Early Holocene Human Burials from Fa Hien-lena and Kuragala, Sri Lanka

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Abstract

Few human burials from Sri Lankan archaeological contexts have been described. Here we report on the analysis of two early Holocene skeletons, FH8, a young adult female skeleton excavated from Fa Hien-lena and dated to 10,640-10,139 cal BP, and BK1, a middle adult male skeleton excavated at Kuragala and dated to 7,170-6,950 cal BP. The skeletons are both highly fragmentary, which poses challenges for their thorough analysis. However, this paper describes the archaeological context, mortuary treatment and archaeothanatology of the burials, post-mortem taphonomy of human remains, the osteobiography of both individuals, and some general observations on their morphology relative to one another and a broader range of late Pleistocene and Holocene foragers. The results demonstrate common elements of funerary treatment between these two burials, such as interment on the left side with right hands placed near or over the face. The FH8 individual died at a young age and shows some signs of early childhood stress. Both skeletons show moderate to high degrees of tooth wear for their relative ages, and no evidence for dental disease. The body size estimates of FH8 and BK1 fall in the range that would be expected of tropical or temperate forest foragers, although BK1 has a relatively low body mass relative to stature, which aligns his phenotype with populations of more arid environments. We demonstrate that much can be potentially learned about human populations and prehistoric behaviours from skeletal analyses.

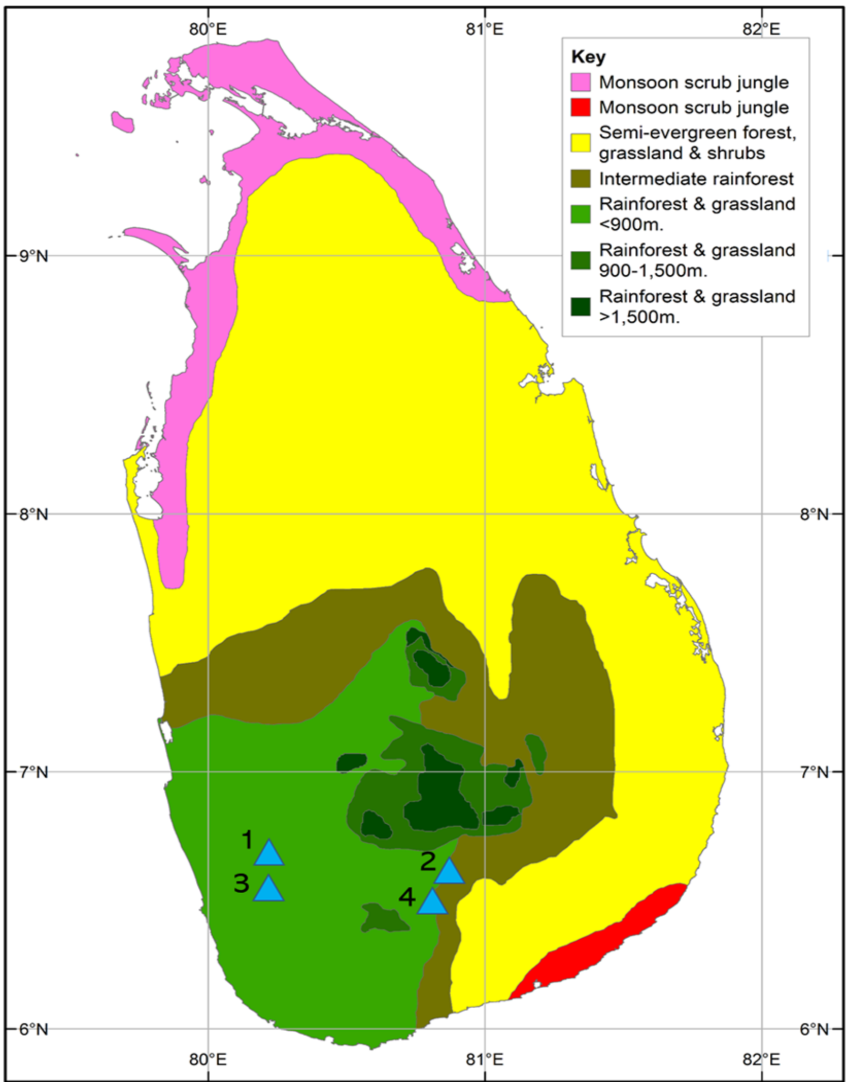
Introduction

The late Pleistocene and early Holocene archaeological record of Sri Lanka is rich and has provided a tremendous amount of information about the earliest occupants of the region (Deraniyagala, 1992; Perera, 2010). The archaeological record of Sri Lanka is well known as providing some of the most important evidence for early human adaptations (Deraniyagala, 1992). The bulk of the earliest archaeological evidence for human occupation of Sri Lanka, dating from the late Pleistocene, comes from sites such as Fa Hien-lena and Batadomba-lena. The human fossil remains from these sites are fragmentary but provide the earliest evidence for human occupation of South Asia at ca. 45,000 BP (Deraniyagala, 1989; Kennedy et al., 1987; Roberts et al., 2015; Wedage, et al., 2019).

The terminal Pleistocene and Holocene skeletal record from Sri Lanka is limited. Fragmentary human remains have been recovered from Bellan-bandi Palassa in the Sabaragamuwa Province, dated to between 11,150 and 12,250 cal BP (Perera, 2010), and Mini-athiliya in the Southern Province, dated to approximately 4,130 cal BP (Kulatilake et al., 2014; Roberts et al., 2022). The analysis of the skeletal remains of these burials provides insights into the lives of people at an important and early period of Sri Lankan prehistory in the terminal Pleistocene and Holocene. In this paper we report on the excavation and analysis of two relatively complete human burials dated to the early

Holocene, from the sites of Fa Hien-lena and Kuragala. These are the most complete primary interments discovered from early Holocene cave sites on the island and, as such, they provide new and important evidence for the mortuary behaviour and biology of hunter-gatherers of the forest ecozone. The site of Fa Hien-lena is situated in a closed rainforest ecozone while Kuragala is to the southwest, a region of transitional more-open intermediate rainforest near the southwestern boundary of the dry zone (Figure 1).

Figure 1. Map showing location and ecological context of: 1) Fa Hien-lena, 2) Kuragala, 3) Batadomba-lena, and 4) Bellan-bandi Palassa (adapted from Roberts et al., 2015)



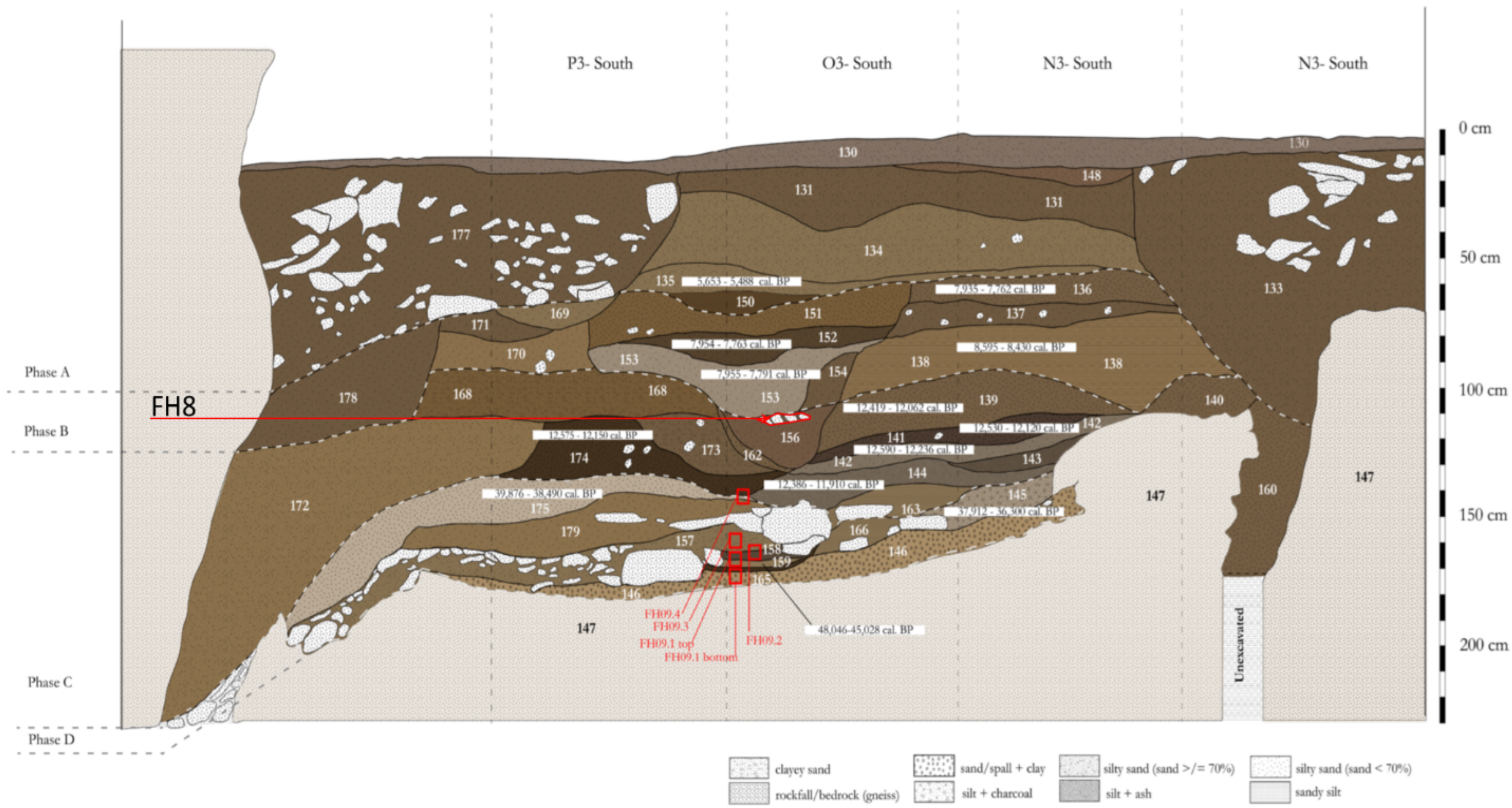
Fa Hien-lena

Fa Hien-lena (site code YP), one of the largest known caves in Sri Lanka, is situated at 80 12' 55" by 6 38' 55" N in Yatagampitiya village near Bulathsinhala in the Kalutara District. The site lies in the foothills abutting the coastal plain and is a complex of interconnected rockshelters developed in a coarse crystalline gneiss cliff. This shelter faces east and is accessed via a short, steep, stone path. The cave mouth has a width of ca. 30 m and an average height above the floor of 20m. The interior is ca. 10 m deep and slopes down from west to east. Secondary lowland forest adjoins the cave complex, the primary rainforest having been cleared for plantations at the turn of the twentieth century.

The site was initially recorded in 1968 by then Assistant commissioner of the Department of Archaeology of the Government of Sri Lanka, S.U. Deraniyagala, when it was being used as a Buddhist cave temple. Subsequently it was reserved for future archaeological investigations. W.H. Wijeyapala, then Assistant Commissioner in charge of excavations, commenced excavations in 1986 as part of stage 5 of Deraniyagala's prehistoric research design (Wijeyapala, 1997). Two areas of the cave, labelled A and B, were explored, with the smaller Shelter B yielding a stratified sequence of habitation deposits that were radiocarbon dated from c. 38,000 to 4,500 cal BP. The top layer 1, comprised brown silty sand with prehistoric occupation debris mixed with recent artifacts, due to the leveling of the floor in modern times. Beneath it, layer 2 consisted of light brown-grey silty sand, approximately 50 cm thick, with a high density of cultural material, and the fragmentary remains of two interred individuals coated with red ochre. The layer is dated by a radiocarbon determination on charcoal to ca. 5,400 cal BP. The layer below, layer 3, is light brown loose sandy silt which is very rich in cultural material. Two radiocarbon dates have been secured on charcoal – ca. 7,700 cal BP and 7,900 cal BP.

The dominant occupation deposit at the site occurred in Layer 4, comprising dark brown silty sand of medium compactness, ca. 25 cm thick, with high density occupation debris (Wijeyapala, 1997). The contents included a partial interment in a lower horizon of layer 4, red ochre, and seven postholes. Three radiocarbon dates (on charcoal from these occupation levels) calibrate to between ca. 38,000 and 30,000 BP. The earliest human occupation at the site is represented by layer 5, with fragmentary human remains. It is a dark brown to yellow, moderately loose sandy silt. layer 5 is very rich in cultural material including faunal remains, stone artifacts and burnt shell, and predates 40,000 years BP. In summary, Fa Hien-lena was inhabited during the late Pleistocene prior to the Last Glacial Maximum (LGM), and during the middle Holocene, but it lacks any dated evidence of occupation between the LGM and terminal Pleistocene, suggesting a lengthy hiatus in occupation between layer 4 and 3.

Figure 2. Archaeological section drawing, Fa Hien Lena 2012 excavation, illustrating context 248 where FH8 was located



In 2008, 2009, and 2012 new excavations of Shelter B commenced under the direction of Nimal Perera, then the Assistant Director of the Excavation Branch, with a view to enhancing the stratigraphic and chronological resolution achieved by Wijeyapala in the 1980s and the collection of additional radiocarbon samples throughout the layers excavated. In addition, Optically Stimulated Luminescence dating and sediment analysis were undertaken in collaboration with Ian Simpson and Nikos Kourampas of the University of Stirling, Scotland to provide additional chronological insight. Much finer-grained stratigraphic resolution was achieved (Figure 2); cultural layers dating to c. 45,000 BP were identified with complex osseous and microlith technologies, and samples secured for in-depth multidisciplinary analyses of the Late Pleistocene and Holocene sequences including botanical analysis, and both radiocarbon and OSL dating. A large assemblage of bone artifacts was retrieved, as well as shell beads from very early contexts.

The radiocarbon and OSL chronology of the site reveals habitation deposits, ranging between ca. 48,000 and 5,000 years ago. These can be divided into four distinct phases: A, B, C, and D (Wedage, Picin, et al., 2019). Phase D (layers 4 and 5 of the 1986 excavation) consists of a series of layers and contexts spanning a lengthy period from ca. 47,000 to 28,000 cal BP, but it still lacks any dated evidence of occupation during the Last Glacial Maximum (LGM, ca. 28,000 to 13,000 cal BP). The microlithic occupation at the Batadomba-lena continues into the terminal Pleistocene with no obvious temporal break in habitation. The deposits at Fa Hien-lena document the lengthy period of occupation during the Late Pleistocene prior to the LGM, and between the terminal Pleistocene and the middle Holocene. The recent excavations at Fa Hien-lena revealed a large pit that cuts through the whole rockshelter sequence and appears to have been dug and then filled between 12,000 and 10,000 years ago, resulting in what appear to be a number of dating reversals throughout the sequence.

The Fa Hien-lena shelter is credited with the oldest known human remains in Sri Lanka, based on their recovery in layers 4 and with calibrated dates between ca.38,000 and 5,000 BP. The description of the remains published by Kennedy (K. A. R. Kennedy, 2000; K. A. R. Kennedy & Elgart, 1998) are summarized in Table 1.

Fa Hien-lena burial (FH8)

New human remains were uncovered during the 2012 excavation from layer 248, a shallow pit feature within layer 247 (Figure 2). Denoted here as FH8, the Fa Hien-lena burial was a relatively complete primary interment of an adult skeleton, although the elements that could be recovered were extremely fragmentary and fragile. Within layer 248, calcium carbonate concretions just below the skeleton suggest that the presence of a burial pit cut into the site from a more recent context. Radiocarbon dates of charcoal samples that were in direct association with the skeleton and likely date to the time of interment place the burial at 10,640-10,139 cal BP (Table 2). Due to the extremely fragile nature of the skeleton, conservation was necessary to ensure maximal preservation for future analyses, and the skeleton was subjected to a thorough program of microCT scanning. This conservation, documentation and analysis work was conducted between 2013 and 2018 in Cambridge England. In 2018 the skeleton was transported to the Department of Archaeology at the Max Planck Institute in Jena, Germany for return to Sri Lanka. The skeleton was transferred to the Sri Lankan Consulate in Germany in 2020. The skeletal remains were subsequently returned to Sri Lanka, where they are currently curated.

Table 1. Previously described human remains from Fa Hien-lena (see Chapter 8, Perera 2010)

Individual number	*Layer*	*Age*	*Sex*	*Representation*
Fa Hien 1 (1)	4	5½ - 6½ (child)	Unknown	Jaws, vault fragments, seven cervical vertebrae
Fa Hien 1 (2)	4	< 1 (infant)	Unknown	Vault fragments
Fa Hien 1 (3)	4	Infant	Unknown	Skull remains
Fa Hien 1 (4)	4	Juvenile	Unknown	Skull remains
Fa Hien 1 (5)	4	Adult	Female	Skull remains
Fa Hien 2	4	Child	Unknown	Mandible, teeth, cranial fragments
Fa Hien 3	4a	Unknown	Unknown	Commingled secondary burials (≥ 2 individuals)
Fa Hien 4	5	Unknown	Unknown	Commingled secondary burials (≥ 2 individuals)
Fa Hien 5	3	~ 5 years	Unknown	Jaws, cranial and postcranial fragments
Fa Hien 6	2	17 – 21	Female	Cranium, postcranial bones
Fa Hien 7 (1)	3a	Juvenile	Unknown	Commingled secondary burial
Fa Hien 7 (2)	3a	Infant	Unknown	Commingled secondary burial

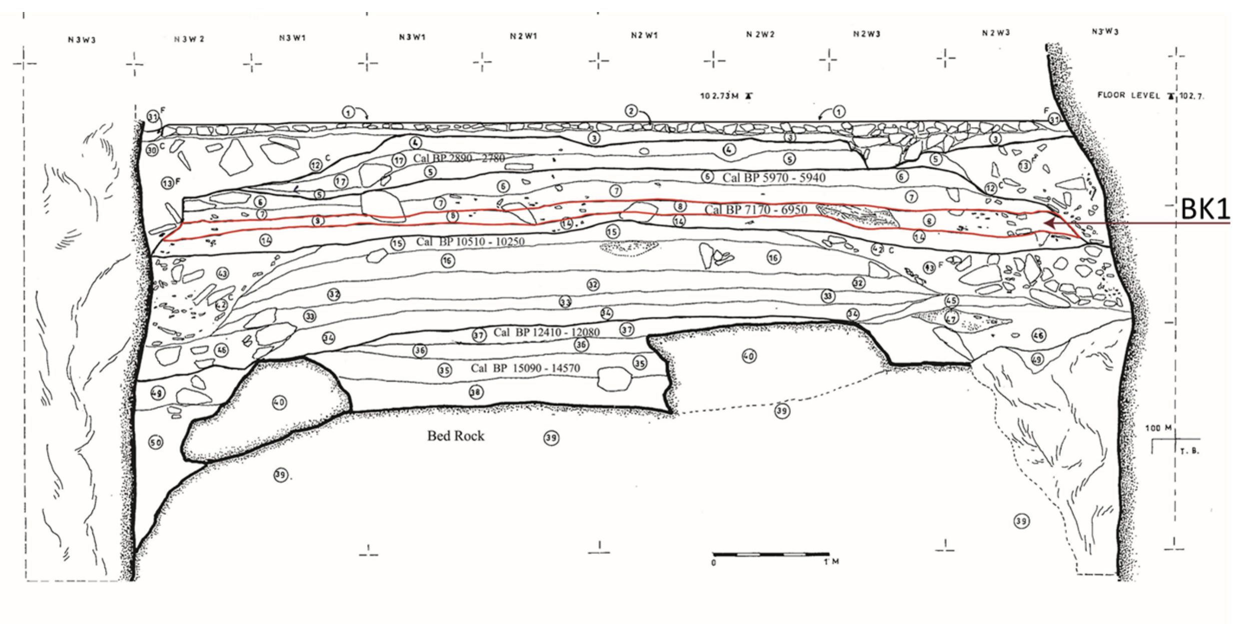
Kuragala

A further significant development in the late Pleistocene and early Holocene archaeology of Sri Lanka came with the excavation of a new prehistoric site in the Intermediate Zone. In 2013, a team from the excavation branch of the Department of Archaeology, Sri Lanka under the field direction of Nimal Perera began detailed excavation of Kuragala (Eregama, 2022). The Kuragala cave complex is an archaeological reserve of approximately 25 hectares, and is situated in lowland ecozone B, with an average annual rainfall of 2050 mm from the intermediate upland of the dry zone. The Kuragala cave complex lies on a wide undulating plateau that has been termed the “Southern platform” (Cooray, 1967), and which is identified as part of the second (middle) erosional peneplain of the island. It is separated from the lower (first) peneplain which extends south-eastwards to the coast by the Kaltota escarpment which rises sharply 325m above the Walawe Valley and plains. The Kaltota escarpment marks the boundary between the highland and Vijayan series. This region receives approximately 2500 mm of rainfall annually, with maximum rainfall during the north-east monsoon in November. The driest months, June to September, coincide with the southwest monsoon, with the total rainfall over the entire four months being ca. 350 mm.

The cave complex consists of several rockshelters and a series of open-air sites. The two main caves are popularly known as Kuragala (derived from Kuhara Gala, rock with a hollow) and Hituwangala (also known as Daththage-lena). Kuragala faces south-east, and the interior of the rockshelter contains ca. 240 sqm of deposits with an estimated depth of ca. 3 sqm at the front and ca. 3.5 sqm at the rear. Water is provided by a small stream located ca. 15m beneath the rockshelter. The rock cave is also situated near the Walawe River, which would have provided access to fresh water, aquatic resources, and game. From the interior of the cave, one is afforded a panoramic view of the valley of Walawe, one of Sri Lanka’s largest rivers, along a large stretch of deciduous rainforest. This site is located on a transitional ecozone between the Wet and Dry Zones of Sri Lanka and, as such, provides an important locality for interpretations of prehistoric environmental adaptations, making the chronological resolution at the site particularly important.

In 2013 a test pit measuring 3 x 2 m was excavated (Figure 3). The excavation reached the base of the deposit at nearly 3 m below the surface and identified eight major occupational phases, which are characterized by a high density of stone artifacts, bone tools and in particular shell beads and faunal remains. The *in situ*, prehistoric habitation deposits end with phase VI, dated to the Mid-Holocene by a single radiocarbon determination of ca. 5,926-6,171 cal BP, which may be the result of later disturbance of deposits. Phase V represents one of the major habitations of the site and contains stone artifacts, faunal remains and shell artifacts, which were found over most of the habitation at the site, as well as a human interment. Phase V is dated to the late early Holocene with calibrated dates of 6,940 – 7,189 cal BP. The dominant occupation deposit at the site occurred in Phase IV, comprising 6 contexts, ca.75 cm thick, with a high density of occupational debris including faunal remains and stone artifacts. The phase is dated by a radiocarbon determination on charcoal to ca. 9,230 BP which calibrates to the period between 10,260 to 10,510 cal BP. Phase III, which is comprised of 10 contexts and which contains stone artifacts and faunal remains, and which was found over most of the habitable area of the cave, reflects intensive habitation at the site. The two radiocarbon dates from this phase are stratigraphically consistent and range, after calibration, between ca. 12,060 and 15,181 cal BP.

Figure 3. Archaeological section drawing, Kuragala 2013 Excavation illustrating Layer 8, the context of the BK1 burial



Kuragala burial (BK1)

New human remains were uncovered during the 2013 excavation from layer 8 (Figure 3), which has been dated by charcoal samples associated with the skeleton to 7,170-6,950 cal BP (Table 2). Denoted here as BK1, the burial was a relatively complete primary interment of an adult. The complete Kuragala burial (BK1) was removed in-block where it was encased in a wooden crate and taken to the Budugala field station for more controlled excavations. The skeleton and all associated cultural material were designated as feature 41. The Kuragala skeleton was also highly fragmented and encrusted in calcium carbonate, which required careful analysis and a program of microCT scanning which occurred between 2013 and 2018 in the Cambridge Biotomography Centre and the Department of Archaeology at the University of Cambridge.

Kuragala (BK2)

Three additional human teeth were found in the proximity of the BK1 skull within Context 8, but they clearly belong to at least one additional individual. They have been designated as BK2a-c. Further descriptions are found in the Skeletal and Dental Inventories and Taphonomy section below.

Table 2. Radiocarbon dates for deposits associated with Fa Hien-lena and Kuragala burials.

Site	Context	Sample number	Sample	Date	calBP range*	d13C
Fa Hien-lena	FH5	OxA-26614	Charcoal	10410 ± 40 BP	10640-10139	29.5
	FH6	OxA-26615	Charcoal	10340 ± 40 BP	10517-10254	28.8
Kuragala	Context 8	BK/2013/N2W1/CX/8	Charcoal	6170 ± 40	7170-6950	-

*calibrated using OxCal 4.4 with IntCal 20 Curve (Reimer et al., 2020)

Mortuary Context and Archaeothanatology

Careful excavation and recording of the relative position of human remains *in situ* can reveal aspects of prehistoric cultural practices and treatment of the dead (Duday et al., 2014). Human remains recovered from the late Pleistocene and early Holocene of Sri Lanka have primarily been fragmentary or isolated, and early complete human primary interments are rare. As such, we know very little about cultural aspects of the treatment of the dead among prehistoric populations of Sri Lanka. The new burials from Fa Hien-lena and Kuragala provide an opportunity to interpret funerary behaviour of hunter-gatherers of the rainforest ecozones at the very end of the Pleistocene and early Holocene. Below are detailed descriptions and interpretations of each burial.

Fa Hien-lena FH8

During the primary interment of the Fa Hien-lena burial, the body was placed in an extended position with the head and torso angled towards the left side, facing towards the back wall of the cave to the North (Figure 4). The left leg was flexed at the knee and positioned below the right leg, which was extended. The arms were extended to the north, in front of the torso, with the elbows flexed so that the hands are situated towards the front of the face. As the skeleton was lying on its left side, the right humerus was above the left in the deposits; however, the right forearm crossed the left to be situated underneath, meaning that the skeleton was interred with crossed forearms and the final position represents some post-depositional movement.

Figure 4. Fa Hien-lena burial (FH8) *in situ* illustrating the burial position, and rocks placed above upper torso and pelvis, with: A) detail of thoracic and pelvic regions after removal or overlying rocks; B) Detail of lower legs and feet demonstrating the high degree of fragmentation of long bones and relative completeness of smaller pedal elements; and C) detail of underside of overlaying rock, with adhering scapula and rib fragments.

Several hand bones were found in close proximity to the skull, in a position which would be slightly distal relative to the mandible, while others were further away on the other side of the distal forearms. The right hand was likely tightly flexed at the wrists towards the face of the skeleton, probably tucked under the chin, and the left hand flexed away from the face. The right ribs have slumped downwards so that their sternal ends are just covering the spinal column, which suggests that the torso was situated on the left side but also somewhat towards the surface of the deposit. Two large rocks were situated directly above the thoracic and pelvic regions and appear to have been deliberately placed above the body at the time of interment, these are responsible for much of the movement of, and taphonomic damage to, the thoracic region of the skeleton. While the general context of the burial included lithics and fauna, the only burial inclusions that appear to be associated with cultural activity at the time of interment are the two rocks placed over the thorax. Ribs from the thorax were found directly adhering to the rocks (Figure 4C), supporting an interpretation that they were placed over the body when it was interred.

Kuragala (BK1)

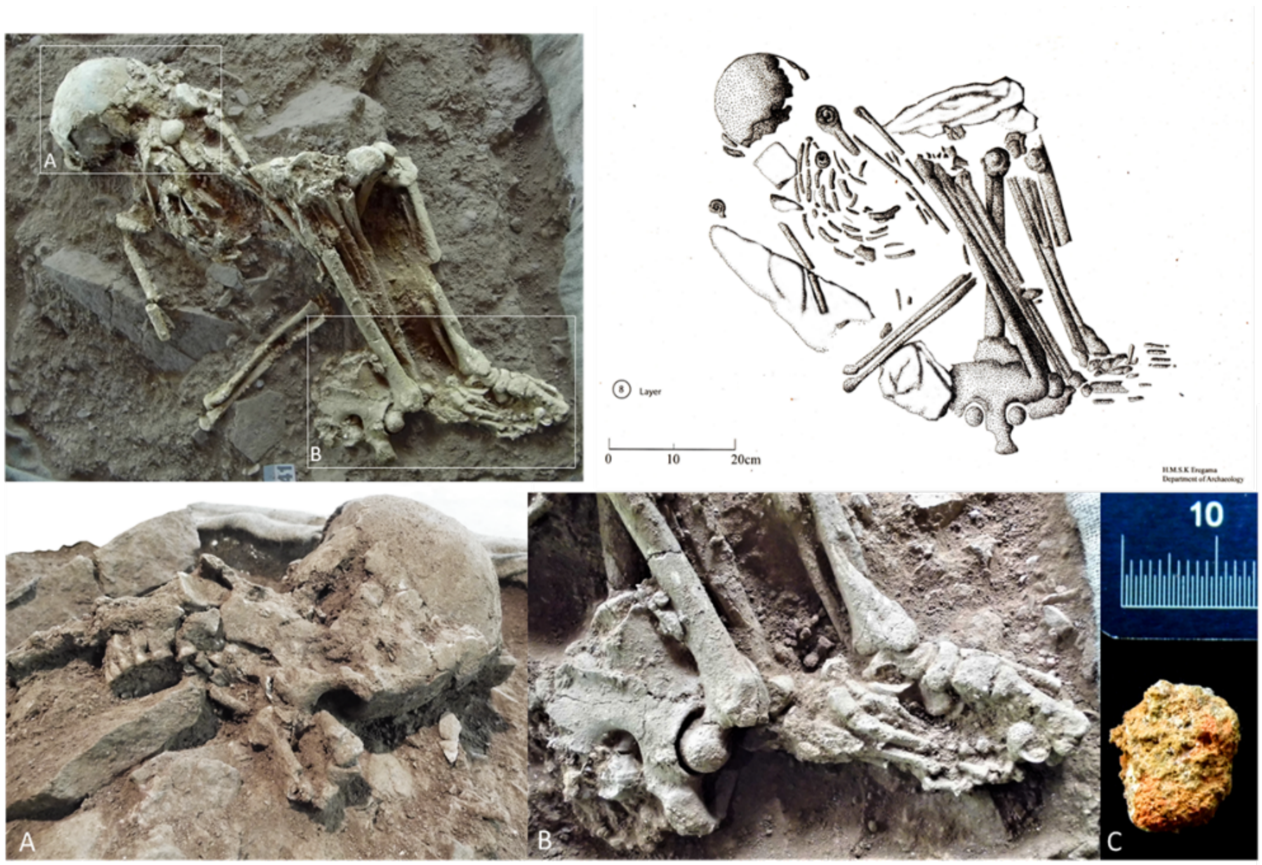
The burial position of the Kuragala skeleton (Figure 5) is tightly flexed and placed on the left side of the body. The burial was laid on top of two large stones with the left arm extended beyond the dorsal side of the thorax. The distal end of the left humerus has moved post-mortem and there are signs of root penetration through the distal end of the humerus suggesting some post-depositional disturbance of this region of the burial.

The skull was resting upon another large rock, which appears to be an intentional placement during interment (Figure 5A). It appears that post-depositional damage to the right side of the skull led to lateral rotation of the head and destruction of the maxillary region and upper dentition. During this movement, the mandible rotated inferior/dorsally. The right arm was tightly flexed in front of the chest with the right metacarpals tightly flexed and extending into the left orbit, which was also likely to have occurred in association with post-depositional movement of skeletal elements. The position of the bones *in situ* is consistent with an interpretation that the body was interred with the right hand covering a portion of the face.

The interment also featured tightly flexed legs, at both the hips and knees. The femoral heads remained articulated with the acetabulae of the ossa coxae, but the calcanei were found in close proximity to the proximal femora with the left and right feet closely aligned (Figure 5B). While there is no direct archaeological evidence, the high degree of flexion of the lower limbs could be explained by some sort of tight funerary wrapping, or the individual being placed in a very small burial pit shortly after death.

In addition to the stones, there were other cultural elements associated with the burial. In the region of the pelvis a chunk of ochre (Figure 5B), a quartz microlithic core and several retouched microliths were recovered, along with some faunal remains including a land mollusc shell, and a mandible and humerus fragments from a monkey. In the same region, between the proximal end of the right femur and the distal end of the left tibia, a further quartz retouched blade and ochre sample were recovered. A further cache of quartz lithics blades and cores were found in association with the skull, along with a heat-treated stone and a monkey premolar.

Figure 5. Kuragala burial (BK1) *in situ* illustrating the burial position, with detail of: A) cranium and position of carpals, b) pelvis and position of feet, and c) ochre inclusion in burial



Common elements of each burial

If we consider the burial context of both the FH8 and BK1 burials there were several common features. Both individuals were interred on their left sides, with arms flexed and right hands oriented near or over the face, and both burials appear to have stone features of the burial that either: A) formed features at the base of the burial, upon which the body was interred; or B) were placed above the body after interment. Given the small sample sizes of terminal Pleistocene or early Holocene primary interments within the rainforest ecozone, we cannot yet interpret these features within a broader context of mortuary variation, but they provide some intriguing evidence for prehistoric funerary behaviour in Sri Lanka.

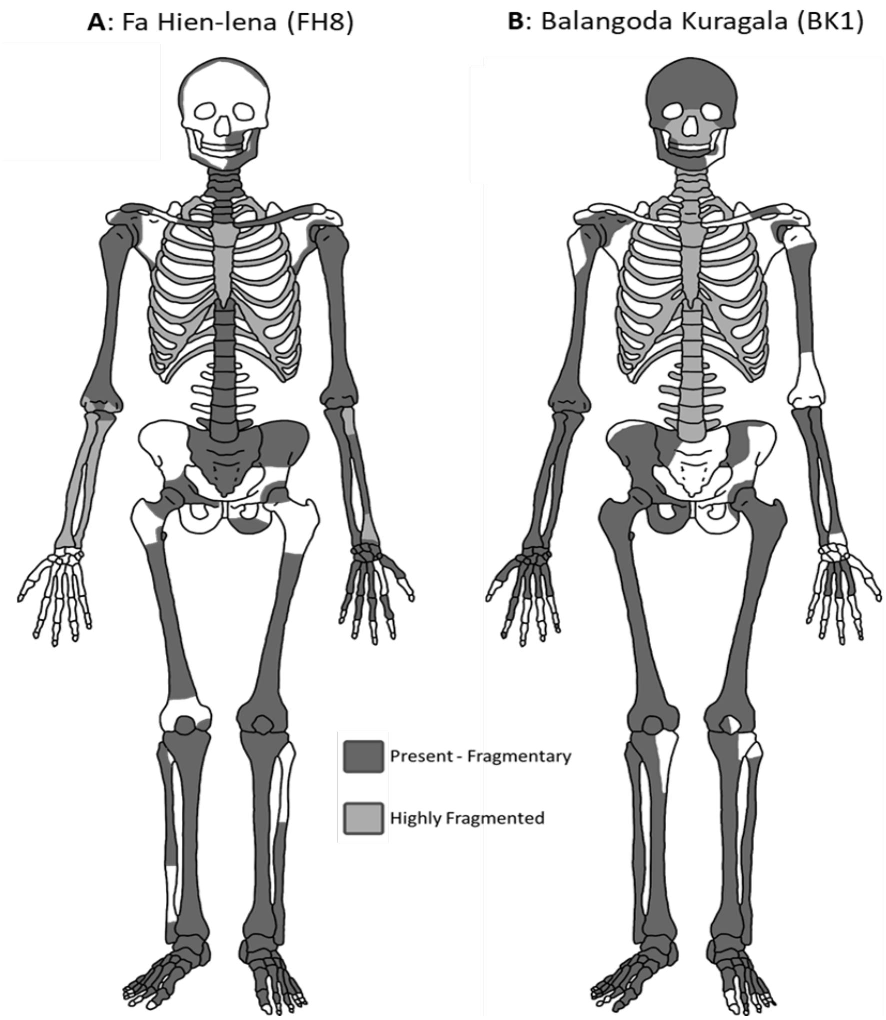
Skeletal and Dental Inventories and Taphonomy

The remains of both the Fa Hien-lena (FH8) and Kuragala (BK1) skeletons were highly fragmented (Figure 6). The only complete bones of either skeleton were several elements of the feet, otherwise we define 'fragmented' bones as specimens where individual fragments are numerous and of a size of approximately 1-10 cm, but for which virtual reconstruction may be possible, and 'highly fragmented' where there are very small fragments of bone that have been recovered but for which no reconstruction or morphological assessment is possible. Despite similarities in the general level of preservation of each skeleton, the taphonomic processes differed. Below, we describe the general preservation of each skeleton and provide a discussion of the taphonomic condition of the remains of each individual that limit, to some extent, the range of analyses that are possible for either skeleton.

Fa Hien-lena (FH8)

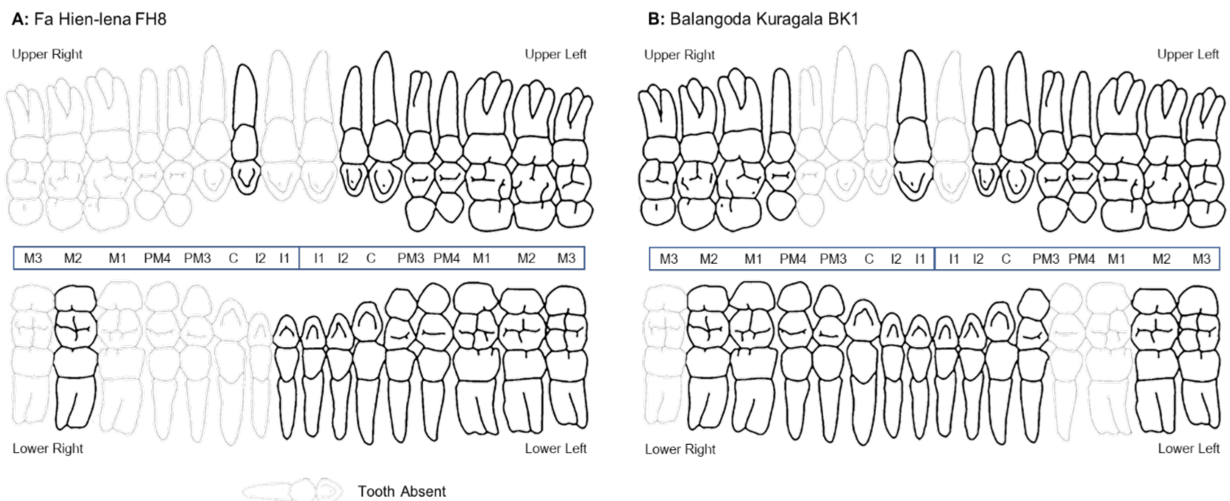
A visual inventory of the skeletal remains of the Fa Hien Burial (FH8) are presented in Figure 6A. Overall, the skeleton is relatively poorly preserved. All bones, except for some pedal elements, are preserved as multiple fragments only. The cranium was extremely fragmentary and could only be recovered in sets of small pieces. In total there are over 100 cranial fragments, with approximately 5-10 of reasonable size. The rest are very small, which makes physical reconstruction impossible and virtual reconstruction extremely challenging. Almost all of the skull fragments belong to the cranial vault. The more fragile bones of the cranial base and face were generally not preserved, with the exception of fragments of zygomatic (malar) bone and left maxilla. There is partial preservation of much of the spinal column, but the ribs, scapulae, and pelvis regions directly underneath the two overlying rocks, were heavily fragmented. Skeletal regions and elements comprised of primarily trabecular bone such as the vertebrae and epiphyseal ends of the long bones are generally poorly preserved, with a few exceptions including the humeral and femoral heads, and the calcanei and tali. Although an attempt was made to conserve the left ilium of the pelvis in the field with some success, it remains fragmentary. Regions of the skeleton comprised primarily of cortical bone, such as the long bone shafts, are, at best, fragmented into several segments and, at worst, these segments are further fragmented into 5-6 very friable fragments of bone, some of which are demineralised to the point where consolidation would be required to ensure against further deterioration. Skeletal elements that are fragmentary but remain reasonably well preserved include both humeri, the left ulna and part of the radius, both femoral heads and much of the femoral diaphyses, the patellae, both tibiae and portions of the fibulae. Right pedal bones that are complete include: the calcaneus, talus, 1st and 5th metatarsals (MT), 1st intermediate phalanx, navicular, cuboid, and medial (first) cuneiform. Of the left foot, the following elements are preserved and complete: calcaneus, MT 2, 3, 4 and 5, cuboid, navicular, cuneiforms medial, intermediate and lateral (1-3), in addition to some of the phalanges of both feet.

Figure 6. Skeletal inventories of the A) FH8 and B) BK1 primary burials, illustrating the degree of preservation



A dental inventory of the Fa Hien-lena FH8 skeleton is provided in Figure 7A. Most of the teeth on the right side were missing. At the time of interment, the body was laid on its left side, and this side of the dentition, which was lower in the deposit, was generally better preserved. The only right-side elements preserved include the upper right second incisor, and the lower right first incisor and second molar. The maxillary dentition on the left side is represented by maxillary teeth from the second incisor to the third molar, and a complete set of adult teeth from the lower left quadrant.

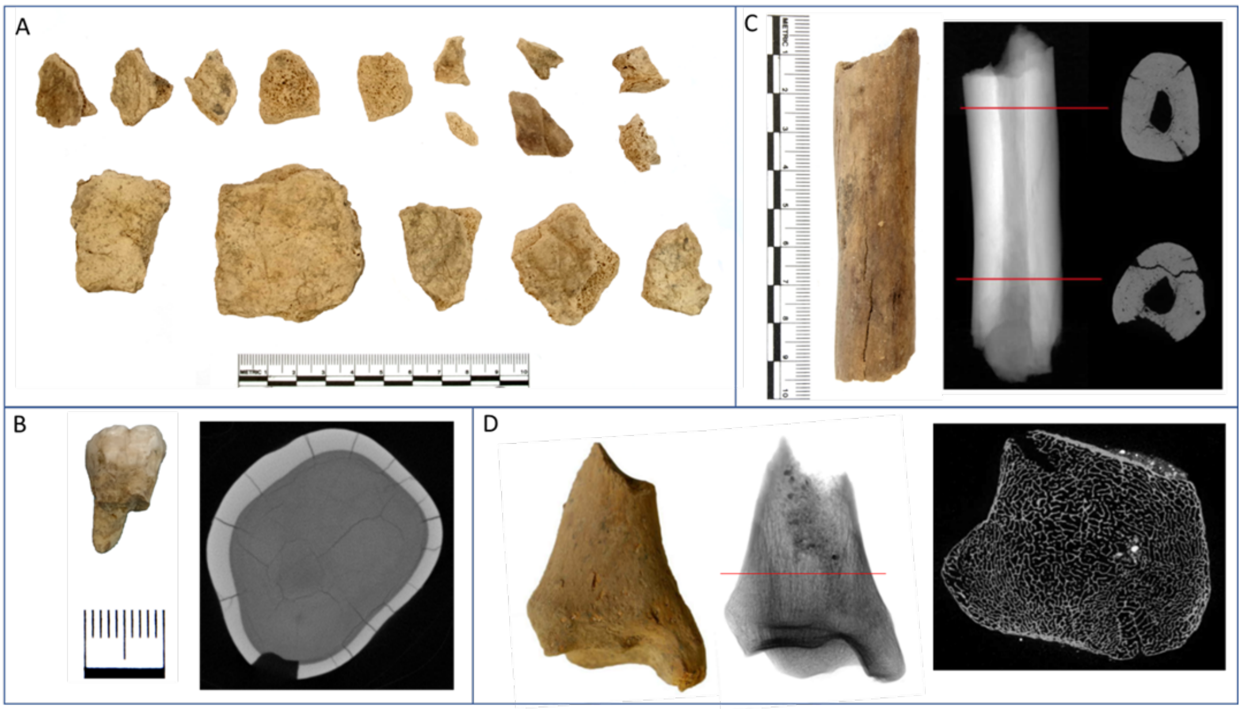
Figure 7. Dental inventories of the A) FH8 and B) BK1 primary burials, illustrating the degree of preservation. I = incisor, C = canine, PM = premolar, M = molar.



While the general preservation of the skeleton can be seen in Figure 4, specific aspects of skeletal taphonomy are illustrated in Figure 8. Figure 8A illustrates the general level of fragmentation of the bones of the cranial vault. Most fragments range from 3-5 cm in diameter, but there are a number that are considerably smaller, posing challenges to cranial reconstruction. Some of the fragments also represent separation at the diploë, between the inner and outer tables of the cranial vault. There is no evidence of remineralization / fossilization of the bone and all bones are free from calcium carbonate concretions, perhaps as a result of the interment being well within the dripline from the outer edge of the cave.

An illustration of the typical preservation of the dentition is presented in Figure 8B, demonstrating some postmortem damage to the roots, and a microCT cross-section showing microfractures to both the dental enamel surface and underlying dentine. Figure 8C illustrates one of the better preserved long-bone segments, approximately 9 cm of the right humeral diaphysis. The microCT cross-sections show the process of taphonomic microfracturing that led to the fragmentation of much of the rest of the skeleton. The distal end of the right tibia (Figure 8D), however, illustrates a rare example of the excellent preservation of some regions of trabecular bone, despite the fragmentation of bone diaphyses.

Figure 8. Taphonomy of the Fa Hien-lena FH8 burial, illustrating: A) the degree of fragmentation and general preservation of the cranium; B) the preservation of the upper left second molar, and, visible externally (left) and in micro-CT derived virtual cross-section (right), to illustrate taphonomic microdamage to dental enamel and underlying dentine; C) an example of some of the more well preserved cortical bone from the right humerus shaft, D) an example of the preservation of both the cortex and trabecular bone of the right distal tibia (anterior view).



Kuragala (BK1)

A visual inventory of the skeletal remains of the Kuragala burial (BK1) is presented in Figure 6B. Overall, the preservation of the skeleton is somewhat better than FH1, and although most bones are fragmentary, the level of fragmentation is somewhat lower. Similar to FH1, several pedal elements are well preserved. The cranium of BK1 is both more complete and less highly fragmented than FH8. The typical level of fragmentation of the cranial vault is illustrated in Figure 9A, along with fragment size. The maxillary region of the cranium is poorly preserved and highly fragmented due to the taphonomic damage to this region relative to the underlying stone within the burial, as described above. Much of the right side of the mandible is preserved but fragmentary. The majority of the thorax is poorly preserved and highly fragmented, including the vertebral column, ribs, and sternum. Only one small segment of the left clavicle was recovered, along with highly fragmented left and right scapulae from the region of the glenoid fossa. The right upper limb is relatively complete, preserving much of the humeral shaft and part of the humeral head, the radius and ulna, carpal and metacarpal bones and several phalanges. The left arm consists of part of the humeral diaphysis, a fragmentary ulna and most of the radius, as well as several metacarpals. The right side of the pelvis, which is visible in figure 5B, was relatively well preserved with some damage to the iliac crest and some fragmentation. Only small fragments of the sacrum and left side of the pelvis were recovered. Both right and left femora were relatively complete, although fragmented, as were large portions of the tibia, apart from some missing regions of the tibial plateaus. The fibulae were relatively well preserved but fragmentary, and most skeletal elements of the left and right feet were present and generally well preserved.

A dental inventory of the Fa Hien-lena FH8 skeleton is provided in Figure 7. At the time of interment, the body was laid on its left side with the head placed upon an underlying stone. As taphonomic processes led to post-depositional damage to the maxillary region and much of the alveolar bone, many of the teeth that were recovered were loose, although relatively well preserved. The preserved upper dentition included the right PM^4 through M^3, and the right first incisor, while on the left side the dentition was complete from the I^2 to M^3. The lower dentition was somewhat better preserved with the right side complete from I_1 through M_2, while the teeth recovered from the left lower dentition included I_1 through PM_3, and both the M_2 and M_3.

Specific characteristics of skeletal taphonomy are further illustrated in Figure 9. The cranial vault fragments illustrated in Figure 9A and the right tibial segment in Figure 9B illustrate the calcium carbonate concretions that were pervasive on all bone surfaces in the burial. These concretions likely contributed to the relatively better state of preservation of some of the BK1 bones relative to the level of fragmentation of the FB8 burial. A microCT based scan of the distal tibia is illustrated in Figure 9B, demonstrating considerable permeation of the periosteal margins of the bone surface, and the accretion of calcium carbonate several millimeters into the underlying trabecular bone, where individual trabeculae have further calcium carbonate concretions. This poses challenges for the analysis of trabecular bone variation that require further mathematical approaches to correct. Another challenge is that many of the better-preserved skeletal elements such as those from the feet, for example, are adhered together by calcium carbonate. Physical separation of these elements will damage the underlying bone. In many archaeological contexts in the past, bones with this level of calcium carbonate would have been cleaned either mechanically or with a light acid solution. However, this method can cause additional damage to the underlying bone, including demineralization of the bone tissue. Using advanced imaging such as microCT scanning allows for virtual analysis of the underlying bone without risk of further damage.

Figure 9. Taphonomy of the Kuragala BK1 burial, illustrating: A) the degree of fragmentation and general preservation of the cranium, note the pervasive calcium carbonate concretions on the bone surface, which is characteristic of all preserved elements; B) an example of the preservation of both the cortex and trabecular bone of the right distal tibia (posterior view). Note the extent to which calcium carbonate has permeated the cortical bone and covers the individual trabeculae beneath the cortex.

Kuragala isolated teeth (BK2)

Three additional human teeth were found in the proximity of the BK1 skull within Context 8, but they clearly belong to at least one additional individual. Based on their identifications and relative tooth wear they are consistent with being from one individual of relatively young adult age, but this association is uncertain. As a result, we have designated them as BK2(a-c). Further details of each tooth are found in Table 3.

Table 3. Additional human remains from Kuragala

ID	Element	Side	Notes
BK2a	lower molar 1 or 2	Left?	Crown completely unworn, roots ¾ complete, but unclear whether taphonomic damage or incomplete development – Sampled for isotopes
BK2b	lower incisor	Left?	Unworn or minimally worn
BK2c	upper molar 1	Left	Adult, crown completely unworn roots broken/missing, Carabelli's cusp

Osteobiographic analyses

What follows is a description of key diagnostic elements of the skeletons that were recovered to provide osteobiographic detail of both the FH8 and BK1 skeletons. This includes information about age and sex of each burial, as well as other features of interest.

FH8 Osteobiography

Of the preserved elements of the FH8 burial, there are several that have diagnostic features which are helpful in sex and age estimation. No single indicator is completely diagnostic of age or sex, but observation of a number of features strengthens interpretations. Fragments of temporal bone include the temporo-mandibular joint and the mastoid process. Based on common methods of sex estimation (Buikstra and Ubelaker, 1994), the size and shape of the mastoid process would be scored as category 1. The left side of mandibular corpus and ascending ramus were fragmentary but sufficient for the observation of sexually dimorphic traits. These include a gonial angle that is quite obtuse, measured at 116 degrees, with no gonial flare, and the mandibular corpus is relatively gracile without particularly well-developed muscle attachments. The inferior side of the mandible is complete mesially to the approximate midline of the mandible, making it possible to observe the region of the mental eminence. There is no sign of a developed mental trigone. A small fragment of bone was recovered from the sub-pubic region of the pelvis during excavation that appeared to be a fragment of the sub-pubic ramus, featuring a partial sub-pubic concavity and ventral arc. Each of these features of the skull are typical of female sex and in combination make for a fairly confident estimate of sex.

Several features of the FH8 skeleton are also strongly diagnostic of age, but primarily the state of epiphyseal fusion, which was observable on a number of skeletal elements. The left and right clavicles had unfused sternal epiphyses. The epiphyseal fusion of the left humeral head was nearly complete, but the fusion line was still open in several locations. The first lumbar vertebra is present in two fragments, and the annular epiphyses are clearly in the process of fusion. Fragments of the neural arch are also preserved, including the inferior zygapophyseal joint and tip of spinous process, which is in the process of fusing. The first thoracic vertebral body is damaged, but the annular epiphyses are unfused. Similarly, a fragment of the medial condyle of the left tibia shows that this epiphysis is fully fused but that the fusion line is still visible. As described earlier, the ribs are highly fragmented but several sternal rib ends were preserved that were useful for age estimation. It was not possible to seriate the rib fragments to identify precise rib numbers, but a right rib of upper-mid thoracic region, likely the 3rd or 4th, features very shallow concavity and smooth margins, typical of phase 0C (İşcan et al., 1984). All of these observations are consistent with the remains of FH8 belonging to a young adult between the ages of 18 and 22 years at the time of death.

BK1 Osteobiography

The right side of the pelvis preserves a number of features that are diagnostic of sex. The greater sciatic notch is relatively narrow and, although the margin is incomplete, the observable curvature would categorize this as 1 or 2 on the scale proposed by Buikstra and Ubelaker (1994). In addition, the left mastoid process of the temporal bone is long and voluminous. The right pubic region is relatively complete and shows a shallow sub-pubic angle and the absence of a ventral arc, while the sub-pubic ramus is relatively broad. These features suggest that the skeleton was male. Calcium carbonate concretions on the right pubic symphysis make observation of the symphyseal morphology difficult, but the underlying shape suggest that the ventral rampart is closed and there is a complete and well defined symphyseal rim. While these characteristics are not particularly diagnostic of age, it is consistent with an adult of middle age (neither young nor particularly old). The dentition demonstrates the complete formation and eruption of the third molars, indicating the full adult status of this skeleton. Collectively, the features of the skull, dentition, and pelvis indicate that BK1 was an adult male, likely between the ages of 30 and 50.

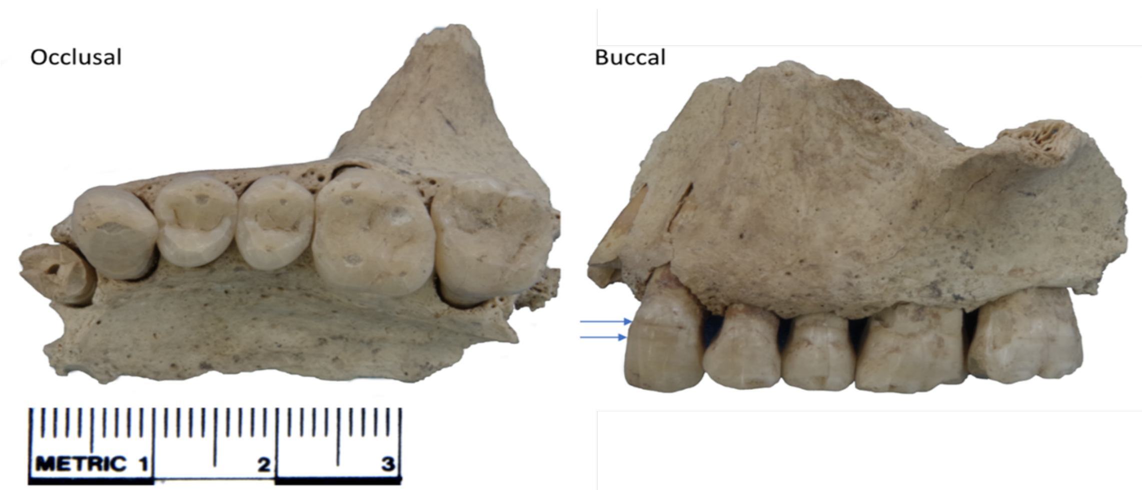
Morphology and other observations

Fa Hien-lena FH8

Partial reconstruction and alignment of postcranial elements is sufficient to directly measure or estimate bone dimensions that are useful in the interpretation of body size. Based on measurements of available bone fragments, and *in situ* measurements in the field, the maximum length of the left femur can be conservatively estimated as 414 ± 10 mm, while the right femur is ca. 420 +-10 mm. The left femoral head is relatively small, with a maximum breadth of 40.62 mm, and an antero-posterior breadth of 39.82 mm. The right tibia is fragmentary throughout most of the shaft and proximal end. Transverse post-depositional fractures divide the bone into seven segments. Despite the relatively poor preservation the approximate length of the tibia was measurable *in situ*, from parts of the tibial plateau to the distal articular surface. Maximum length is estimated at 370 mm excluding the medial malleolus, so the maximum length may be as much as 380 mm: we here conservatively estimate it to be 375+-5mm. To estimate body mass, the mean of three regression equations based upon femoral head diameter was used (Ruff et al., 1997), yielding an estimate of 54.5 kg. To estimate stature, regression equations derived from DXA based measurements of the limbs of South Asian populations were applied to the estimated femur and tibia lengths (Pomeroy et al., 2018). Stature from left femur length provides an estimate of 152.5 cm, and the right femur produced a slightly higher estimate of 154.1 cm Application of a regression equation to estimate stature from tibial length provides an estimate of 159.1 cm. Overall, these estimates point to a young adult female that would have stood between 152 and 159 cm tall, approximately 4’11” to 5’3” in stature and was approximately 54 kg or 120lbs. The general characteristics of the skeleton provide some evidence for the development of a small bodied, gracile skeletal phenotype in the Late Pleistocene, characteristics that are not typically found in other regions until the Holocene. These characteristics could be the result of adaptation to a tropical rainforest environment (Stock, 2013) but will require further analyses to assess.

Several other observations could be made on the FH8 skeleton to provide further insights into the biology and lifestyle of this individual. The distal tibia feature squatting facets, thought to reflect repetitive hyperflexion of the tibio-talar joint, consistent with a repetitive squatting posture (Singh, 1959; Trinkaus, 1975). The right and left clavicles both feature large cortical defects at the location of the conoid tubercules. Similarly, the right humerus shaft features a deeply concave enthesopathy, a benign cortical defect, at the pectoralis major insertion. It has been hypothesized that such cortical excavation may be the result of higher levels of habitual loading at these insertion sites, although the etiology is poorly understood (Capasso et al., 1999; Mann & Hunt, 2012).

Figure 10. Fa Hien Lena (FH8) maxillary dental wear and linear enamel hypoplasia (blue arrow)



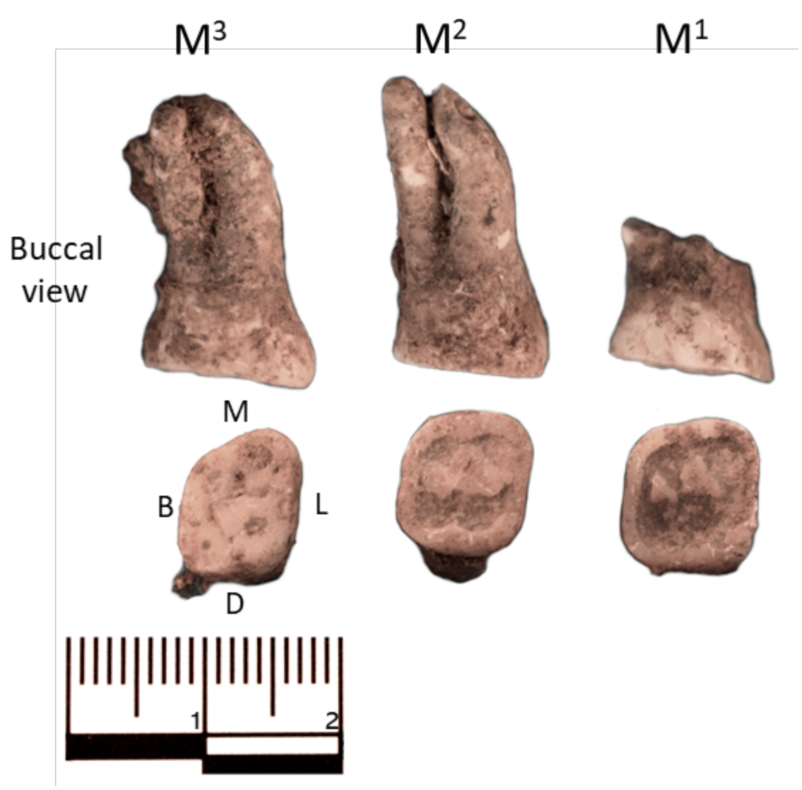
The maxillary and mandibular dentition both show moderate tooth wear and signs of early developmental stress in the form of linear enamel hypoplasia (LEH). There was no evidence of dental caries or deliberate cultural modification of the FH8 dentition. Figure 10 illustrates the extent of dental wear on the left maxillary dentition, as well as two transverse bands of LEH on the left maxillary canine, situated towards the cemento-enamel junction. The maxillary canine crown finishes forming at approximately 6-7 years of age, indicating that this individual experienced some form of short-term chronic stress or disease at this approximate age, from which they subsequently recovered.

Considering patterns of tooth wear using the standards of Molnar (1971), the wear of the permanent M1 was scored as 3, the permanent M2 as 2. This different wear between maxillary M1 and M2 is relatively slight, representing slow pace of tooth wear in the 6-year interval from 6-12 years of age. Given our confidence that this skeleton belongs to a young adult of 18-22 years of age, we can infer that the process of tooth wear was particularly rapid in this population and that the diet may have included a relatively high proportion of fibrous food or food with grit inclusions.

Kuragala BK1

The long bone of BK1 that could be most accurately measured is the right femur, which has a maximum length of 439 ±3 mm and a relatively small femoral head diameter of 37.61 mm. The diaphysis has a moderate degree of anterior curvature and a moderately developed linea aspera. An estimate of stature from femur length is 161.6 cm using South Asian specific stature estimation equations (Pomeroy et al., 2018). An estimate of the body mass of BK1, using femoral head diameter and the mean of three regression equations (Ruff et al., 1997), provides a body mass of 45.5 kg.

Figure 11. Balandgoda Kuragala (BK1) maxillary dental wear (upper right molars 1-3)



Overall, the dentition of BK1 showed no signs of dental caries or deliberate cultural modification, and no evidence of enamel hypoplasias which would serve as a non-specific indicator of childhood stress. Figure 11 illustrates the extent of dental wear on the right maxillary molars. The right M^1 shows an advanced state of tooth wear with almost extensive secondary dentine, consistent with Molnar's category 6 (Molnar, 1971). The extent of tooth wear progressively decreases to the M^2 and M^3, which are scored at category 5 and 4, respectively. As the general pattern of tooth wear between molars represents approximately 6 years of wear that occurred between the timing of eruption and occlusion of each tooth, the observed pattern is consistent with a high rate of tooth wear resulting from a relatively coarse diet, as for FH8.

Discussion

A comparison of the body size estimates of the Fa Hien-lena FH8 and Kuragala BK1 skeletons with other hunter-gathers globally can provide preliminary insights into the general growth characteristics of the late Pleistocene and early Holocene foragers of the rainforest ecozone. Here we place these estimates within the context of comparative data representing global variation in skeletal morphology of hunter-gatherers (Stock, 2013), including small bodied and rainforest foragers from the Andaman Islands, the Philippines, and the Congo Basin, as well as a wide range of hunter-gatherers from other populations. A comparison of the relationship between stature and body mass estimates of Fa Hien-lena FH8 and Kuragala BK1 to other global foragers is presented in Figure 12. Fa Hien-Lena falls at the upper end of the range of size for small-bodied rainforest foragers, and within the range of temperate coastal foragers. The body mass of Kuragala BK1 is low, within the range typical of rainforest foragers, but the stature is higher, closer to statures typically found in temperate coastal and more arid regions. The general body dimensions of FH8 are within the range that might be predicted for a generalized small-bodied adaptation to a tropical rainforest environment. The somewhat unusual position of the BK1 skeleton from Kuragala is on account of the relatively low femoral head diameter and resultant body mass estimates. This unusual phenotype may relate to the transitional environment in the region of Kuragala Cave at the very edge of the intermediate/transitional rainforest and close to the more open forest and grassland environments to the East.

This paper reports on the analysis of late Pleistocene and early Holocene skeletons from the sites of Fa Hien-lena and Kuragala, from excavations in 2012 and 2013 respectively. The burial from Fa Hien-lena (FH8) was determined to be a young adult female. It was dated to between 10,640-10,139 cal BP. The skeleton from Kuragala was determined to be an adult male, which was dated to 7,170-6,950 cal BP. The excavations revealed a number of common elements of funerary treatment between these two burials, including the use of larger stones variably as a base to the grave in the case of BK1, or as inclusions placed over the body in the case of FH8. While the burials differed in the relative placement of the legs, both were interred on the left side with right hands placed near or over the face.

Both skeletons were highly fragmented, and the taphonomy differed. Neither skeleton showed any sign of fossilization, although the BK1 skeleton was moderately encrusted with calcium carbonate concretions, which permeated the periosteal margin of many bones. The FH8 skeleton was heavily fragmented in some regions posing challenges to the thorough analysis of this skeleton. The FH8 skeleton had two bands of linear enamel hypoplasia on much of the anterior dentition, which suggests at least two bouts of early childhood stress, and the individual died at a relatively young age of 18-22. Both skeletons show moderate to high degrees of tooth wear for their relative ages, and no evidence for dental disease.

Figure 12. Comparison of the relationship between stature and body mass estimates of Fa Hien-lena FH8 and Kuragala BK1 to other global foragers classified by ecology.

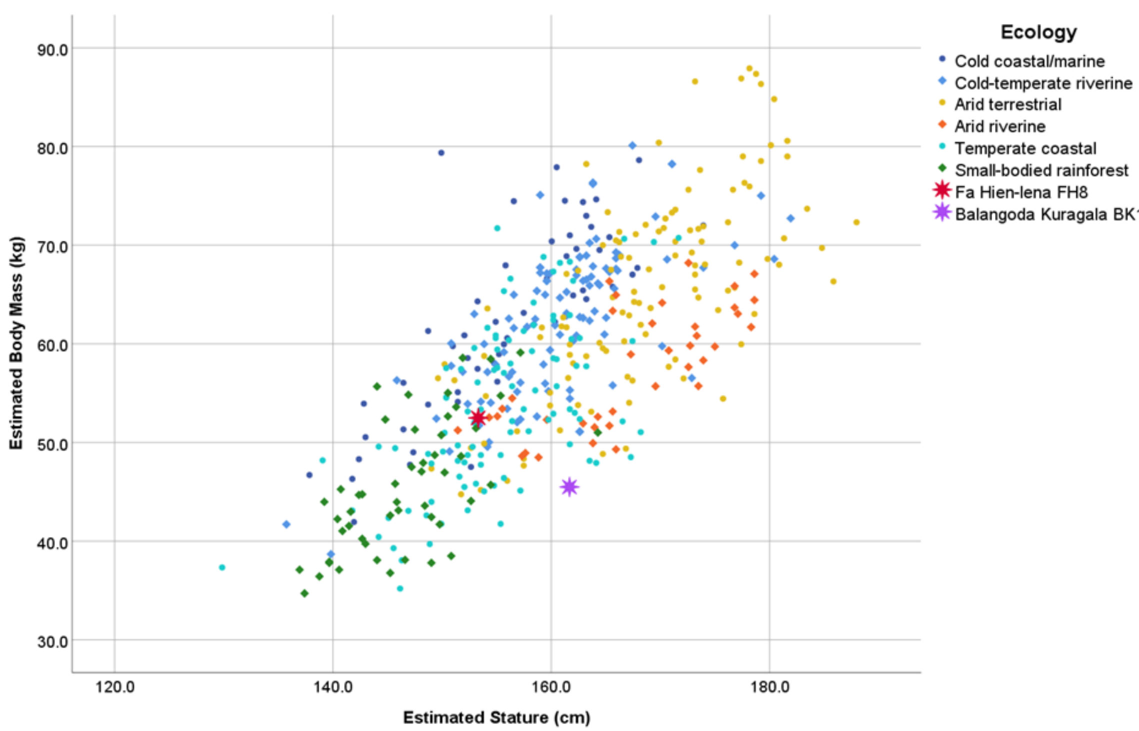


Table 4. Comparative data for other global foragers, from Stock 2013.

Ecological Context	**Population**	**Sample Size n (m, f, indet)**
Cold coastal marine	Sadlermiut	27 (13,9,5)
	Yaghan, Tierra del Fuego	25 (13,9,3)
Cold-temperate riverine	Archaic Great Lakes	14 (5,5,4)
	Kitoi, Siberia	55 (30,19,6)
	Serovo-Glazkovo, Siberia	33 (16,16,1)
Temperate coastal	Later Stone Age, South Africa	53 (25,28,0)
	Jomon, Japan	36 (17,12,7)
	Mesolithic, France	8 (5,3,0)
Small-bodied rainforest	Andaman Islanders	31 (16,15,0)
	Aeta, Philippines	15 (10,5,0)
	Efe, DRC	4 (2,2,0)
Arid terrestrial	Natufian, Levant	20 (8,6,6)
	Early-Mid Epipalaeolithic, Levant	6 (4,2,0)
	Later Stone Age, Kenya	10 (4,4,2)
	Later Stone Age, Tanzania	9 (8,1,0)
	Iberomarusian, Morocco, Algeria	38 (16,8,14)
	Masai pastoralists, Tanzania	9 (8,1,0)
Arid riverine	Jebel Sahaba, Sudan	7 (6,0,1)
	Aboriginal Australian	19 (3,3,13)
	Aboriginal Tasmanian	1 (1,0,0)
	Badarian Neolithic, Egypt	10 (3,3,4)

The body size estimates of FH8 and BK1 fall in the range that would be expected of tropical or temperate forest foragers, although BK1 has a relatively low body mass relative to stature, which aligns his phenotype with populations of more arid environments. The results presented here provide a description of the osteobiography and mortuary archaeology of two important burials which provide new light on the lifestyles of the late Pleistocene and early Holocene peoples of Sri Lanka.

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