on the three hides; however, none of these skins were fully defleshed, with each experiment ending after approximately 10 min. The handaxes (H11 and H4) were used first, positioned at 90° along the main longitudinal axis, and briefly using the basal end of the handaxe. These tools were found to be ineffective due to the sinuous edge, which removed the flesh discontinuously as striae and frequently pierced the skin at high points of the tool edge. The skin was cut seven times during the exercise, which would have been disastrous as a prerequisite to hide treatment. Both handaxes were rated three for hide fleshing, supporting the conclusion that bifacial handaxes are unsuitable for precise scraping tasks.

The unifacial retouch on the refined scrapers was advantageous for hide fleshing. While the handaxes tended to rip the flesh off as striae, the straight edge of the scraper (positioned between 45 and 90°) peeled the flesh from the hide cohesively. The skin was cut twice during this activity; however, the butcher attributed this to his own error by not keeping the skin adequately taut. S1 was scored five for hide fleshing and S12 was scored six this smaller scraper offered greater control, with noticeable advantages over the long working edge of S1 according to the butcher. The Quina type scrapers performed similarly to the refined scrapers, effectively peeling off the residual flesh without cutting through the skin; Q1, Q7, Q9, and Q11 were all rated five. Q14 was rated two as it was too narrow to facilitate a comfortable grip at only 32 mm wide.

Discussion

Tool Functionality

The observations from these experiments support accepted tool form-function relationships envisaged for tool size (Key & Lycett, 2014, 2017a, 2017b; Merritt & Peters, 2019) and edge angle (Baena & Santafé, 2010) in cutting efficiency. As anticipated, larger tools (> 10 cm) were favoured for heavy-duty subtasks (*e.g.* removing forelimbs and fillets) where the extra weight and cutting length appears to have reduced the number of cutting strokes and the effort experienced by the butcher. Smaller tools (5–10 cm) were preferentially selected to execute precise tasks (*e.g.* skinning and hide scraping), with a greater control of the cutting edge. The impact of edge angles in cutting efficiency can also be inferred, with the more acute edges on handaxes and scrapers favoured by the butcher. Edge sinuosity was variably useful in tasks depending on whether the increased friction was beneficial; the sinuous handaxe edges were better at penetrating through tough and elastic elements (*i.e.* skin and tendons) but were less appropriate for neatly removing flesh from the skeleton and adipose fat from the hide.

An important outcome of this research is the clear functional discrepancies observed between the Quina and refined scraper groups, demonstrating variability within this broad flake-tool category. While both tool sets were relatively efficient at hide scraping, the larger size and more acute edge angles characterising the refined scrapers were consistently more effective for butchery in measures of time, effort, and meat yield. The butcher also found scrapers between 5 and 10 cm in length more suitable for hide processing as they offered the most control, potentially reducing the risk of cuts to the hide. While there is a preferential selection of larger flakes and a relatively high standardisation of edge angles between 40 and 60° at High Lodge, small and more abruptly retouched scrapers are also present, which may indicate multifunctionality.

Compared to the handaxes, the refined scrapers were faster, left less meat on the carcass, and were preferred by the butcher ergonomically. However, the recorded differences between these two tool groups were marginal, with handaxes only taking 41 s longer to complete the butchery exercise. The most notable difference between these groups was the number of tools used during the experiment, with 8 handaxes and 11 refined scrapers. This likely reflects the longer cutting perimeters of the handaxes compared to the scrapers, 60% of which were retouched on one side only. The reasons for tool changes were not formally controlled, making this result tentative. There was no clear indication during the experiment that unifacial or bifacial retouch was any more susceptible to blunting.

The greater sinuosity of the bifacial handaxe edge provided greater friction during the cutting exercises, which the butcher likened to modern serrated butchery knives—similar comments were also made by Machin and colleagues (2005). This largely seemed to be a hindrance on the roebuck carcass, yielding rougher cuts and more residual flesh. Sinuosity is perceived as an undesirable feature of handaxes, with more 'refined' handaxes exhibiting straighter edges (Hutchence & Debackere, 2019; Shipton, 2018). However, the handaxes were slightly quicker than the refined scrapers in butchery subtasks where the meat was unencumbered by large bones (Table 5), perhaps because the sinuous bifacial edge was advantageous in cutting through large meat packages and thick animal skins.

The association between handaxes and large carcass butchery is frequently inferred from experimental and archaeological data (*e.g.* Toth & Schick, 2019; Linares Matás & Yravedra, 2021). The High Lodge Bed C2 faunal record includes the megafauna species *Palaeoloxodon antiquus* and *Stephanorhinus hundsheimensis*, alongside smaller species of bovid, equid, and cervid (Preece & Parfitt, 2012; Stuart, 1992). Bone preservation is scarce from these deposits and no marks from hominin-processing have been identified, limiting inferences of local faunal diets, but the refined scrapers could have been involved in the butchery of such taxa.

The experiment results indicate functional differences between the refined scraper and handaxe groups but demonstrate the comparable efficiency of these tools in butchering a ~ 25-kg carcass. Some caution is necessary in interpreting these results, given that there are only two repeats for each tool and subtask combination (left and right sides of each carcass) by a single participant. While further work—including butchery of larger carcasses—will allow a deeper exploration of the ideas discussed, the current findings challenge the functional distinctions between unifacially retouched flake tools and bifacially shaped LCTs.

Are the High Lodge Scrapers Large Cutting Tools?

The term, large cutting tool, usually refers to retouched tools over 100 mm in length, believed to have functioned in heavy-duty cutting tasks. Many of the High Lodge scrapers conform to this basic definition of LCTs. However, there are also important differences between traditional bifacial

Table 5 Mean times taken for each sub-task of butchery using each tool type, colour coordinated by fastest (light blue) to slowest (dark blue) relative performance

	Disjointing hindlimb	Defleshing tibia and metatarsal	Defleshing femur	Removing fillet	Removing forelimb	Defleshing forelimb	Removing tenderloin and flesh on ribs
Handaxe	1 min 41 secs	3 mins 8 secs	2 mins 13 secs	2 mins 36 secs	47 secs	4 mins 22 secs	2 mins 15 secs
Refined scraper	1 min 15 secs	2 mins 26 secs	2 mins 11 secs	2 mins 51 secs	1 min	4 mins 18 secs	2 mins 36 secs
Quina scraper	1 min 53 secs	4 mins 20 secs	2 mins 12 secs	2 mins 39 secs	1 min 8 secs	5 mins 24 secs	4 mins

LCTs and these scrapers, the latter being less formalised regarding shape, size, and extent of retouch. While Paterson and Fagg (1940: 29) compare the High Lodge scrapers to 'pseudo-biface shapes', this analogy is only true for convergent scraper forms which constitute just 23% of the High Lodge scrapers analysed, alongside single (36%), transverse (21%), double (12%), and 'endscraper' (7%) forms. In this regard, the scrapers do not demonstrate the same attention to 'imposed forms' evidenced by handaxe assemblages. Instead, the distribution of retouch seems to reflect the opportunities for retouch presented by individual flake blanks and the extent of tool curation.

A morphometric analysis by Hosfield (2013) concluded that the High Lodge scrapers from Bed C2 and the handaxes from Bed E had similarly low coefficients of variance in ratios of length, width, and thickness, indicating there were some consistencies in production that could represent mental templates. The consistent morphology of the scraper retouch is the strongest indicator of standardised production methods in the Bed C2 assemblage, maintaining edge angles between 40 and 60° via invasive flaking. This edge configuration is the only attribute described by Brumm and McLaren (2011) as a manifestation of imposed form in the High Lodge scraper collection, demonstrating controlled production methods going 'against the path of least resistance'. FS could only produce refined scrapers akin to the High Lodge assemblage via tangential percussion using soft hammers, indicating a specific toolkit and technique that distinguishes these flake-tools. While the use of soft hammers in the Bed C2 industry remains speculative, this would be consistent with other observations, including the weak correlation between GIUR and edge angle (Brumm & McLaren, 2011). Soft hammer technology is directly evidenced at Boxgrove during MIS 13 (Parfitt & Bello, 2024; Pitts & Roberts, 1998) and if soft hammers were used at High Lodge, this would be the earliest example in a non-handaxe assemblage (Parfitt et al., 2022).

Another important distinction from traditional LCTs is the smaller dimensions of the High Lodge scrapers (mean length = 97 mm) and the greater size variation, ranging from 50 to 180 mm. Their size is likely constrained in part by the flake blanks used to make them; although the Cretaceous flint of north-west Europe can be an excellent raw material, it is generally found in secondary contexts as smaller nodules or clasts that are usually unsuitable for large flake production. This may explain why most LCTs in Britain are reduced from nodules (Sharon, 2010). Small handaxes are known in the Acheulean, including in the Bed E High Lodge assemblage, where 30% of complete handaxes from the historic and excavated collections are < 100 mm in length (Ashton, 1992). Warren Hill has an even larger proportion of small handaxes, with 75% < 100 mm in length, and 14% between 54 and 70 mm (Emery, 2010); however, fluvial size-sorting may have biased this record (Davis et al., 2021). By comparison, 62.7% of the High Lodge scrapers are < 100 mm in length, and 8% are < 70 mm. Small handaxes are often explained as exhausted tools (Shipton & Clarkson, 2015; Shipton et al., 2013) and the same argument can be applied to some of the smaller High Lodge flake-tools, including 'limace' type scrapers (Ashton, 1992). However, small scrapers with non-invasive retouch are present in the High Lodge collection, indicating that smaller flake blanks were also selected for retouch. It is unclear whether retouch was applied to unused flake blanks or if this reflects subsequent rejuvenation; this is another distinction from handaxes, where there is a clearer separation from the original blank form.

The handaxes produced for this experiment took over 10 min each to finish but the refined scrapers were consistently finished in under 5 min, requiring fewer removals in the process. In some instances, a single core produced several scraper blanks, whereas the clasts used for handaxe reduction were less productive, each yielding a single handaxe. Bifacial reduction is more cognitively demanding, particularly to produce thin handaxes typical of the late Acheulean (Stout et al., 2014). Refined handaxe manufacture is described by Lycett and Eren (2019) as having 'built-in misdirection', requiring complex interactions to communicate actions to a naïve audience. By comparison, the unifacially retouched scrapers require less investment in toolmaking; this could explain why the High Lodge scrapers are less formalised than the handaxes, requiring lower fidelity to reproduce the characteristic cutting edge. Given that refined scrapers are functionally equivalent for deer butchery and easier to produce than handaxes, it is unclear why these are not more common during the Lower Palaeolithic. It is possible that unifacially retouched flakes are less suitable for processing larger carcasses including megafauna, which are understood to have played an important dietary role to some Acheulean groups. Indeed, this experiment suggests handaxes are more effective at piercing skin and cutting through large muscle blocks; a more difficult task on larger animals with thicker hides.

Cultural conservatism could also be a factor in the dominance of handaxes, with the tool representing an entrenched strategy (Finkel & Barkai, 2018) with implications for social cohesion (Shipton et al., 2021), maintained despite the viability of other LCT forms. There is increasing archaeological evidence that Lower Palaeolithic flake-tools were used to butcher large carcasses (Chazan, 2013; Solodenko et al., 2015; Sánchez-Yustos et al., 2016; Venditti et al., 2019), undermining deterministic explanations of handaxe technology as an inevitable solution within the hominin ecological niche. While the Bed C2 assemblage may represent LCT innovation during the Middle Pleistocene, it could be seen as the exception to prove the rule. Handaxes broadly conform to a basic *bauplan*, exhibiting variation in specific features, rather than full suites (Gowlett, 2006; Lycett & Gowlett, 2008; Wynn & Gowlett, 2018). This experiment and the High Lodge scrapers evidence the opportunity for alternative tool conception, capable of supporting similar functions. In sum, the proficiency of contemporaneous non-handaxe industries provides further evidence that the Acheulean phenomenon is a cohesive techno-complex, representing socially inherited behaviours, rather than latent reinventions.

Given that the High Lodge scrapers display greater similarities to Acheulean flake-tool assemblages than other core-and-flake industries, the Bed C2 assemblage contradicts the notion of a single 'Clactonian' tradition. While the handaxe is a reliable continuity marker, their absence is not; some populations likely never encountered handaxe technology, while others feasibly lost this component. The Bed C2 industry may represent a departure from the Acheulean, with refined unifacial flake-tools becoming more prominent and formalised technological components, replacing bifaces in butchery tasks. The utility of the refined scrapers in hide preparation is also significant given the location of High Lodge towards the northern limit of the known hominin range, with consequential thermoregulatory pressures (Hosfield, 2016, 2020).

Final Conclusions

The High Lodge scrapers clearly represent different modes of tool production and use from Acheulean LCTs, bearing a greater resemblance to Middle Palaeolithic flake-tool strategies. However, the larger scraper forms represent a recurrent tool type that likely functioned in part as heavy-duty knives; in this regard, many of the High Lodge scrapers conform to the basic definition of LCTs. The experiment results have important ramifications to the understanding of Acheulean and non-Acheulean groups, challenging the assumption that populations with handaxes were more technologically adept. It is possible that handaxes have advantages in megafauna butchery that were not testable within this study, but it is clear that there were viable alternatives for Middle Pleistocene hominin lifeways involving large butchery tools. This strengthens the argument that the Acheulean represents a cohesive techno-complex with shared cultural origins, rather than an inevitable solution to the problem of butchery. An important avenue for future research will be to expand the range of carcass sizes, with implications for toolkit variation across the Lower Palaeolithic and into the Middle Palaeolithic, the latter characterised by the predominance of retouched flake-tools over handaxes.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s41982-024-00172-4.

Acknowledgements We are grateful to the British Museum and staff at Franks House for facilitating access to study the High Lodge collection. We would also like to thank George Lazarus for kindly providing the deer carcasses and conducting the butchery experiments, Dr Alastair Key for providing the steel-frame apparatus for the clay and rope-cutting experiment, and to Dr Tomos Proffitt for creating the tools used in this pilot study. FS thanks Dr Matt Pope for supervising his undergraduate dissertation and Dr Andrea Zupancic for sharing his data from the Qesem Cave scrapers with us. NA thanks the Calleva Foundation for funding the Pathways to Ancient Britain project to which this paper is a contribution.

Author Contribution F.S.: conceptualization, data curation, formal analysis, investigation, methodology, resources, visualization, writing—original draft; C.S.: supervision, conceptualization, validation, writing—review and editing; N.A.: supervision, conceptualization, validation, writing—review and editing.

Funding No financial support for the research, authorship, and/or publication of this article.

Data Availability The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

Declarations

Competing Interests The authors declare no competing interests.

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