Supplemental Materials

Supplemental Background

History of previously reported human remains

The first recovered Later Stone Age (LSA) forager remains were reported from the Muchinga Province of Zambia, based on excavations at Nachikufu Caves in 1948 and two nearby sites in 1949, described as "few isolated human fragments (notably an ulna)" (Clark 1950:93). Clark (1956) then excavated at Hora 1 (HOR-1) in the Mzimba District of Malawi in 1950. Together with amateur archaeologist W. H. J. Rangely, Clark excavated two articulated adult skeletons (Clark 1956), which were then described by L. Wells (1957). At HOR-1, new excavations by Malawi Ancient Lifeways and Peoples Project (MALAPP) in 2019 revealed at least one additional complete primary inhumation and one secondary or disturbed inhumation, both infants (Lipson et al. 2022). These two individuals and the two adults excavated by Clark (1956) all yielded ancient DNA (aDNA) (Lipson et al. 2022; Skoglund et al. 2017).

Clark later excavated at Chencherere II in the Dedza District of Malawi in 1972 and reported a single adult burial under a pile of stones (Clark 1973). Although most of the materials from Chencherere II were exported from Malawi to the United States, a visit in 2016 to the Malawi National Repository by the MALAPP team resulted in the discovery of still more additional human remains. These included an upper right incisor and a left femur from two non-adults initially identified as different individuals based on ontogenetic age and spatial provenience at the site and later confirmed as such by aDNA (Skoglund et al. 2017); it is possible that one of these elements is from one of the original eight individuals reported by Crader (1984).

Sandelowsky (1972) excavated six rock shelters in the Rumphi, Mzimba, and Thyolo Districts between 1966 and 1967. Of the five with bone preservation, one (Fingira, in the Rumphi District) contained remains from 16 individuals of mixed ages, reported in Appendix B of her dissertation by D. R. Brothwell and T. Molleson (Sandelowsky 1972:405). Upon revisiting the Fingira site in 2016 as part of MALAPP, J.C.T. observed human remains eroding from exposed sections of the original 1966 excavations. Ancient DNA analysis of remains recovered from the surface of the site confirmed that they represent at least two adults and two infants, with unknown relationships to the original 16 individuals reported by Sandelowsky (Lipson et al. 2022; Skoglund et al. 2017).

Mgomezulu excavated five rock shelters in the Dedza District in 1976 and discovered human remains at two. He reported an infant skeleton in a pit with the lower 10-cm "cut into the granite bed-rock" (Mgomezulu 1978:72) at Changoni Bible Training School (CBTS) and commingled elements of at least six adult individuals at Mtuzi. The Mtuzi remains were reported by H. de Villiers (Mgomezulu 1978:368) as an appendix to the dissertation. Additionally, many of the Malawi individuals were later described in more detail by Morris and Ribot (2006).

In eastern Zambia, only 180 km east of the Dedza sites, Phillipson (1976) excavated at three rock shelters (Makwe, Thandwe, and Kalemba) in 1966, 1970, and 1971, respectively, and found fragmentary human remains in all of them. These were described by de Villiers as specialist chapters in Phillipson (1976). One individual from Kalemba in Zambia identified as "SK-5" in Phillipson (1976) yielded aDNA (Lipson et al. 2022).

History of study and locations of remains

The remains of Hora 2 (UCT 243) are held at the Department of Human Biology at the University of Cape Town, and the remains of Hora 1 (UCT 242) are split between this repository and the Natural History Museum in London (Morris and Ribot 2006). The remains were initially analyzed by Wells (1957) as part of the excavations by Clark (1956) in the 1950s, then later by Morris and Ribot (2006). All other remains reported here were recovered by MALAPP and analyzed by the authors and are located at the Department of Museums and Monuments in Lilongwe, Malawi. All supplementary information is also lodged with the Malawi Department of Museums and Monuments.

Bio-osteological summary of Hora 1 and Hora 2

Hora 1 (Burial 1)

Reports by Clark (1956), Wells (1957), and Morris and Ribot (2006) all describe this person as a young adult male (consistent with genetic sex) of short stature, extremely robust, and muscular. Age at death was estimated to be in the thirties or perhaps forties based on

the morphology of the pubic symphysis, which aligns with observed dental wear. Stature was estimated to be 156.14 ± 2.56 cm using maximum femur and tibia lengths (Morris and Ribot 2006). No pathologies or trauma have been described.

The burial was estimated to rest at about 75 cm below the ground surface (Clark 1956). Because the remains fell mostly outside the initial excavation area, Clark (1956) reports that Rangely completed the excavation after he left. Therefore, the only excavation report of the Hora 1 burial in situ is regarding portions of the cranial vault, mandible, an unspecified upper arm bone, and an unspecified number of ribs and vertebrae. The remains are described as crushed, with parts of the skull "widely separated" (Clark 1956:108). This is corroborated by Morris and Ribot (2006), who note that the majority of the face and base of the cranium are missing, while the mandible is present and nearly complete, and the skeleton was fairly complete, preserving most cervical, some thoracic, and all lumbar vertebrae but only three rib fragments and the left clavicle. Missing elements include the left radius, all left hand elements, and most manual phalanges, as well as most of the tarsals, metatarsals, and all pedal phalanges. It remains unclear whether these elements were intentionally removed in the past, destroyed through post-depositional taphonomic processes (e.g., sediment crushing, dissolution, scavenging animals), never recovered by the excavators, or lost in transit or during curation.

The remains are partially fossilized, with a "skin" of carbonate crust. A percussion-flaked stone axe was found under two lumbar vertebrae, but it is not certain if this is an accidental association. No animal remains were reported from within the burial, which is unexpected because our excavations have shown that all sediments at the site contain abundant fragmented faunal remains at densities of at least one specimen larger than 1 cm per 10 cm^3. Although initial attempts to directly date Hora 1 failed due to insufficient collagen (Skoglund et al. 2017), Lipson et al. (2022) successfully obtained a direct date of 9,124–8,972 cal. B.P. (PSUAMS#5145) on tooth enamel.

Hora 2 (Burial 2)

This individual described by Clark (1956) and analyzed by Wells (1957) represents a female in her early twenties at death based on genetic (Skoglund et al. 2017) and morphological features indicating sex and age (Morris and Ribot 2006). There was a lack of fusion at the medial clavicular epiphyses, and she had erupted but only slightly worn third permanent molars. The skeleton was relatively complete, with an estimated stature of 156.1 ± 63.8 cm based on maximum femur length, and slenderly built (Morris and Ribot 2006). No trauma or pathologies have been identified by the previous analysts.

The articulated adult female was buried at ~75 cm below the ground surface—a similar depth as Burial 1. She was positioned on her left side, with arms and legs flexed, and the head oriented north. An image of this burial was published as a plate and on the book cover (Pachai 1972:Plate 1.6) showing an articulated skeleton with the left elbow touching the left knee and a well-preserved and uncrushed but incomplete cranium resting on an articulated left hand (see also Fig. 2 in this article). Clark (1956) reports that the bones have a calcium carbonate "skin," which we have noted is common in faunal remains found in our own excavations at a similar depth. Morris and Ribot (2006:14) mention that "in the cranium, the only area of extensive damage is in the central portion of the face (Figure 2e–i). The upper parts of the maxillary bones have been lost, which means that the inferior aspect of much of the orbits and the sides of the nasal aperture are missing. The base of the skull is broken in the sphenoid region, and the whole of the pterygoid area is lost. The mandible is complete, and there is only minor damage." The left fibula was missing, and the broken shaft of the right fibula was present. In addition, several hand bones and all foot elements except for both tali and three unspecified right tarsals were missing. The right calcaneus was recovered in the patella position. The maxilla of an ungulate, possibly a bushbuck, was discovered under the right scapula of the individual. Skoglund et al. (2017) directly dated Hora 2 to 7,960–8,170 cal. B.P.

Supplemental Methods

New archaeological excavation and documentation

Excavation, site recording, and processing of recovered materials were the same across all sites. Each general locality has a three-letter identifier, and each site has a sequential Arabic numeral. For example, the Hora Mountain inselberg is the "HOR" locality, and "HOR-1" refers to a specific rock shelter on the inselberg. The HOR-5 site, ~500 m away, is a different rock shelter at the same general locality. At each individual site, a handheld GPS was used to identify a starting coordinate and UTM north (WGS84, UTM Zone 36S). Control points were established on shelter walls and surrounding immovable rocks by chiseling an unobtrusive divot into the stone, and these were used to reestablish the grid across multiple excavation seasons. All mapping was done using a five-second total station.

Sites were divided into 1-m × 1-m squares using the UTM grid, with each square assigned an alphanumeric alias (north–south columns are letters, and east–west rows are numbers). Each square was further subdivided into NW, NE, SW, and SE quadrants named a, b, c, and d, respectively. These 50-cm × 50-cm quadrants formed the maximum horizontal units of excavation, except for some mixed-surface cleanings where original sediment provenience could not be ascertained. Contiguous blocks of excavated squares formed "Areas," designated with Roman numerals. Within each quadrant, individually excavated volumes were assigned a "context" number for vertical provenience in the order of excavation, such that they generally increase with depth. The maximum vertical depth of a context for excavation was 5 cm or when the excavator encountered a discernible change in sediment (natural or anthropogenic, for example, an ash feature). Therefore, a context may represent a 5-cm spit or a portion of a feature or natural break in stratigraphy not exceeding 5 cm in depth. The full provenience code for each individual volume of excavated sediment contains all of this information; for example, "HOR-1-I-D11-d-18" represents the locality, site number, excavation area, square, quadrant, and context, respectively. Figure 3 shows this for the HOR-1 site, together with the spatial location of identified human remains.

Data recording procedures were similar to those described in Oestmo and Marean (2015). Each individually excavated sediment volume was assigned a unique "lot number" from a running series that continues across the entire MALAPP project. The lot number operates as a universal cross-site database key for the provenience of recovered materials; for example, the unique identifier "Lot 1002" is shorthand for the entire provenience code "HOR-1-I-D11-d-18." All provenience information is keyed to a Microsoft Access lot number database containing information about the sediment that was removed (e.g., date excavated, excavator, sediment characteristics, disturbances, inclusions, and excavator notes). Data recording took place directly into Access in the field using Windows tablets. Plan photographs of each surface before and after excavation were tied to each lot record using the tablet onboard cameras. A digital SLR camera was used to more formally document features (including inhumations), specialist samples, unusual artifacts in situ, and profiles. Profile photos and images taken for photogrammetry included numbered targets so that they could be georectified and viewed in a GIS environment (Fisher et al. 2015).

All non-human remains, including all artifacts and manuports (e.g., chipped and ground stone, pigments, beads, modified bones, pottery) and ecofacts (e.g., unmodified bones, land snail shells, charcoal) >1 cm, were piece-plotted in three dimensions using a total station and assigned a unique specimen identifier tagged in the field with a barcode. Orientations were taken on objects with a long axis (Bernatchez 2010), which facilitates reconstruction of the specific position of each skeletal fragment, feature, and associated object. All sediments were washed separately for each lot number through nested 3-mm and 1-mm sieves to recover objects not found during piece-plotting. This exposed human remains from the sieve to water immersion. Artifacts recovered in the screen and designated for further individual analysis were given barcode numbers in the lab using the same sequential numbering as the piece-plotted finds. Because these do not have individual three-dimensional coordinates, they are visualized in the GIS at the midpoint of each excavated lot of sediment.

Descriptions of recovery and analysis of remains

All remains identified as human or potentially human in the field were piece-plotted using preprinted barcodes with a unique number and wrapped in tissue paper for transport. In the field lab, adhering sediment was removed with a fine paintbrush, and the specimens were rinsed in water only if they were heavily encrusted and the surfaces could not otherwise be observed to record taphonomic details. All other remains were identified as human only during sorting of faunal remains. At this point, they had already followed the general processing pipeline used for faunal remains: piece-plotted specimens were cleaned with water and a soft toothbrush, left to air-dry, labeled with their individual barcode and lot number, and then sorted by skeletal part by a faunal specialist (J.C.T. or A.B.); sieved specimens that had already been water-screened in the field were cleaned again via sonication for ~five minutes in clean water, air-dried, and then sorted by a faunal specialist. Faunal assemblages were temporarily exported to the United States for further study, and sorting took place at Emory University and Yale University. After analysis, all specimens were returned to the Department of Museums and Monuments in Lilongwe, Malawi.

In July 2019, A.B. plotted two unfused and disarticulated hemimandibles, but complete faunal elements are extremely rare at the site. This alerted J.C.T. to the possibility of a burial, which A.B. then carefully excavated and documented over three days. A.H. prepared and identified the elements in the field lab, and J.C-R. confirmed identifications and estimated the age-at-death using detailed photographs. Human remains determined to be part of the two

infant burials from HOR-1 were identified in the field by A.H., photographed, packaged, and left with the Department of Museums and Monuments without export. All other human bone fragments were exported for detailed study by J.C-R., and any additional human remains recovered from the faunal remains were also studied by J.C-R. prior to their return to Malawi. The sample reported here represents all identified human remains from the five sites that were excavated between 2016 and 2019, both plotted and from the 3-mm sieve. The HOR-1 and HOR-5 samples also include remains from the 1-mm sieve.

Plotting remains

Plotted elements were represented in ArcGIS version 8.0+ with a single x, y, z point consisting either of one point taken in the field or the calculated midpoint of two shots taken on the total station at each endpoint if the element had an elongated shape. Positions of fragments from the sieve were estimated by calculating the midpoint of all the spatial coordinate data from a given context. The supplementary data set includes spatial coordinate data together with their plot/sieve status, catalog information (i.e., square, subsquare, individual ID, element, etc.). All coordinates in the data set have been systematically shortened by an arbitrary amount from their original UTM coordinates so that spatial relationships within each site are retained but the true site locations are obscured. Full site locations and true UTM coordinates are lodged with the Malawi Department of Museums and Monuments.

For sites where more than one fragment was present, fragments were assigned to an individual based on ontogenetic age, spatial proximity within a single excavated feature, and stratigraphic provenience. Only a single fragment was recovered from each of KAD-1 and KAD-2. At other sites, broad ranges of only two stratigraphic associations were used to minimize chances of duplicating individuals. At HOR-1 and MAZ-1, which have large excavated volumes of sediment with complex stratigraphy and multiple features, associations were grouped into simple "Holocene" or "Pleistocene" categories. At the much smaller HOR-5 excavation, two stratigraphic layers were based on field observations of sediment changes. HOR-1 is the only site in the sample with two separate noncontiguous excavation "Areas" (Fig. 3), and as these were separated by ~5 m, fragments recovered from each Area were also considered separate individuals. Fragments were only assigned to individuals if all lines of evidence were consistent with this assignment. If not, then fragments were assigned to an individual as either "possible" or "unassigned."

Methods to estimate the biological profile

For non-adults, age-at-death was estimated using dental development, calcification, and eruption of the dentition; diaphyseal length of unburned and complete long bones; and appearance and union of epiphyses following standards (AlQahtani et al. 2010; Arizona State Museum 2018; Buikstra and Ubelaker 1994; Cunningham et al. 2016). The age-at-death of the adults was estimated using various methods, including observations of the auricular surface and the pubic symphysis (when those elements were present) and the use of transition analysis (ADBOU software version 2.1) that can give physiological age range at death using probability and error margins following accepted standards (Boldsen et al. 2002; Buikstra and Ubelaker 1994; Cunningham et al. 2016). Sex was then estimated for adult individuals following standard protocols using the pelvis, skull, and metric analysis (Asala 2001; Asala et al. 1998; Buikstra and Ubelaker 1994; Igbigbi and Msamati 2009; Klales 2020; Klales et al. 2012; Mall et al. 2000; Phenice 1969; Spradley and Jantz 2011). Using accepted protocols (Buikstra and Ubelaker 1994; Ortner 2003; Wilczak and Jones 2011; Wedel 2013), evidence of pathological conditions and traumas on the skeletal material was recorded when present. Pathologies, traumas, and cut marks were documented by making measurements, taking photographs, and estimating etiology and time (antemortem, perimortem, or postmortem).

Methods to assess bone surface modifications

The modifications illustrated in Figure 7 were all examined under a 10–40· binocular light microscope, following protocols described in Blumenschine et al. (1996). Fragment 60086 (Fig. 7A) is a plotted long bone fragment from HOR-1 Pleistocene layers. It exhibits a single, linear, V-shaped groove that is at least 1 cm long before running off the fracture edge. A thin calcium carbonate skin covers the entire bone surface, fracture edges, and interior of the bone. Blackened color along one edge suggests carbonization rather than mineral coloration because the color grades smoothly from black to light brown and into the otherwise tan color of the bone, rather than occurring in patches. The carbonate skin continuously covers the alteration, and embedded inclusions (likely sand grains) are present on the side of and within the groove. It is therefore a modification that occurred prior to archaeological recovery. It runs perpendicular to the natural bone texture and is therefore not a vascular groove or other anatomical feature. Accompanying more subtle features such as shoulder effect or interior microstriations cannot be evaluated because of the presence of the matrix. However, its

manifestation as an isolated striation with displaced bone to either side that is deep enough to be apparent under the matrix skin indicates a singular process of incision, rather than a general process of abrasion and/or trampling (Domínguez-Rodrigo et al. 2009). Its high length-to-width ratio, straight trajectory, lack of termination in a notch, and narrow V-shape are most similar to cut mark morphology, as compared to a carnivore tooth groove or insect damage (Fernández-Jalvo and Andrews 2016).

Fragment 54639 (Fig. 7B) is a right intermediate manual phalanx V recovered in the sieve from HOR-5. It is complete except for the distal end, which is broken away across an ancient fracture, as evidenced by small clumps of matrix adhering to the fracture edge. The fragment is light gray and the surface is smooth and covered with microabrasion. We interpret this microabrasion as sieve damage. The modification of interest consists of three primary grooves on the dorsal aspect and at the distal break. These are discretely clustered, subparallel, deeper and wider than the microabrasion, and infilled with sediment. In the center of the striations is a patch of exfoliated bone, and the entire feature is adjacent to a fracture that has propagated longitudinally from the mark at the fracture edge and toward the proximal end of the element. These features, in combination with the fact that the mark occurs on the part of the fracture propagation that is depressed downward relative to the other side of the bone, are all most consistent with a single impact blow delivered directly to the bone surface by an object with a rough surface. It is therefore most consistent with interpretation as a hammerstone percussion mark.

Fragment 53693 (Fig. 7C) is a proximal manual phalanx recovered in the sieve from HOR-5. It comprises a complete proximal end broken away across an ancient fracture, as evidenced by consistent coloration across the fracture and bone surfaces, a rounded fracture microsurface, and small scratches across the fracture surface that are also rounded and the same color as the exterior of the bone. The fragment is black, likely because of carbonization. Additional evidence of burning presents as pocking and exfoliation across the entire surface. All these alterations are slightly rounded, and matrix infill indicates that this rounding occurred prior to recovery. Although there is generalized damage across the bone surface, the microtexture is smooth and microabrasion is not readily apparent. There is a large invasive section of removed bone at the fracture edge, on the raised portion of bone on the dorsal aspect immediately distal to the proximal epiphysis. Directly to the side of this portion of removed bone, there is extensive damage, including one prominent groove, small pockmarks, and a large overlapping patch of subparallel microstriations. The primary groove in isolation is consistent with a carnivore tooth mark, as it has a deep, rounded entry point that expands into an elongated groove that is U-shaped in cross section. However, its association with a large patch of removed bone, together with a large patch of microstriations that also emanate down into and across the fracture edge, is more consistent with a direct impact to the bone using a rough object. We interpret this mark as a percussion mark.

Fragment 54638 (Fig. 7D) is a manual intermediate phalanx recovered in the sieve from HOR-5. It comprises a complete distal end broken away across an ancient transverse fracture. The fracture itself contains adhering matrix, which is also present in depressions across the bone surface. The fragment is black, likely because of carbonization. Additional evidence of burning presents as pocking and exfoliation across the entire surface, as well as mosaic cracking across the distal epiphysis. All these alterations are slightly rounded, and matrix infill indicates that this rounding occurred prior to recovery. Although there is generalized damage across the bone surface, the microtexture is smooth and microabrasion is not readily apparent. Instead, at the raised portion of bone on the palmar aspect of the element, a patch of subparallel microstriations is rounded and contains some matrix. This patch crosses over where a longitudinal crack propagates from the transverse fracture toward the distal end of the element, suggesting its emplacement was associated with the same process that generated the fracture. On the dorsal aspect of this same element (not pictured), there is a large patch of removed bone, which is suggestive of impact or perhaps placement on an anvil, but this cannot be confirmed because it does not have any associated surface modifications such as striae or pockmarks.

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