1   **Late Pleistocene to Early-Holocene Rainforest Foraging in Sri Lanka: Multidisciplinary**
2   **analysis at Kitulgala Beli-lena**
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40 **Abstract**

41 Sri Lanka has produced the earliest clear evidence for *Homo sapiens* fossils in South Asia and

42 research in the region has provided important insights into modern human adaptations and

43 cultural practices during the last *ca*. 45,000 years. However, in-depth multidisciplinary

44 analyses of Late Pleistocene and Holocene sequences remain limited to just two sites, Fa

45 Hien-lena and Batadomba-lena. Here, we present our findings from the reinvestigation of a

46 third site, Kitulgala Beli-lena. New chronometric dating from the site confirms the presence

47 of humans as early as *ca*. 45,000 cal. BP. in the island's Wet Zone rainforest region. Our

48 analyses of macrobotanical, molluscan, and vertebrate remains from the rockshelter show that

49 this early human presence is associated with rainforest foraging. The Late Pleistocene

50 deposits yielded evidence of wild breadfruit and kekuna nut extraction while the Holocene

51 layers reveal a heavy reliance on semi-arboreal and arboreal small mammals as well as

52 freshwater snails as a protein source. The lithic and osseous artefacts demonstrate that

53 populations developed a sophisticated tool kit for the exploitation of their immediate

54 landscapes. We place the rich Kitulgala Beli-lena dataset in its wider Sri Lankan context of

55 Late Pleistocene foraging, as well as in wider discussions of our species' adaptation to

56 'extreme' environments as it moved throughout Asia.

57

58 Keywords:

59 Rainforest, Human adaptation, Modern human dispersal, South Asia, Pleistocene

60 Archaeology

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1. Introduction

South Asia has emerged as a crucial region for understanding the timing and nature of human dispersals from Africa and the Middle East into Southeast Asia and Australasia (Petraglia et al., 2012; Blinkhorn et al., 2013, 2019; Roberts et al., 2017a). In addition to it being located at a key geographical juncture, it also sits at a major biogeographic boundary between the Sahara-Arabian and Afrotropical regions to the west and Palearctic and Sino-Japanese regions to the north (Watts, 1984; Holt et al., 2013; Blinkhorn et al., 2013). Archaeological research in South Asia over the past two decades has pointed to potential multiple, early routes of dispersal into the region (Petraglia et al., 2010; Boivin et al., 2013; Bae et al., 2017; Blinkhorn and Petraglia 2017), and emphasized the varied and complex local patterns of technological and cultural change (Petraglia et al., 2010, 2012; Blinkhorn et al., 2013), as well as the diversity of the types of terrestrial environments, utilized by early humans (Blinkhorn et al., 2016; Roberts et al., 2015a, 2017b). This is in contrast to a prominent model that assumes a rapid, coastal *ca.* 60 ka dispersal of humans, associated with uniform technological features around the Indian Ocean Rim (Mellars, 2006; Mellars et al., 2013).

Research in Sri Lanka, an island at the southern tip of South Asia, has highlighted how early members of our species employed adaptive strategies to take full advantage of their environments such as tropical rainforests. Traditional anthropological and archaeological assumptions have viewed rainforests as barriers to human occupation due to a scarcity of resources, including calorie-rich plants and large animals (Bailey et al., 1989; Gamble, 1993). Nevertheless, Sri Lanka has produced the earliest clear evidence for *Homo sapiens* fossils in tropical rainforest environments in South Asia (Kennedy, et al., 1987; Kennedy and Deraniyagala, 1989; Deraniyagala, 1992; Kennedy, 2000) as well as evidence for heavy reliance on rainforest resources, including specialized hunting of arboreal and semi-arboreal

90   fauna from ~45,000 years ago through to 3,000 years ago (Roberts et al., 2015a,b, 2017b;

91   Wedage et al., 2019a) facilitated by microlithic and osseous technologies (Deraniyagala,

92   1992, Wijeyapala, 1997, Perera et al., 2011, Wedage et al., 2019a; Langley et al., 2020).

93   However, knowledge of the scale of Late Pleistocene tropical rainforest occupations in the

94   region remains limited since multidisciplinary analyses of archaeological sequences are

95   restricted to two sites: Fa Hien-lena, dated to *ca.* 45,000 years ago (Wedage et al., 2019a) and

96   Batadomba-lena, dated to *ca.* 38,000-36,000 years ago (Roberts et al., 2015b).

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98   Traditionally, a third site, Kitulgala Beli-lena, has been grouped with these other two

99   sequences as a source of early human fossils (Kennedy et al., 1987; Kennedy and

100   Deraniyagala, 1989; Wijeyapala, 1997) and microlith adaptations (Deraniyagala, 1992). Yet,

101   this site has been overlooked in recent debates given that existing radiocarbon dates place this

102   sequence considerably later (31,000 years ago – Kourampas et al., 2009). Moreover, a lack of

103   published zooarchaeological, archaeobotanical (though see Kajale, 1989), and detailed

104   technological analysis, as well as the fact that the site required re-dating using methods better

105   equipped to deal with contamination in tropical environments (see Higham et al., 2008), have

106   meant comparisons of Kitulgala Beli-lena to Fa Hien-lena and Batadomba-lena are somewhat

107   superficial. Here, we present the results of renewed excavation and multidisciplinary analyses

108   of materials recovered from Kitulgala Beli-lena. We provide a revised stratigraphy for the site

109   as well as new chronological information. Alongside detailed insights into prey choices, plant

110   use, and sedimentary formation processes at the site, lithic data from the site indicate that

111   Kitulgala Beli-lena was potentially part of a social network of technological procurement and

112   production. In addition, our research highlights possible differential spatial use of cave and

113   rockshelter sites in the Sri Lankan rainforest in the Late Pleistocene and Holocene. By placing

114   our data from Kitulgala Beli-lena in its wider Sri Lankan and Asian context we are able to

115   reveal a more complete picture of Late Pleistocene and Holocene human adaptation and

116   presence in this increasingly significant region for human evolutionary research.

117

118   ***Figure 1.*** *Map of Sri Lanka showing the location of Kitulgala Beli-lena and the island's*
119   *vegetation zones (Ashton et al., 1987, Erdelen, 1988) (A), the 2017 excavation of the*
120   *rockshelter (B) and the plan showing the location of the excavation squares of the site (C).*
121

122   **2. Kitulgata Beli-lena Rockshelter: History of Research**

123   Kitulgala Beli-lena is located in the Kegalle district of Sri Lanka's Sabaragamuwa Province,

124   approximately 85 km east of Colombo (Figure 1). With a *ca*. 30 x 15 m north facing entrance,

125   the rockshelter is formed from gneiss bedrock, part of the metamorphic terrain of Sri Lanka's

126   Highland Complex (Cooray, 1984). Kitulgala Beli-lena is situated in the island's lowland Wet

127 Zone with a mean annual precipitation between 2500-3500 mm/year (Dömros, 1974; Roberts

128 et al., 2015b), surrounded by humid tropical rainforest. The rockshelter was first explored by

129 P.E.P. Deraniyagala in 1960-1961, who excavated several test pits and noted an abundance of

130 historic and prehistoric archaeological materials. However, no detailed description of this first

131 investigation was ever published. Systematic excavation of the rockshelter continued in 1978

132 by the Department of Archaeology of the Government of Sri Lanka under the supervision of

133 S.U. Deraniyagala. Excavations continued in 1979, 1983, 1985 and in 1986 (under W. H.

134 Wijeyapala). The Department of Archaeology, this time led by Oshan Wedage, carried out a

135 small excavation of 1 m^2 in the southeast corner of the rockshelter in 2013. Collectively, these

136 excavations sampled depths of more than 3 m of cultural deposits and produced a total of 25

137 radiocarbon dates (Table 1), indicating a chronology extending back to *ca*. 31,000 cal. years

138 BP. Two thermoluminescence dates (17,217 $\pm$ 3300 and 18,565 $\pm$ 2610) have also been

139 reported (Abeyratne, 1994).

140

141 Excavations of Terminal Pleistocene sediments of the site, with associated charcoal dated to

142 12,260 $\pm$ 870 years BP, had previously yielded several human remains including a partial

143 skeleton of an adult of indeterminate sex, a skull of a child 10-11 years of age at the time of

144 death, and bones and teeth from at least ten different individuals (Kennedy et al., 1987;

145 Kennedy and Deraniyagala, 1989; Wijeyapala, 1997). Sparse microlithic tools, manufactured

146 from quartz, were also recorded from the beginning of site occupation (Wijeyapala, 1997).

147 However, these technologies, as well as osseous tools, were not systematically analysed. In

148 2017, a new excavation in Kitulgala Beli-lena was conducted by the Max Planck Institute for

149 the Science of Human History and University of Sri Jayewardenepura in collaboration with

150 the Department of Archaeology, Government of Sri Lanka. The aim of the excavation was to

151 recover new materials to produce a refined chronology for the site, using appropriate pre-

152   treatment methodologies for charcoal samples as well to conduct systematic

153   zooarchaeological, archaeomalacological and archaeobotanical analyses. Three 1 x 1 m

154   squares were opened in the inner western section of the rockshelter, close to the wall,

155   following the grid laid out during the 1980s excavation (Figure 1). The excavation reached a

156   final depth of 192 cm from the surface rockshelter deposits.

157   **Table 1.** *Previous radiocarbon dates for Kitulgala Beli-lena (from Deraniyagala, 1992,*
158   *Wijeyapala, 1997, Perera, 2010).*
159

Stratum	Lab Code	$^{14}C^{\dagger}$	cal. BP*
VIIa2	Beta 18448	3640 ± 60	4,150 - 3,829
VIIa1	PRL 1012	3170 ± 120	3,691 - 3,661
VIb1	Beta 18446	8160 ± 80	9,407 - 8,976
VIa1	Beta 18445	7040 ± 80	8,000 - 7,698
Va3	BS 287	10,200 ± 170	12,517 - 12,493
Va3	BS 288	10,280 ± 170	12,571 - 11,394
Va3	BS 289	10,010 ± 160	12,156 - 11,146
Va3	PRL 861	11,910 + 430/-410	15,298 - 12,981
Va3	BS 290	11,550 ± 180	13,751 - 13,076
Va3	Fra-91	11,780 ± 220	14,155 - 13,151
Va3	BS-292	11,570 ± 210	13,933 - 13,901
Va2	BS-292	11,520 ± 220	13,825 - 12,901
Va1	BS-293	12,240 ± 160	14,933 - 13,758
IVb3	Beta 33287	11,860 ± 70	13,816 - 13,481
IVb2	BS-294	11,750 ± 390	14,948 - 12,831
IVb2	Beta 33286	13,150 ± 80	16,071 - 15,477
IIIc3	Beta 33285	13,150 ± 90	16,084 - 15,435
IIIc2	Fra-163	15,780 ± 400	20,086 - 18,236
IIIc2	Fra 164	16,400 ± 650	21,605 - 18,458
IIIc2	Beta 18443	18,050 ± 180	22,352 - 21,414
IIIc1	Beta 18442	17,810 ± 170	22,001 - 21,036
IIIb1	PRL 1013	17,870 +510/-530	22,862 - 20,411
IIIb1	Beta 18441	18,900 ± 350	23,666 - 22,024
IIIa3	Beta 33283	20,560 ± 130	25,190 - 24,370
IIIa2	Beta 18439	older than 26,425	-

160
161   †Radiocarbon dates were from charcoal samples *All samples were calibrated using the OxCal 4.3
162   software (Bronk Ramsey 2017) and IntCal calibration curve (Reimer et al., 2013)
163
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3. Methods

3.1 Excavation

The 2017 excavation of Kitulgala Beli-lena aimed to recover new archaeological material in order to refine/revise the chronology of the site and better understand human culture, technology, and subsistence strategies. The excavation was situated in the inner western section of the rockshelter, some 5 m from the wall. Following the excavations in the rockshelter in 1985, the exposed sections were covered by stone walls to preserve the integrity of the site. The only portion that was not protected was a 2 m^2 excavation square (grid code: G12-G11) which was sampled for micromorphology in 2005 and 2009 (Perera, 2010, Kourampas et al., 2009). The new excavation extended this unprotected square southward, opening excavation square G12 and the previously unexcavated squares H14 and I14 (Figure 1) and allowing for the correlation of the results with the micromorphological analyses of Kourampas et. al (2009).

Excavations were conducted using hand tools dividing artefacts and sediment samples into discrete sediment units, or subdividing discrete sediment units into 5cm arbitrary horizons, where single contexts were deeper than 5cm. Three dimensional recording of the excavated area, the interface between sediment deposits and major artefacts (>20 mm) was undertaken using a Leica Builder 505 total station. After removal, excavated sediments were placed on polythene sheeting and a 10-20 liter sub-sample was taken for flotation. A total of 1120 liters of sediment were floated (using a 250 micron mesh) during the excavation. The remainder of the excavated sediments was wet sieved to allow for the recovery of cultural materials. In addition, samples of approximately 100 g were recovered at 5 cm intervals to enable a range of sediment analyses (including ongoing analyses i.e. laser particle size analyses, phosphate analyses etc.).

190

191   ***3.2 Radiocarbon dating***

192   Fourteen charcoal fragments recovered during excavation were submitted for dating to the

193   Oxford Radiocarbon Accelerator Unit. The charcoal samples were prepared using the acid–

194   base oxidation/stepped combustion (ABOx-SC) protocol (Bird et al., 1999; Higham et al.,

195   2008). Of these, 13 samples yielded ^{14}C measurements that were calibrated using the IntCal13

196   calibration curve and the OxCal 4.3 programme (Reimer et al., 2013; Bronk Ramsey 2017).

197

198   ***3.3 Zooarchaeological analysis and osseous technology analysis***

199   All recovered bone fragments from the 2017 excavation of Kitulgala Beli-lena were analysed,

200   including fragmentary remains as well as diaphyses and rib shafts. All specimens were sorted,

201   counted, and measured (length, width, and thickness) using a digital caliper (Mitutoyo 500–

202   463). Identified specimens were recorded in detail using codes for anatomic zones following a

203   zonation system modified from Dobney and Reilly (1988) to allow for the description of

204   fragmentation patterns. Diagnostic skeletal elements were identified using comparative

205   vertebrate specimens from the Field Museum of Natural History and American Museum of

206   Natural History and from the Laboratory of Comparative Anatomy of the Muséum national

207   d'Histoire naturelle (MNHN). Naming of identified taxa follows the nomenclature published

208   by Wilson and Reeder (2005). The identified taxa were classified to size class based on live

209   weight following a modification of the criteria established by Thomas (1969) and Grayson

210   (1984): (a) micromammals: 100 g to1 kg, (b) small mammals: 1 kg to 25 kg, (c) large

211   mammals class 1: 25 kg to 200 kg, (d) large mammals class 2: 200 kg to 1000 kg, and (e)

212   large mammals class 3: > 1000 kg.

213

214 All fragments were examined for natural, animal, and anthropic modifications, including

215 weathering (Behrensmeyer, 1978; Andrews, 1995), abrasion (Shipman and Rose, 1988),

216 burning, staining, and butchery marks (Fernandez-Jalvo and Andrews, 2016). Bone surface

217 modifications, including traces of bone tool manufacture, were recorded/observed using an

218 Olympus BX53 light microscope. Bone artefacts were further examined under a Keyence

219 VHX-6000 digital microscope to record traces of use. Bone surface modifications resulting

220 from tool production and use were identified following published criteria (i.e. Shipman and

221 Rose, 1988; Blasco et al., 2008; Bradfield and Brand, 2015; Langley et al., 2016).

222

223 In terms of zooarchaeological quantifications, the minimum number of element (MNE) and

224 minimum number of individual (MNI) counts were calculated following a modification of

225 Dobney and Rielly's (1998) zonation system. This system is based on the recording of distinct

226 morphological zones in a skeletal element. The MNE was taken as the total number of non-

227 overlapping zones (i.e., greater than 50% of the diagnostic zone present) for every skeletal

228 element of a taxon. The highest MNE value, considering side and age (epiphyseal fusion and

229 dental wear, following Klein and Cruz-Uribe (1984), was used to estimate the MNI. The

230 MNE counts were converted to minimum animal unit (MAU) values by taking into account

231 the number of times the element occurs in the skeleton. The normalized MAU values (%

232 MAU) were used to compare skeletal part representation in the different phases of cave

233 occupation (Lyman, 1994).

234

235 *3.4 Molluscan Analysis*

236 The invertebrate assemblage of Kitulgala Beli-lena consists of all remains collected during the

237 2017 excavation of the site, including fragmentary specimens recovered from dry and wet

238 sieving of sediments. Prior to analysis, all samples were washed to remove excess sediment

239   and air-dried for 24-48 hours. As a physical comparative reference collection was not

240   available for specimen identification, all taxonomic attributions were made following the

241   descriptions and/or illustrations provided in Hausdorf and Perera (2000), Naggs and Raheem

242   (2000), Raheem and Naggs (2006) and Starmuhlner (1974). Recent correspondence with Dr

243   Dinarzarde Raheem (Natural History Museum, London) indicates that significant taxonomic

244   revision of the Sri Lankan terrestrial and freshwater mollusc fauna is needed.

245

246   Although the resources currently available are useful for identifying genera and are likely to

247   be of limited value for species level-identification, specimens were attributed to taxonomic

248   categories (e.g. to species, genus, or family) based on the preservation of identifiable

249   diagnostic features. Taphonomic indicators, such as dissolution, burning, and predatory

250   boring, were also noted. While the assemblage was recorded in such a way so as to enable the

251   calculation of the MNI, due to the small sample size the quantification measures reported here

252   are restricted to NISP and weight (in grams).

253

254   *3.5 Archaeobotanical analysis*

255   The archaeobotanical assemblage analysed in this study comprises materials from flotation

256   samples from five sedimentary contexts spanning the Pleistocene sequence of Kitulgala Beli-

257   lena, namely contexts 10, 17, 21, 24, 23. The flotation samples were sieved into >4mm, 2-

258   4mm, 1-2mm, and <1mm fractions. The >4mm and 2-4mm fractions were sorted under low

259   magnification (x8–x40) using an Olympus SZ61 stereozoom microscope and the 1-2mm

260   fraction was scanned for any smaller remains. Analysis of this material is ongoing and subject

261   to the establishment of a comparative ethnobotanical reference collection for Sri Lanka.

262   Where possible, taxonomic identifications were based on published descriptions (e.g., Kahn

263 and Ragone 2013; Kajale 1988; Levin 2015) and available comparative botanical material in

264 the University of Queensland's Archaeobotany Laboratory.

265

266 *3.6 Lithic analysis*

267 The technological analysis of the lithic assemblages was performed using the *chaîne*

268 *opératoire* concept, a methodological framework that defines the reconstruction of the various

269 processes of flake production from the procurement of raw materials through to discard

270 (Lemonnier, 1986; Pelegrin et al., 1988). The assemblages were firstly discriminated by raw

271 material units, defined according to variety of stone and macroscopic features including type

272 of cortex, colour, grain size, and texture (Roebroeks, 1988). The technological features were

273 then reconstructed through the diacritic analysis of the scar pattern organization on the cores'

274 flaking surfaces and on the flakes' dorsal side. Previous studies on the lithic collections in Sri

275 Lanka report the extensive use of the bipolar method (Lewis, 2017; Wedage et al., 2019a;

276 2019b). In order to address the variability of this lithic reduction strategy, the analysis was

277 performed following more recent definitions based on experimental knapping data (Crabtree,

278 1972; de la Peña, 2015; Donnart et al., 2009; Mourre, 1996). The flake assemblages were

279 classified by dimensional criteria and only the lithic items greater than 1 cm were analysed.

280 Bladelets are considered elongated blanks in which the ratio length to width is ≥ 2, and with a

281 percussion axis length of less than 4 cm (Petraglia et al., 2009). A distinction has not been

282 made between bladelets produced from true bladelet cores and flake-bladelets. Siret knapping

283 accidents were distinguished following the criteria of Mourre (1996) whereas *bâtonnet* flakes

284 (or bipolar spalls) and splinter flakes were defined following Brun-Ricalens (2006).

285

286 **4. Results**

287 *4.1 A Revised Chronostratigraphy for Kitulgala Beli-lena*

288   The fill of Kitulgala Beli-lena consists of *ca*. 192 cm of stratified detrital sediments deposited

289   on a heavily weathered and phantomed gneiss bedrock over the last *ca*. 44,000 years. Thirteen

290   new radiocarbon dates (Table 2) anchor the stratigraphy and resolve it into four phases, each

291   corresponding to a major period of human occupation of the rockshelter (Figure 2). The

292   sedimentary layers excavated in 2017 correspond to those recorded during the previous

293   excavation of squares H6 and I6 as well as the micromorphological sequence reported by

294   Kourampas et al. (2009) (Table 3).
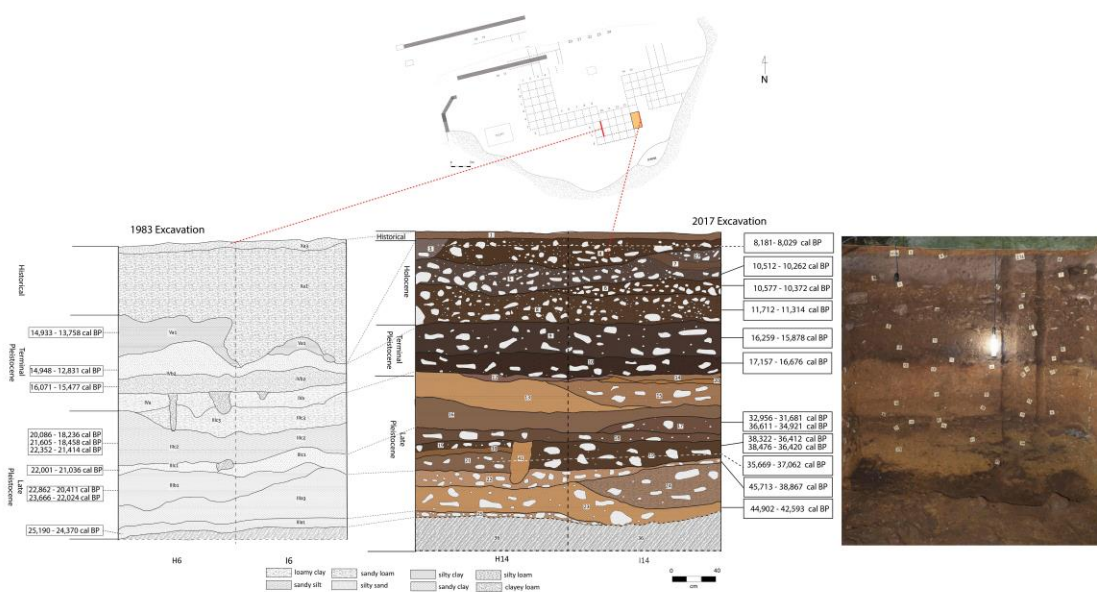
295   **Figure 2.** *Comparison of the 1983 (Wijeyapala, 1997) and 2017 stratigraphy for Kitulgala*
296   *Beli-lena.*
297
298   **Table 2.** *New radiocarbon dates on (charcoal) from the 2017 excavation of Kitulgala Beli-*
299   *lena*

Context	Labcode (OxA)	Measured Date	Calibrated (cal. BP)*
3	37930	7,309 $\pm$ 34	8,181- 8,029
5	37932	9,230 $\pm$ 40	10,512 - 10,262
6	37933	9,280 $\pm$ 37	10,577 - 10,372
8	37934	10,015 $\pm$ 39	11,712 - 11,314
9	37935	13,360 $\pm$ 50	16,259 - 15,878
10	37936	13,960 $\pm$ 50	17,157 - 16,676
17	37808	28,420 $\pm$ 180	32,956 - 31,681
17	37789	31,880 $\pm$ 390	36,611 - 34,921
19	37809	33,120 $\pm$ 330	38,322 - 36,412
19	37810	33,230 $\pm$ 390	38,476 - 36,420
21	37724	32,410 $\pm$ 260	35,669 - 37,062
22	X-2782-17	37,500 $\pm$ 1700	45,713 - 38,867
23	37483	39,900 $\pm$ 700	44,902 - 42,593

300 *All samples were calibrated using the OxCal 4.3 software (Bronk Ramsey 2017) and IntCal
301 calibration curve (Reimer et al., 2013).

302

303 **Table 3.** *Major phases of Kitulgala Beli-lena occupation based on radiocarbon dates and site*
304 *stratigraphy.*

Occupational Phase	Sedimentary Stratum (1983)	Dates (cal. BP)*	Sedimentary Context (2017)	Dates (cal. BP) *
Historical	Xa3	-	1	-
Holocene	-	-	3 5 6 8 7, 27	8,181- 8,029 10,512-10,262 10,577- 0,372 11,712-11,314 -
Terminal Pleistocene	V	-	9	16,259 -15,878
	IVb3	13,816-13,481;		
	IVb2	14,948-12,831	10	17,157 -16,676
	IVb2	16,071-15,477		
	IVa	-		
Late Pleistocene	IIIc3	16,084-15,435;	12, 13, 14, 15, 20	-
	IIIc2	20,086-18,236; 21,605-18,458; 22,352-21,414	-	-
	IIIc1	22,001-21,036	17	32,956 - 31,681;
				36,611 - 34,921
			19	38,322 - 36,412;
				38,476 - 36,420
			21	37,062- 35,669
			18, 39, 41	-
	IIIa3	25,190 - 24,370	22	45,713 - 38,867
			23	44,902 - 42,593
			24	-
	IIIa2	older than 26,425†	25	-

305 *All samples were calibrated using the OxCal 4.3 software (Bronk Ramsey 2017) and IntCal
306 calibration curve (Reimer et al., 2013)
307 †uncalibrated

308 *Late Pleistocene Phase*

309 The Late Pleistocene phase of the rockshelter represents intermittent/episodic human

310 occupation, from around *ca*. 44,000 to 31,000 cal. BP. It is characterized by pebbly clayey

311 loams with angular gneiss slabs and subhorizontal layers of yellowish brown, sandy clay to

312 sandy silt deposits. Just above the gneiss bedrock is a *ca*. 10 cm clast-supported conglomerate

313 with well-rounded imbricated pebbles that is hypothesized (Wijeyapala, 1997; Kourampas,

314 2009) to have been deposited by a stream that at the present flows 60 m below the level of the

315 rockshelter's entrance. This layer, notably devoid of any cultural materials, is overlain by a

316 series of sandy loam and sandy clay deposits containing angular gneiss slabs and abundant

317 charcoal.

318

319 Kourampas et al. (2009) suggest that these layers most likely represent an admixture of roof

320 fall and colluvial deposits reworked by bioturbation and rockshelter floor processes including

321 trampling and surface runoff. The first in the series, Context 23, returned dates as early as

322 42,593-44,902 cal. BP. These sedimentary layers, referred to as phases IIIa(2)-IIIc(3) by

323 Wijeyapala (1997), were previously dated to 25,190 - 18,236 cal. BP. New dates now place

324 these layers as being deposited between ca 44,902-31,600 cal. BP (Figure 2). Evidence of

325 human activities in the Late Pleistocene phase includes artefacts (ochre fragments and stone

326 tools) and macrobotanical remains. No faunal remains were recovered in the Late Pleistocene

327 layers during the 2017 excavations.

328

329 *Terminal Pleistocene Phase*

330 The Terminal Pleistocene phase of site occupation is characterized by dark greyish brown

331 sandy loam and silty clay deposits notable for a heavy concentration of quartz microliths and

332 macrobotanical remains (e.g. contexts 9-10). This *ca*. 30 cm phase of occupation correlates to

333 sedimentary layers IV and V from the 1983 excavation which were dated to 13,600-12,100

334   cal. BP (Wijeyapala, 1997) and contain the densest occupation debris in terms of charcoal and

335   lithic materials. Discrete patches of burnt sediments and ashes point to possible hearths within

336   the layers. Angular gneiss slabs most likely from roof fall or wall disintegration are also

337   abundant in these layers. Charcoal from these layers recovered from the 2017 excavation

338   returned dates between 17,157-11,314 cal. BP. Kourampas (2009), in his micromorphological

339   analyses of the stratigraphy from the 1986 excavation, interpreted these layers as resulting

340   from accelerated sedimentation brought about by human activity, high rates of colluvation,

341   and accelerated water seepage.

342

343   Previous reports (Deraniyagala, 1992; Wijeyapala 1997) noted that faunal remains (both

344   vertebrate and invertebrate) were recovered from the Terminal Pleistocene layers of Kitulgala.

345   However, not a single piece of faunal material was recovered from the 2017 excavation.

346   Kourampas et al. (2009) also reported an absence of microscopic bone fragments in the

347   micromorphological sections from these layers. It is unlikely that the absence of animal bones

348   and molluscan remains from the Late Pleistocene and Terminal Pleistocene phases of our

349   excavation unit at the site resulted from natural taphonomic processes as abundant

350   macrobotanical remains and unweathered quartz flakes were recovered in the same layers.

351

352   *Holocene Phase*

353   The Holocene Phase of Kitulgala consists of at least six distinct sedimentary layers with

354   abundant charcoal, quartz microlith, and ochre content. These layers, previously dated to

355   9,070-3,550 cal. BP (layer VI to VII), have been re-dated to 10,577-8,029 cal. BP. Unlike the

356   underlying sedimentary layers, the Holocene layers yielded numerous faunal materials. *In situ*

357   hearths with burnt seeds and animal bone fragments were also recorded. The lowermost layer,

358   a compact mid-yellowish brown sandy loam, contains frequent mid-sized (up to 15 cm)

359   angular gneiss slabs suggestive of a roof-fall episode that happened sometime during the

360   onset of the Holocene. Overlying this is a series of almost horizontal loamy clay and silty

361   sand layers rich in debris from human activity.

362

363   *Historical Phase*

364   A *ca*. 10 cm silty sand deposit represents the Historical Phase of occupation of Kitulgala Beli-

365   lena. Much thicker near the entrance (i.e. *ca*. 50 cm in the previous excavation of H10/I10),

366   this layer has been interpreted as reworked sediment and residue resulting from the extraction

367   of guano-rich deposits used as fertilizer in nearby rubber plantations during colonial times

368   (Wijeyapala, 1997). It is chronologically mixed, containing potsherds and abundant mollusc

369   fragments as well as animal bones and quartz flakes most likely reworked from earlier phases

370   of site occupation. The guano extraction digging had cut through Early Holocene deposits in

371   some parts of the site (Wijeyapala, 1997). Kourampas et al. (2009) noted that the historical

372   deposit did not penetrate below Mid-Holocene levels in the profile they studied. The new

373   dates, however, suggest that much of the Mid-Holocene deposits of Kitulgala Beli-lena were

374   removed during the historical phase.

375

376   *4.2 Vertebrate Fauna*

377   A total of 5502 animal bone fragments were recovered from the 2017 excavation of Kitulgala

378   Beli-lena. As noted above, all of the vertebrate remains were recorded from sedimentary

379   contexts dated to the Early Holocene. Small mammals (< 25kg) dominate the faunal

380   assemblage, accounting for 70.5% (Total number of fragments, TNF= 3859, Number of

381   identified specimens, NISP=2156) of the remains recorded, suggesting deliberate targeting of

382   these animals by the people that settled in Kitulgala (Table 4, Figure 3). Large mammals

383   account for 3.9% of the recovered animal bones and micromammals (mostly murids and bats)

account for 10.7%. Reptiles (11.1% NISP), fish (4.8% NISP) and birds (2.1% NISP) were

also identified in the assemblage.

Table 4. *Vertebrate remains recovered from the 2017 excavation of Kitulgala Beli-lena.*

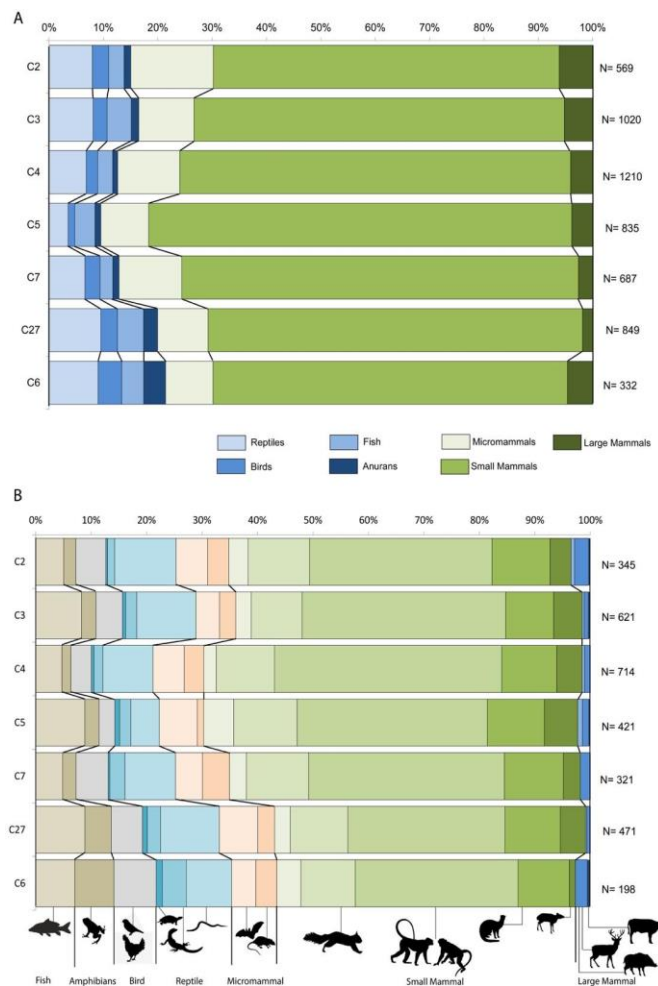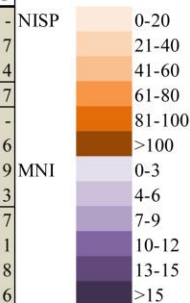| Context	Unidentifiable Bone Fragments					NISP	% NISP	TNF
	Micromammal	Small Mammal	Large Mammal	Non-Mammals	Total			
2	54	124	24	22	224	345	60.6%	569
3	61	244	45	49	399	621	60.9%	1020
4	68	327	38	63	496	714	59.0%	1210
5	41	341	27	5	414	421	50.4%	835
6	10	92	10	22	134	198	59.6%	332
7	45	287	14	20	366	321	46.7%	687
27	32	288	12	46	378	471	55.5%	849
Total	311	1703	170	227	2411	3091	56.2%	5502

Figure 3. *Distribution of animal taxa identified in different Holocene sedimentary contexts of Kitulgala Beli-lena based on (A) the total number of bone fragments recovered (TNF) and (B) number of identified specimens (NISP).*

424 ***Table 5.*** *Number of identified specimens and minimum number of individuals of the different vertebrate taxa identified in Kitulgala Beli-lena.*

Class	Order	Family	Taxon	2 NISP	2 MNI	3 NISP	3 MNI	4 NISP	4 MNI	5 NISP	5 MNI	6 NISP	6 MNI	7 NISP	7 MNI	27 NISP	27 MNI	TOTAL NISP	TOTAL MNI
Actinopterygii				8	-	28	-	21	-	27	-	7	-	10	-	26	-	127 (4.1%)	-
	Cypriniformes	Cyprinidae		2	1	3	1	4	1	2	1	1	1	1	1	5	1	18 (0.6%)	7
	Siluriformes	Siluridae		1	1	1	1	-	-	1	1	-	-	-	-	1	1	4 (0.1%)	4
Amphibia	Anura			2	1	7	2	11	4	9	3	8	3	4	1	10	3	51 (1.6%)	17
Aves				5	-	5	-	4	-	4	-	2	-	5	-	5	-	30 (1.0%)	-
	Apodiformes	Apodidae		1	1	3	1	-	-	1	1	3	1	2	1	1	1	11 (0.4%)	6
	Galliformes	Phasianidae	*Gallus* sp.	3	1	4	2	2	1	1	1	2	1	4	2	4	1	20 (0.6%)	9
	Strigiformes	Strigidae		1	1	-	-	-	-	1	1	-	-	-	-	1	1	3 (0.1%)	3
Reptilia	Testudines	Bataguridae		1	1	3	1	3	1	3	1	2	1	1	1	4	1	17 (0.5%)	7
	Squamata	Varanidae	*Varanus* sp.	2	1	8	2	4	1	3	2	2	1	5	2	6	2	30 (1.0%)	11
		Agamidae		1	1	2	1	5	2	4	1	4	1	3	1	4	1	23 (0.7%)	8
		Geckonidae/Scinicidae		1	1	1	1	2	1	-	-	2	1	1	1	1	1	8 (0.3%)	6
		Pythonidae	*Python*	21	1	37	2	32	1	10	1	8	1	16	1	28	1	152 (4.9%)	8
		Colubridae/Viperidae		14	1	21	1	29	2	8	1	7	1	14	1	21	2	114 (3.7%)	9
Mammalia	Primates	Cercopithecidae		92	7	173	12	254	18	105	11	46	5	104	9	118	10	892 (28.9%)	72
			Macaca sinica	7	1	18	3	14	2	10	1	6	1	9	1	10	2	74 (2.4%)	11
			Semnopithecus/Trachypithecus	5	1	8	2	9	1	5	1	2	1	3	1	3	1	35 (1.1%)	8
	Rodentia	Hystricidae		10	2	13	2	12	2	18	3	8	1	10	2	11	3	82 (2.7%)	15
		Sciuridae	*Ratufa* cf. *macroura*	76	8	157	15	127	10	109	12	39	4	41	5	88	6	637 (20.6%)	60
			Petinomys/Petaurista	2	1	3	2	4	2	4	2	1	1	2	1	1	1	17 (0.5%)	10
		Muridae		12	2	16	3	24	5	4	2	7	2	16	3	14	4	93 (3.0%)	21
	Lagomorpha	Leporidae	*Lepus*	1	1	-	-	-	-	1	1	-	-	-	-	2	1	4 (0.1%)	3
	Chiroptera			18	3	22	4	42	5	24	3	8	2	15	3	32	5	161 (5.2%)	25
		Hipposideridae		1	1	-	-	-	-	-	-	-	-	1	1	-	-	2 (0.1%)	2
		Rhinolophidae		-	-	1	1	1	1	-	-	-	-	-	-	-	-	2 (0.1%)	2
	Carnivora	Viverridae	*Paradoxurus sp.*	34	4	45	4	64	5	35	4	22	2	37	2	49	4	286 (9.3%)	25
		Mustelidae	*Lutra*	1	1	4	1	3	1	3	1	-	-	1	1	1	1	13 (0.4%)	6
	Artiodactyla	Tragulidae	*Moschiola sp*	12	4	30	4	33	4	21	2	6	2	10	2	21	3	133 (4.3%)	21
		Suidae	*Sus scrofa*	2	1	2	1	3	1	3	1	-	-	-	-	1	1	11 (0.4%)	5
		Cervidae	*Rusa/Axis*	8	2	4	1	7	2	4	1	4	1	6	1	3	1	36 (1.2%)	9
		Bovidae		1	1	2	1	-	-	1	1	1	1	-	-	-	-	5 (0.2%)	4
Total				345	52	621	71	714	73	421	60	198	35	321	44	471	59	3091	394

NISP
0-20
21-40
41-60
61-80
81-100
>100

MNI
0-3
4-6
7-9
10-12
13-15
>15

425
426

427   From the 5502 vertebrate remains recovered from the site, 3091 (56.2%) can be confidently

428   assigned to family, genus, or species (Table 5). Cercopithecid monkeys dominate the Early

429   Holocene assemblage of the site, with a total of 1001 remains from at least 91 individuals

430   recorded. Both cercopithecines (macaque) and colobines (langurs) were identified in the

431   assemblage based on teeth and certain post-cranial elements. However, the high degree of

432   fragmentation prohibits confident identification of these elements to species. Only 74 (7.4 %,

433   MNI= 11) specimens can be confidently identified as representing *Macaca sinica* and 35

434   (3.5%, MNI=8) were identified as coming from langurs (*Semnopithecus/Trachypithecus*). All

435   skeletal elements were represented in the assemblage suggesting that complete monkey

436   carcasses were brought in and processed on the site.

437

438   Distal articular ends of long bones and metapodials and other dense skeletal elements (carpals

439   and tarsals) as well as teeth are slightly over-represented in the assemblage. In terms of

440   anthropogenic signature, 35.8% of the identified cercopithecid specimens exhibited evidence

441   of burning. Cutmark frequency is relatively low, with only two specimens (a distal humerus

442   and proximal femur fragment) exhibiting evidence of butchery. Age-at-death profile of

443   cercopithecid monkeys in the assemblage based on dental wear suggests deliberate targeting

444   of sub-adults and adults. Most of the aged individuals fall within the age category J7 to A3

445   outlined by Ingicco et al., (2012) for the genus *Trachypithecus*. These individuals are of full

446   sexual maturity, with completely erupted third molar (aged between 3 and 5 years old,

447   Harvati, 2000; Bolter, 2011).

448

449   Sciurids represent the second most common taxa in the Holocene faunal assemblage of

450   Kitulgala with a total of 654 dental and skeletal elements identified. 97.4% of the elements

451   correspond in terms of size and morphology, particularly for dental elements, to comparative

452   specimens of the grizzled giant squirrel (*Ratufa macroura*) while the rest (NISP= 17)

453   represent flying squirrels (*Petinomys/Petaurista*). Burning and calcination were observed in

454   12.3% and 5.4% of the identified sciurid specimens, respectively. Other small mammals

455   identified in the assemblage include civet cats (9.3% NISP, MNI=25), otters (0.4% NISP,

456   MNI=6), chevrotains (4.3% NISP, MNI=21) and porcupines (2.7% NISP, MNI=15). Similar

457   to cercopithecids, these animals are represented mostly by dental and dense postcranial

458   elements.

459

460   A total of 222 specimens representing large mammals were recorded in the assemblage. From

461   these, 23.4% can be assigned confidently to taxa. These include 11 (0.4% NISP, MNI=5) suid

462   specimens, 36 (1.2% NISP, MNI=9) cervid and 5 (0.2% NISP, MNI=4) bovid fragments.

463   Anthropic modifications were mostly restricted to burning (12.6%). Butchery marks were not

464   observed in any large mammal bone fragments, albeit a proximal cervid metatarsal exhibited

465   evidence of impact fractures and two bovid and one cervid metapodial fragments showed

466   evidence of modifications consistent with tool/artefact production.

467

468   Non-mammalian fauna represents 15.2% (19.7% NISP) of the animal remains from the site.

469   Fish (NISP=149) are represented mostly by cyprinids (carps), identified from pharyngeal

470   teeth and certain cranial elements. Silurid (catfish) specimens (spine) were also identified,

471   albeit in very low frequency (NISP=4). Reptiles (11.1% NISP) on the other hand are

472   represented by varanids, pond/river turtles, agamid/iguanid lizards, pythons and colubrid

473   snakes (Table 5). The fish bones recorded in the site exhibited a high degree of burning

474   (40.9%). Likewise, several reptile bone fragments, particularly varanids and *Python,*

475   exhibited evidence of burning and calcination (11%), suggesting that they were probably also

476   utilized as a food source. Although bird skeletal elements are present in all sedimentary

477   contexts dated to the Holocene (2.1% NISP), only 20 (23.8%) fragments can be confidently

478   identified to taxa. These include owls (Strigidae), swifts (Apodidae) and jungle fowls

479   (Phasianidae).

480

481   Several animal taxa in the assemblage, such as frogs (1.6% NISP) and micromammals (<1kg)

482   including murids (3% NISP) were most likely accumulated by non-human cave dwelling

483   species (i.e. raptors). This is in addition to the colubrid snakes and small agamid lizards

484   mentioned earlier. Swifts and bats (5.6%), on the other hand, most likely represent the

485   rockshelter's natural faunal communities.

486

487   *4.3 Osseous Technology*

488   A total of 21 (0.38% of the bone assemblage studied) finished tools manufactured from small

489   mammal long bones were identified in the site, including 10 finished unipoints, seven

490   bipoints, and four geometrics (Figure 4). Morphological features retained in some of the

491   unipoints in the assemblage suggest that they were manufactured from cercopithecid fibulae

492   (Figure 4A) and ulnae (Figure 4B). The bipoints and the geometrics (Figure 4C-G), on the

493   other hand, were most likely manufactured from cercopithecid humerus or femur shaft

494   fragments. However, further studies are needed to confirm this. At Fa Hien-lena, the bipoints

495   and geometric bone tools from the Terminal Pleistocene and Early to Mid-Holocene layers

496   were manufactured from cercopithecid femur shaft fragments, based on the presence of

497   blanks and unfinished tools (Wedage et al., 2019; Langley et al., 2020).

498

499   In terms of typology, the osseous tools recorded in Kitulgala Beli-lena are identical to those

500   identified at Fa Hien-lena (Wedage et al., 2019a; Langley et al., 2020) and Batadomba-lena

501   (Perera et al., 2011). The unipoints exhibit side notches suggesting that they were hafted to a

502 shaft by ligature. These hafted bone points, again like those found in Fa Hien, most likely

503 represent projectile points that were used by hunter-gatherers to selectively target certain

504 arboreal animals (Wedage et al., 2019a; Langley et al., 2020). This is also consistent with the

505 high-impact fracture observed in some of these specimens. However, unlike in Fa Hien-lena

506 where 1.7% (N=246) of the faunal remains studied exhibited modifications consistent with

507 tool manufacture (grinding/polishing) (Wedage et al., 2019a), only finished tools were

508 identified in Kitulgala Beli-lena. This suggests that the tools were not manufactured in the

509 site, or at least in this part of the rockshelter.

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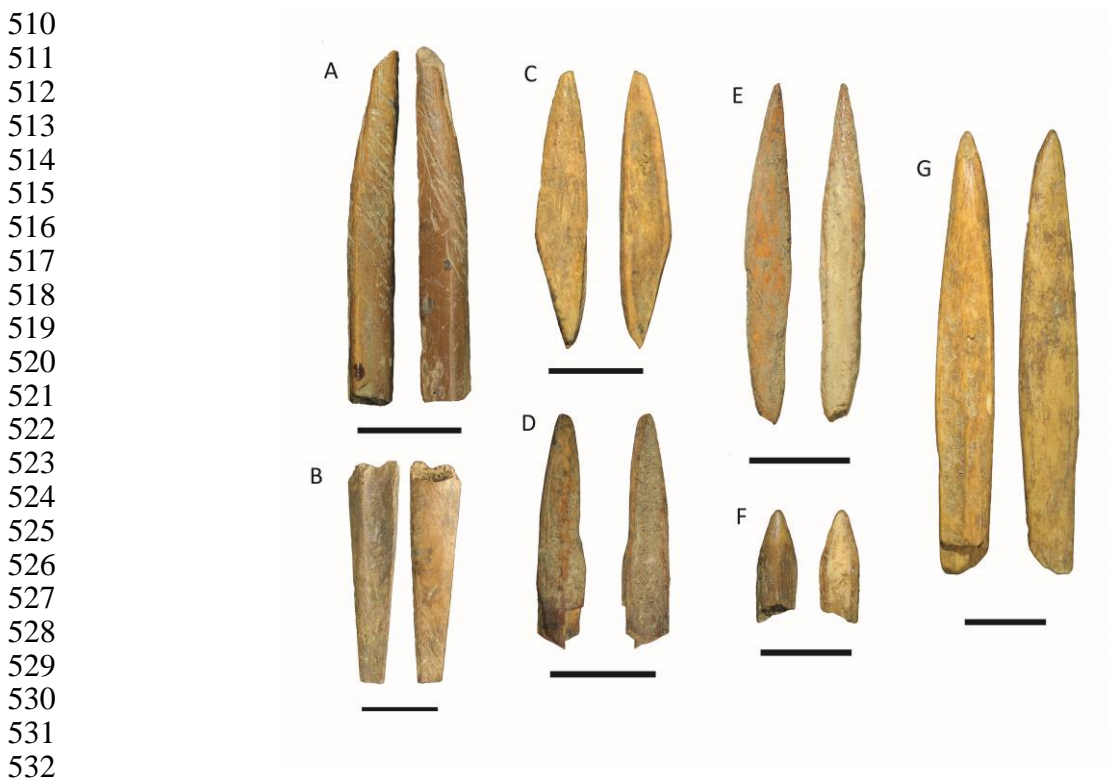
533 ***Figure 4.*** *Osseous tools manufactured from cercopithecid appendicular skeletal elements*
534 *recovered during the 2017 excavation of Kitulgala Beli-lena (A-B unipoints C-G bipoints). .*
535 *Scale bars in microphotographs= 1 cm.* (context 3: A, F; 4: B,E; 5:C, D; 27- E,G)
536

537 In addition to finished tools manufactured from small mammal bones, three bone tool

538 fragments manufactured from cervid metapodial shafts were also recorded in the Holocene

539 layers of the site. The fragments represent scraper and spatula-type tools, again similar to

540 those recorded in Fa Hien-lena. The use wear on the edges of the tools identified at Kitulgala

541 resembles the use wear of flaked tools recorded in Fa Hien-lena, such as striations suggestive

542 of use as scrapers (Langley et al., 2020). Overall, the similarity of the osseous tools recovered

543 from Kitulgala Beli-lena to those from Fa Hien-lena as well as those from Batadomba-lena

544 suggests a shared technology that facilitated hunting and foraging in the rainforest

545 environments of Sri Lanka.

546

547 *4.4 Invertebrate Fauna*

548 The total data for the invertebrate assemblage recovered from the 2017 excavation of

549 Kitulgala Beli-lena are presented in Table 6, listing the taxonomic categories and total

550 quantification data (NISP and weight) for each. The sample size reported here is relatively

551 small, with a total NISP of 3799 and total weight of 2002.90g (or *ca*. 2kg). Similar to animal

552 bones, the invertebrate remains were recovered only in layers dating to the Holocene and no

553 specimens were recovered from Pleistocene contexts.

554
555
556 **Table 6.** Taxonomic categories and total quantification data of the invertebrate remains from
557 Kitulgala *Beli-lena.*

Habitat	Family	Taxon	NISP	%NISP	Wt (g)	%Wt
Freshwater	Paludomidae	*Paludomus* spp.	1527	40.19	521.89	26.06
		Paludomus bicinctus	648	17.06	465.16	23.22
		Paludomus chilinoides	118	3.11	99.79	4.98
		Paludomus loricatus	62	1.63	29.86	1.49
		Paludomus neritoides	230	6.05	219.17	10.94
		Paludomus solidus	241	6.34	240.22	11.99
		Paludomus sulcatus	244	6.42	149.65	7.47
	Unionidae	*Lamellidens* sp.	6	0.16	3.3	0.16
Terrestrial	Acavidae	Acavidae	366	9.63	183.59	9.17
		Acavus spp.	18	0.47	13.42	0.67
		Acavus haemostoma	1	0.03	12.2	0.61
		Acavus superbus	8	0.21	45.32	2.26
		cf. *Oligospira* sp.	3	0.08	0.97	0.05
	Cyclophoridae	*Cyclophorus* spp.	2	0.05	1.86	0.09
		Cyclophorus menkeanus	2	0.05	4.98	0.25
Indeterminate		Indet Crab	1	0.03	0.88	0.04
		Indet Landsnail	2	0.05	0.13	0.01
		Indet Shell	320	8.42	10.51	0.52
Total			3799		2003	

NISP legend: 0-200, 200-400, 400-600, 600-800, 800-1000, >1000

Weight legend: 0-100, 100-200, 200-300, 400-500, 500-600

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561

562　Breaking down the identified taxonomic groups, there is one category at the family level

563　(9.63% NISP, 9.17% Wt), five categories at the genus level (40.96% NISP, 27.03% Wt), nine

564　categories at the species level (40.91% NISP, 63.23% Wt), and three indeterminate categories

565　(8.50% NISP, 0.58% Wt). The latter category encompasses indeterminate crab, land snail, and

566　shell, all of which do not retain key characteristics for identification beyond these broad

567　attributions. Figure 5 graphs the taxonomic categories in descending order (highest to lowest)

568　by %NISP (Figure 5A) and %weight (Figure 5B). Taxonomic rank order varies based on the

569　quantification measure used, a factor that relates to shell size and morphology, robusticity,

570　and also likely the differential degree of taphonomic modification within and between taxa.

571

572　Regardless of the quantification measure used, the dominant taxa are the Paludomidae

573　(freshwater gastropods) and the Acavidae (terrestrial gastropods). In many respects this is not

574　unexpected, particularly given the similar trends reported for the Batadomba-lena rockshelter

575　invertebrate assemblage (Perera et al. 2011). This dominance is also apparent when the

576　assemblage is rank ordered by family (Figures 6A and 6B), where the Paludomidae and

577　Acavidae are ranked first and second, followed by the indeterminate categories, by both

578　%NISP and %weight. In combination with the occurrence of freshwater Unionidae bivalves,

579　these data indicate the presence of flowing freshwater and lowland rainforest habitats around

580　Kitulgala Beli-lena during the Holocene.

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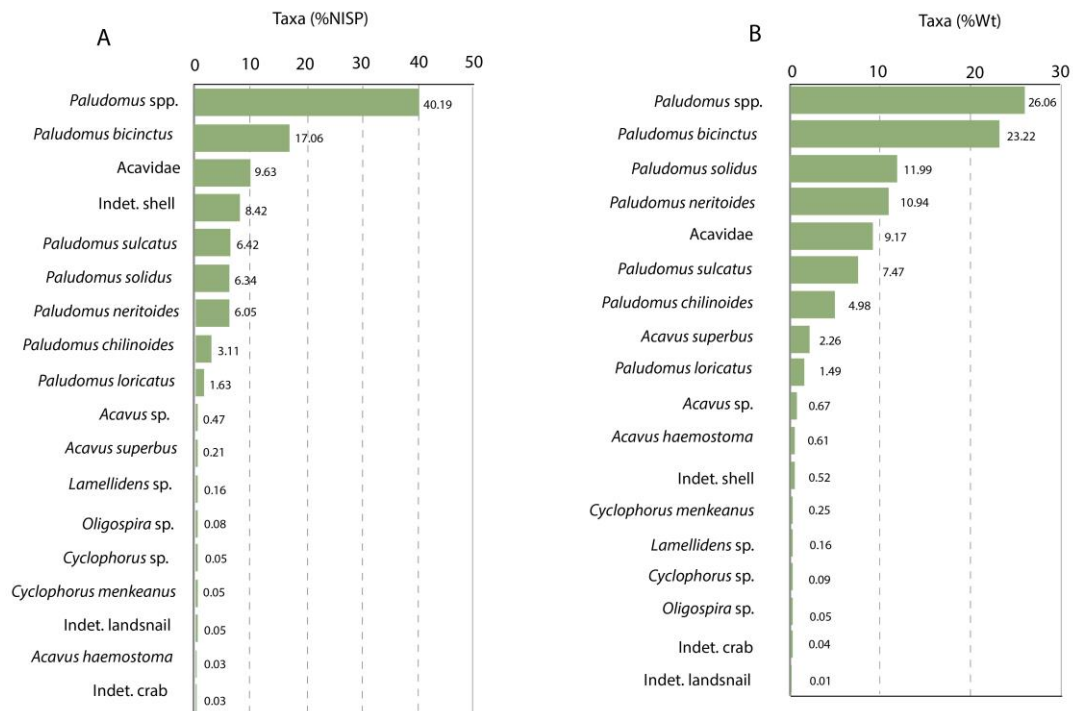
Figure 5. *Kitulgala Beli-lena mollusc taxa by %NISP (A) and %Weight (B).*
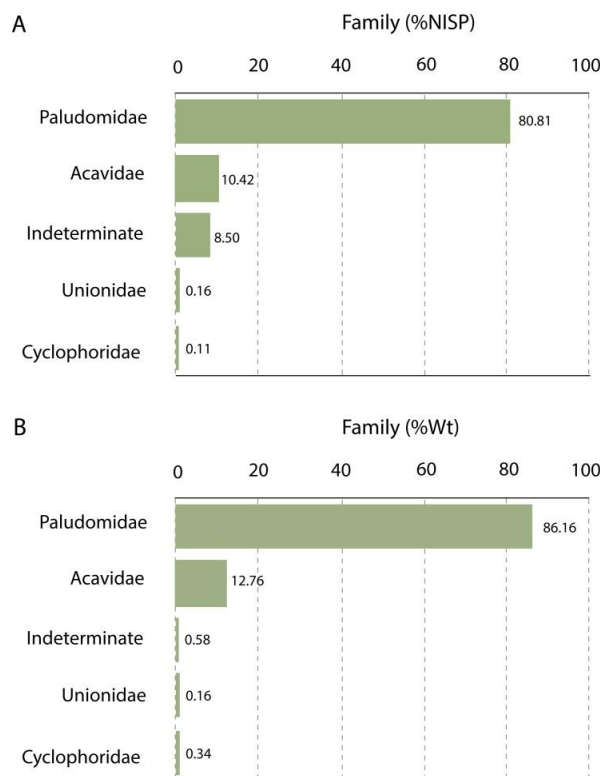
607 **Figure 6.** *Kitulgala Beli-lena mollusc taxa at the family taxonomic level by %NISP (A) and*
608 *%Weight (B).*

611 The distribution of the freshwater and terrestrial molluscs by context is presented in Table 7.

612 These data are based on family or genus level, to account for some of the issues surrounding

613 accurate identification to species level noted earlier. Based on these data, there would appear

614 to be a level of consistency in taxonomic representation and habitat exploitation throughout

615 the Holocene sequence at Kitulgala Beli-lena. The *Paludomus* spp. (range 76.9-86.3% NISP)

616 and Acavidae (range 8.4-13.7% NISP) dominate the assemblage and occur relatively

617 consistently across these contexts, with the freshwater bivalve *Lamellidens* sp. and the

618 terrestrial gastropod *Cyclophorus* spp. occurring at very low percentages. The ratio of

619 freshwater to terrestrial molluscs through the sequence also stays relatively consistent as a

620 result, ranging between 6.2 and 7.4 in contexts 7/5, 4, 3 and 2, with a minor increase in

621 freshwater taxa occurring in context 27 (with a ratio value of 9.7).

622

623 ***Table 7.*** *Kitulgala Beli-lena taxonomic distribution at family or genus level by sedimentary context (contexts 7 and 5 combined).*
624

Habitat	Taxon	Context 2 NISP	%	3 NISP	%	4 NISP	%	27 NISP	%	7/5 NISP	%
Freshwater	*Paludomus* spp.	349	84.91	1328	80.68	473	76.91	756	80.68	164	86.32
	Lamellidens sp.							6	0.64		
Terrestrial	Acavidae	49	11.92	178	10.81	64	10.41	79	8.43	26	13.68
	Cyclophorus spp.	1	0.24	2	0.12	1	0.16				
Total Context NISP		411		1646		615		937		190	
Freshwater:Terrestrial Ratio		6.98		7.38		7.28		9.65		6.31	

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632   These data suggest that there was a consistent focus on clean, flowing freshwater

633   environments for the exploitation of molluscan resources, with some exploitation, albeit to a

634   lesser extent, on lowland rainforest habitat gastropods. At Batadomba-lena, analyses of the

635   invertebrate sample indicate that there was an increase in mollusc deposition after *ca*.16,000

636   cal. BP, with freshwater taxa increasing and terrestrial taxa decreasing into the terminal

637   Pleistocene (Perera et al. 2011). While the Kitulgala Beli-lena molluscan assemblage does not

638   extend beyond the Holocene, the dominance of the freshwater taxa would appear to

639   correspond with the expectations derived from the molluscan faunal shifts seen at Batadomba-

640   lena rockshelter. The Kitulgala Beli-lena invertebrate faunal assemblage presents a similar

641   range and distribution of freshwater and arboreal/terrestrial taxa to that seen in other cave

642   sites in southwest Sri Lankan rainforest environments, particularly Batadomba-lena

643   rockshelter.

644

645   *4.5 Plant Remains*

646   Preliminary assessment of the macrobotanical assemblage from the Pleistocene sedimentary

647   contexts of Kitulgala Beli-lena revealed the presence of charred plant remains in all contexts

648   analysed. These remains included charred fragments of wood, nutshell, fruits, and seeds.

649   Overall, preservation in these contexts is limited with the macroremains generally exhibiting a

650   high degree of fragmentation. The identification of these remains is ongoing, but initial

651   assessment indicates the likely presence of economic taxa including cf. *Artocarpus* sp.

652   (breadfruit) and cf. *Canarium* sp. ('kekuna' nut).

653

654   Charred fragments of fruit exocarp comprising distinctive roundish to polygonal nodules or

655   disks, *ca*. 1-2mm in size, with a small central perforation were identified in all five

656   Pleistocene contexts analysed. Based on published descriptions including of previously

657 identified archaeobotanical material from Holocene contexts at Kitulgala, these are tentatively

658 identified as breadfruit (*Artocarpus* sp.) skin. Fissuring of the nodules is consistent with the

659 fracture patterns observed in experimentally cooked and charred breadfruit cultivars in

660 Oceania (Kahn and Ragone 2013), suggesting the charred Kitulgala fragments were also

661 produced by roasting, though additional experiments with Sri Lankan wild varieties is needed

662 to replicate these observations. In addition, a single fragment of cf. *Canarium* sp. endocarp

663 (nutshell) was identified in Context 10. The fragment was <3mm in size and identified

664 tentatively based on the presence of a distinctive cellular pattern observed on the inner seed

665 locule (Fairbairn pers. comm. 2018). Additional comparative work with modern reference

666 material is needed to confirm this identification. Other nutshell fragments were also observed

667 in other contexts but these have not yet been identified.

668

669 The presence of cf. *Artocarpus* sp. and cf. *Canarium* sp. in the archaeobotanical assemblages

670 is consistent with a rainforest plant food economy being practised at Kitulgala throughout the

671 Late Pleistocene, as also observed at other rockshelter sites in the Wet Zone (Perera et al.

672 2011; Kajale 1988). Previous archaeobotanical studies at Kitulgala also identified charred

673 breadfruit and *Canarium* remains, as well as wild banana (*Musa* sp.) in Holocene deposits

674 dating to at least 12,500 BP. Whilst additional work is needed to confirm the identifications of

675 some of the new Kitulgala samples, the present study tentatively extends the chronology of

676 the rainforest plant gathering into the Pleistocene. Furthermore, it indicates that at least wild

677 breadfruit was probably exploited from initial occupation of the site at around 44,000 years

678 ago. Wild breadfruit (*Artocarpus nobilis*) and kekuna nut (*Canarium zeylanicum*) are both

679 endemic to Sri Lanka and grow today in the lowland rainforest (Gunatilleke et al. 2008).

680 Together these provide a rich source of starch, fats and protein, and require little processing

681 other than cooking (in the case of breadfruit), making them high ranked food resources. The

682   storability and transportability of *Canarium* nuts would have made them an attractive resource

683   for a mobile hunter-gatherer population.

684

685   *4.6 Lithic Technology*

686   The lithic assemblage of Kitulgala Beli-lena comprised of 15,151 lithic items and 33 quartz

687   pebbles, probably utilized as hammerstones (Table 8). The main raw material used was

688   quartz, with small numbers of chert artefacts identified, including four flakes and one

689   fragment in the Holocene, five flakes, two chips and one core-on-flake in the Terminal

690   Pleistocene, and three flakes and three fragments in the Late Pleistocene. Small and medium

691   size quartz pebbles can be found in immediate vicinity of the site, including in the nearby

692   stream and in open sedimentary sections. The primary source of chert is unresolved, and

693   likely represents elements of toolkits that have been transported to the site.

694

695   The technological reconstruction of the lithic *chaîne operatoire* indicates the continuous use

696   of the bipolar-on-anvil method from the Late Pleistocene to the Holocene. The cores are

697   characterized by the typical battering marks of the hammerstones on the proximal end and by

698   small breakages produced by the contact with the anvil. Generally, the quartz pebbles were

699   exploited along their longer axis in order to maximize the length of the by-products. At times,

700   during the knapping events, the striking platforms were shifted in order to achieve a better

701   stability on the anvil. This behaviour is common in the different chronological phases and

702   several examples document the opportunistic use of striking platforms opposed to flat

703   surfaces, natural or created during the reductions (Figure 7, 2-3), and the rotations of the cores

704   of 90° degrees (Figure 7, 1), producing flakes with orthogonal scars on the dorsal surfaces.

705

706   The flake assemblage is composed mostly of fragments and small chips whereas complete

707   flakes and flake bladelets are recorded in lower frequencies (Table 8, Figure 7, 4-8).

708   Comparison of unbroken flakes by length intervals indicates that the knapping events were

709   aimed to produce small blanks with the size of most of the artefacts smaller than 30 mm

710   (Figure 8). However, some slight changes through time were documented. From the Late

711   Pleistocene, there was a decrease in the frequency of flakes smaller than 20 mm and an

712   increase in the frequency of artefacts in the intervals of 30 - 40 mm (Figure 8). Since during

713   the bipolar-on-anvil reduction, the size of knapping by-products is not controlled as in other

714   hierarchical technologies (Picin and Vaquero, 2016; Boëda, 2013), the greater number of

715   larger flakes during the Terminal Pleistocene and Holocene could be linked to the gathering

716   of bigger quartz nodules or the exploitation of different secondary outcrops where larger

717   cobbles were available. Typical by-products of the bipolar-on-anvil reduction sequences are

718   few in the flake assemblage. Siret knapping accidents represent 10.5% of the fragments from

719   the Late Pleistocene, 8.4% from the Terminal Pleistocene and 7.1% from the Holocene.

720   Conversely, splinter pieces total only 32 blanks in Late Pleistocene, 33 blanks in the Terminal

721   Pleistocene and 25 blanks in the Holocene.

722

723 ***Table 8.*** *Total number and percentage of the lithic assemblages of Kitulgala Beli-lena by*
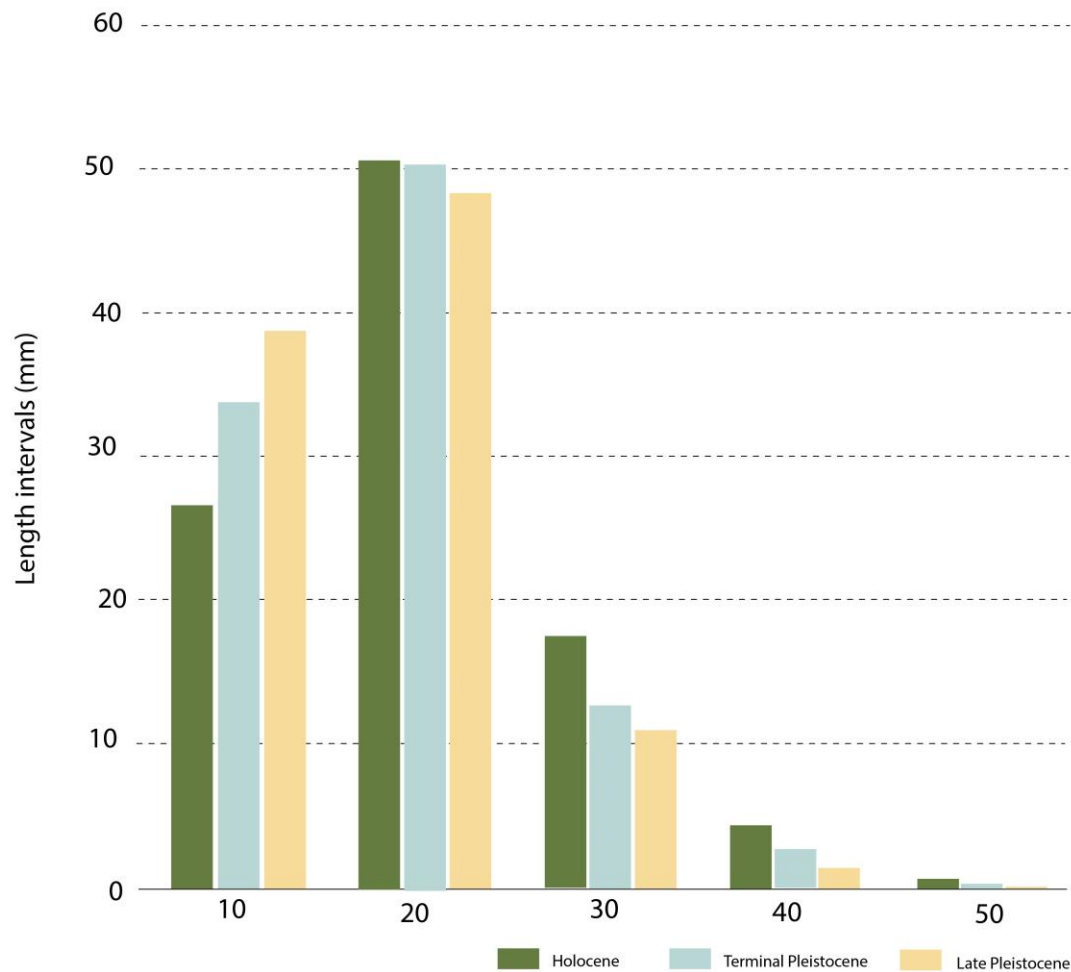724 *chronological phases.*
725

Phase	Flake	Flake Bladelet	Fragment	Debris	Core	Core Frag.	Hammer	Total
Holocene	523	9	2367	620	43	34	7	3603
%	*14.5*	*0.2*	*65.7*	*17.2*	*1.2*	*0.9*	*0.2*	*100*
Terminal Pleistocene	592	1	2635	3230	68	45	6	6577
%	*9*	*0*	*40.1*	*49.1*	*1*	*0.7*	*0.1*	*100*
Late Pleistocene	544	2	2324	1998	57	67	20	5012
%	*10.9*	*0*	*46.4*	*39.4*	*1.1*	*1.3*	*0.4*	*100*
Total	1659	12	7326	5848	168	146	33	15192
%	*10.9*	*0.1*	*48.2*	*38.5*	*1.1*	*1*	*0.2*	*100*

726
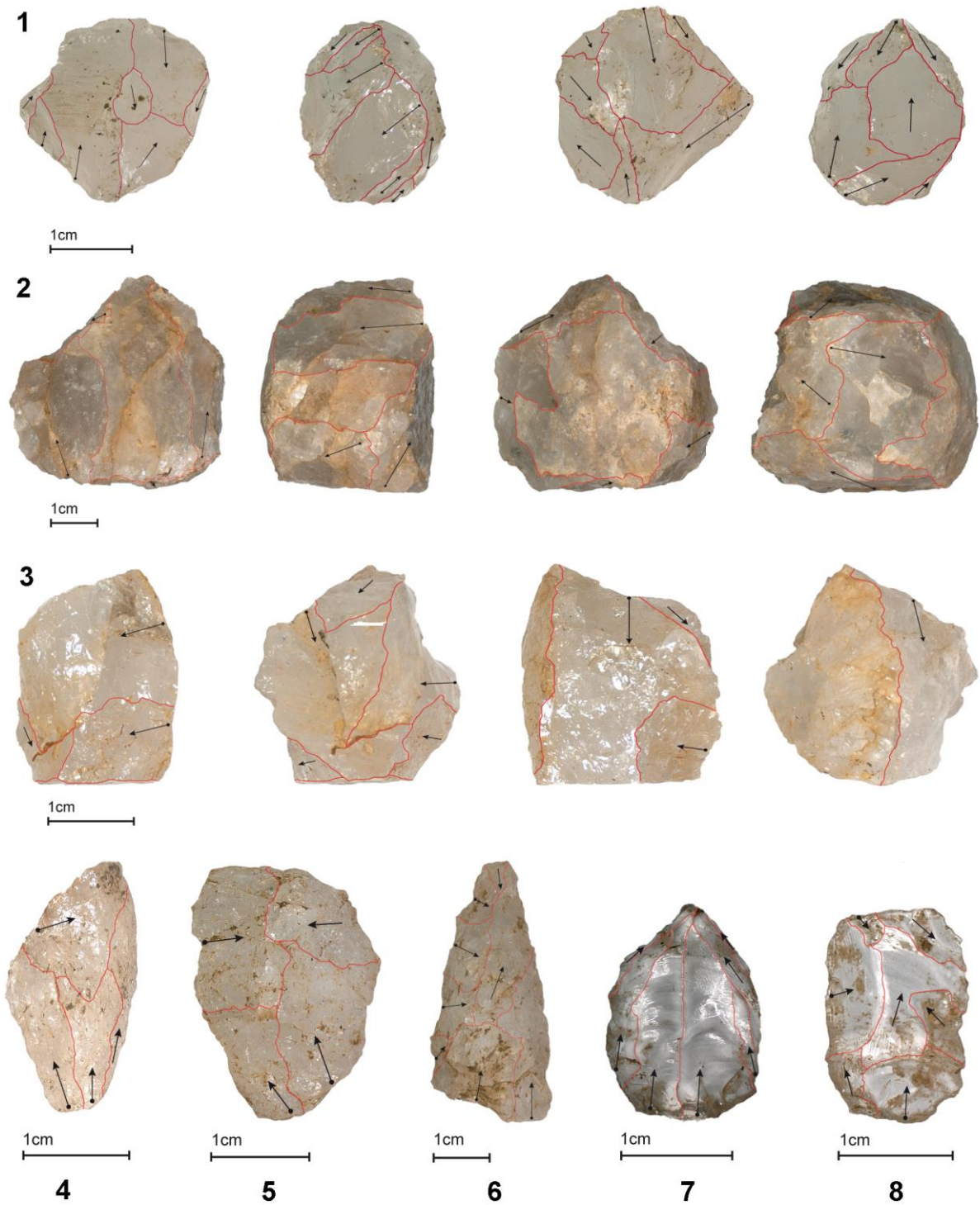
727 ***Figure 7.*** *Bipolar-on-anvil cores (1 – Holocene; 2 – Terminal Pleistocene; 3 Late*
728 *Pleistocene) and bipolar flakes (4, 5 – Holocene; 6 – Terminal Pleistocene; 7-8 Late*
729 *Pleistocene) from Kitulgala Beli-lena.*
730
731
732
733

60

50

40

Length intervals (mm)

30

20

10

0

10   20   30   40   50

■ Holocene   ■ Terminal Pleistocene   ■ Late Pleistocene

Figure 8. Histogram of the frequency of complete flakes by length intervals during the different chronological phases at Kitulgala Beli-lena.

Although they were documented, albeit in low frequencies, in previous fieldwork and analyses (Roberts et al., 2015a; Lewis, 2017), retouched tools and backed microliths are absent in the lithic assemblage analysed. From the 24,772 artefacts and more than 500,000 pieces of debris recorded in previous excavations, only 28 were identified as retouched tools. The technological continuity recorded at Kitulgala Beli-lena is in accordance with the evidence documented in other cave sites located in the modern Wet Zone rainforest of Sri Lanka. At Fa Hien-lena Cave, the lithic production was aimed at small blanks, and the bipolar-on-anvil method on quartz, with the expedient technique of rotating the core and changing the striking platform, was used from ~48-45 ka up to the Holocene (Wedage et al.,

748   2019a; 2019b). At Batadomba-lena Cave, bipolar cores were found in association with

749   freehand flake and bladelet cores along with numerous backed microliths, a type of artefact

750   that is not generally found in the other two sites (Lewis, 2017).

751

752   **5. Discussion**

753   *Human behaviour and adaptations at Kitulgala Beli-lena*

754   Our data provide new insights into the foraging strategies and material culture of human

755   populations living at the site of Kitulgala Beli-lena. Firstly, our new radiocarbon dating

756   programme has dramatically revised the dates for the site, making it now one of the oldest

757   dated rockshelter/cave sites in Sri Lanka, and indeed South Asia more broadly. Indeed, the

758   earliest occupation date of 44,000 cal. years BP places it approximately contemporaneous to

759   Fa Hien-lena Cave and now earlier than the 38,000-36,000 cal. years BP recorded for

760   Batadomba-lena (Perera et al., 2011; Roberts et al., 2015a). This re-dating emphasises the

761   importance of applying robust pre-treatment methodologies in the tropics (as also highlighted

762   by Higham et al. (2008) for the Niah Caves, Borneo), in order to avoid erroneously young

763   dates as a result of detrital contamination. In the context of charcoal, this involves the

764   application of the Acid Base Oxidation (ABOX) pre-treatment steps (Higham et al., 2008).

765   Moreover, the re-dating of Kitulgala Beli-lena confirms the early presence of humans in the

766   Wet Zone rainforests of Sri Lanka as early as *ca.* 45,000 years ago, an assertion that was

767   previously solely based on the record at Fa Hien-lena (see also Wedage et al., 2019a).

768   The multidisciplinary approach presented here also enables us to confirm that this early

769   record of human presence at Kitulgala Beli-lena is associated with clear evidence for

770   rainforest plant gathering and manufacture of quartz flakes using the bipolar-on-anvil method

771   in the Pleistocene and targeting of arboreal animals starting with the onset of the Holocene.

772   Archaeobotanical evidence from the Late Pleistocene and Holocene levels demonstrates the

773   likely continued extraction and use of wild breadfruit (*Artocarpus nobilis*) and possibly also

774   kekuna nut (cf. *Canarium zeylanicum*) by foragers at the site. Both of these plants provide a

775   rich source of starch, fats, and protein, and require little processing. This makes them highly

776   productive food resources in an environment that has often been considered to lack reliable

777   plant-based sources of carbohydrate and protein (Bailey et al., 1989; Gamble, 1993).

778   *Canarium* sp. nuts have also been documented at Fa Hien-lena and Batadomba-lena (Perera et

779   al., 2011; Wedage et al., 2019a), as well as Late Pleistocene sites in Southeast Asia and New

780   Guinea (Summerhayes et al., 2010; Barker and Farr, 2013), highlighting their potential

781   significance to early human tropical foragers in these parts of the world.

782

783   Zooarchaeological and taphonomic insights from the Holocene layers (8,029-10,577 cal. BP)

784   of Kitulgala Beli-lena further support a specialized rainforest exploitation and use of small

785   mammals, primarily semi-arboreal and arboreal primates and squirrels, that has been

786   documented with striking similarities at Late Pleistocene and Holocene levels at Fa Hien-lena

787   and Batadomba-lena. Wijeyapala (1997) reported the presence of animal bones in the

788   Pleistocene layers of Kitulgala during his excavation of the outer, eastern section of the

789   rockshelter. Although no systematic zooarchaeological analyses were conducted, he noted the

790   presence of cercopithecid bone fragments in the site's lower sediment layers. Interestingly,

791   however, faunal remains were not recorded from the Pleistocene levels during the 2017

792   excavations of the inner wester section of Kitulgala Beli-lena. The absence of any animal

793   skeletal or dental remains was also noted in the sediment micromorphological analysis

794   conducted by Kourampas et al. (2009). This seemingly indicates that animal butchery and

795   processing were done in different parts of the site during the Pleistocene.

796

797   The osseous and lithic technological remains recovered from Kitulgala Beli-lena further

798   confirm evidence from Fa Hien-lena that Late Pleistocene and Holocene foragers in Sri Lanka

799   had developed a sophisticated repertoire for the exploitation of their immediate landscapes.

800   Osseous tools were found within the Holocene levels of Kitulgala Beli-lena, including

801   finished unipoints, bipoints and geometrics. The bone points were most likely utilized as

802   projectile points similar to those found in Fa Hien-lena (Wedage et al., 2019a; Langley et al.,

803   2020). The lithic materials, while not representing any backed microliths, show a bipolar-on-

804   anvil reduction method on quartz with stark similarities to those seen at Fa Hien-lena and

805   Batadomba-lena where microlithic points appear to have been the final goal (Lewis et al.,

806   2014; Lewis, 2017; Wedage et al., 2019a; 2019b). The absence of retouched tools and backed

807   flakes in this area of the site may indicate that tool-use occurred in a different part of the

808   rockshelter or at another location altogether. Since faunal remains were recorded previously

809   in the Pleistocene deposits (Wijeyapala, 1997) and they are lacking in the area excavated in

810   2017, it is probably that butchering activities, microlith preparation, and gear retooling were

811   carried out in task-specific locations of the rockshelter.

812

813   Albeit a preliminary evaluation, this different spatial distribution of the remains suggests a

814   complex organization of the site that is common in prolonged (long-term) settlements

815   (Bartram et a., 1991; O'Connell et al., 1991). This, alongside the lack of bone tools and faunal

816   remains from the Late Pleistocene layers, supports the differential use of space by Late

817   Pleistocene and Holocene foragers at Kitulgala Beli-lena. Recent analysis of the lithic

818   assemblages of the previous excavations recorded the presence of 27 microliths in the Late

819   Pleistocene, and four in the terminal Pleistocene. Similarly, where bone tools are present in

820   Holocene levels, there is no *débitage* evidence implying that they were manufactured

821   elsewhere. As a result, while material culture and archaeobotanical and zooarchaeological

822   evidence at Kitulgala Beli-lena, and its neighbouring sites, demonstrates a well-tuned,

823   persistence foraging adaptation to the rainforest environments of Sri Lanka, there appears to

824   be spatial complexity into how this adaptation was practised on a site and landscape basis,

825   represented within a given site, in a given period, and, indeed, perhaps across the landscape.

826   Given that systematic lithic, material culture, and subsistence analysis has now taken place at

827   Fa Hien-lena (Deraniyagala, 1992; Roberts et al., 2015b; Wedage et al., 2019a,b),

828   Batadomba-lena (Perera, 2010; Perera et al., 2011; Roberts et al., 2017a), and, here, Kitulgala

829   Beli-lena (sites that lie within $100km^2$ radius of each other in the Wet Zone evergreen

830   rainforests), future, systematic comparative work promises to further enrich understandings of

831   the spatial organisation of tropical rainforest use by Late Pleistocene and Holocene hunter-

832   gatherers on the island of Sri Lanka.

833

834   ***Kitulgala Beli-lena in context - Late Pleistocene-Holocene rainforest foraging and its***

835   ***social context in Sri Lanka and South Asia***

836   The multidisciplinary evidence from Kitulgala Beli-lena, Fa Hien-lena, and Batadomba-lena

837   now demonstrates the persistent use of tropical rainforest resources from 48,000-45,000 years

838   ago through to 3,000 years ago in the Wet Zone of Sri Lanka (Wedage et al., 2019a). Stable

839   isotope evidence of human and animal tooth enamel from Batadomba-lena, Fa Hien-lena, and

840   Balangoda Kuragala demonstrates that between 36,000 and 3,000 years ago human foragers

841   were reliant on tropical rainforest resources year round (Roberts et al., 2015a, 2017b), while

842   detailed zooarchaeological and archaeobotanical information demonstrates that this lifestyle

843   was supported by a heavy focus on semi-arboreal and arboreal primates and tree products and

844   supplemented by freshwater molluscs and squirrel taxa (Perera et al., 2011; Wedage et al.,

845   2019a). This research, as well as finds in East Africa, Southeast Asia, and Melanesia (Barker

846   et al., 2007; Summerhayes et al., 2016; Shipton et al., 2018), has gone a significant way to

847   rehabilitating tropical rainforests as key habitats for *Homo sapiens* during its dispersal within

848   and beyond Africa - environments that were once considered barriers to human dispersal

849   (Gamble, 1993; Bird et al., 2005; Boivin et al., 2013). The scale and intensity of rainforest

850   occupation and exploitation in Sri Lanka during the Late Pleistocene remains to be fully

851   elucidated. Although one could argue that this occupation is characterized by highly-mobile

852   and low density human populations, growing evidence, including from stable isotope analyses

853   (Roberts et al., 2017a), as well as intense evidence of occupation of rockshelter and cave sites

854   (Perera et al., 2011; Wedage et al., 2019a; 2019b), suggests the persistent presence of groups

855   fully adapted to the dynamics of a rainforest environment.

856

857   Such a specialized adaptation is supported by evidence reported here from Kitulgala Beli-lena

858   that tool production and faunal butchery may have taken place across a wider social and

859   economic landscape in the Wet Zone rainforests of Sri Lanka. It is possible that Kitulgala

860   Beli-lena, Fa Hien-lena, and Batadomba-lena all formed part of a network of hunting ranges,

861   plant exploitation routes, and settlement strategies that were likely also augmented by open-

862   air sites that may never be discovered (see Mercader et al., 2003 for pessimism in this regard

863   in the Central African rainforest). The existence of the formation of social and economic

864   networks between different groups, potentially operating simultaneously, is also supported by

865   growing evidence for contact between foraging communities in the rainforest and populations

866   on the coast. Evidence for marine shell beads and shark teeth has emerged in the Pleistocene

867   and Holocene levels of Fa Hien-lena and Batadomba-lena (Perera, 2010; Perera et al., 2011;

868   Langley et al., 2020), as well as the Dry Zone site of Bellan-bandi Palassa (Perera, 2010).

869   These items were most likely obtained by trade with communities present in Sri Lanka's

870   southern coast, identified in sites such as Bundala, Patirajawela and Minihagalkanda

871   (Deraniyagala, 1992), given that isotopic evidence points to year-round reliance to rainforest

872   resources by communities in the island's Wet Zone (Roberts et al., 2015a, 2017a). As a result,

873   it seems that the Wet Zone rainforests were home to an established population that was part of

874   wider social and symbolic networks with groups living in other Sri Lankan biomes, not only

875   on the coast but potentially also in the drier north and south-eastern reaches given the lack of

876   Pleistocene investigation of these regions to-date (Deraniyagala, 1992; Roberts et al., 2015b).

877

878   Intriguingly, the basic lithic assemblage of bipolar-flaked cores on quartz documented at the

879   early rainforest sites in Sri Lanka, persists at postulated coastal sites, as well as at a number of

880   Holocene hunter-gatherer sites (Roberts et al., 2015b). This includes the rockshelter site of

881   Balangoda Kuragala in the Intermediate Zone, Bellan-bandi Palassa in the Dry Zone, a series

882   of 'Microlithic' shell middens sites and, indeed, underlying contexts at the later Iron Age and

883   urban site of Anuradhapura (Deraniyagala, 1992, 1997; Perera, 2010). Bone tools, supposedly

884   of a similar nature to those found in the Wet Zone, have also been documented at Bellan-

885   bandi Palassa (Perera, 2010). On top of isotopic evidence for the persistence of rainforest

886   reliance at Batadomba-lena and Fa Hien-lena until 3,000 years ago and the arrival of the Iron

887   Age in this part of the island (Roberts et al., 2015a), it therefore appears that human groups

888   using similar technological repertoires persisted in the different biomes of Sri Lanka

889   throughout the Late Pleistocene and into the Early and Mid-Holocene. Moreover, these

890   groups apparently remained connected by exchange, and perhaps cultural affinities,

891   throughout this period. Exploration of the scale and demography of these populations will

892   require future work in different parts of the island. However, it seems reasonable to assume

893   that the Wet Zone foragers were not isolated, mobile populations leaving ephemeral traces on

894   their environment Rather, their ability to persist in these settings implies a certain

895   sustainability of rainforest resource exploitation, perhaps in the form of spatial variation in

896   hunting routes during different times of year or variation in targeted taxa (Roberts, 2016).

897

898   *A Wider South Asian and Asian Perspective*

899   From earlier assumptions of a rapid coastal arrival in South Asia *ca.* 60 ka (Mellars, 2005,

900   2006; Field et al., 2007), our understanding of the appearance of our species in this part of the

901   world have become much more complex over the course of the last decade (Groucutt et al.

902   2015; Blinkhorn & Petraglia 2017; Roberts et al., 2017a). Significantly, given the data

903   available from Kitulgala Beli-lena and the other Wet Zone sites of Sri Lanka, it is now clear

904   that *H. sapiens* occupied and utilized a diversity of terrestrial environments, away from the

905   coast, from its earliest arrival in South Asia. This includes the arid environments of the Thar

906   Desert, from potentially as early as *ca.* 114 ka, perhaps supported by increased precipitation

907   and the freshwater of palaeochannels and lakes (Blinkhorn et al., 2013, 2017, 2019). The

908   Jurreru River Valley has also provided evidence for human populations in mosaic of dry

909   forest, grassland, and riparian habitats, with fluctuating periods of aridity from 77 ka through

910   to the Holocene (Petraglia et al., 2007; 2010, 2012; Clarkson et al., 2012). It is perhaps in Sri

911   Lanka, however, that human adaptability to different extremes is most evident in South Asia.

912   Here, sites producing the earliest current evidence for human fossils in the entirety of South

913   Asia, as well as long-term records of human behaviour, are associated with specialized

914   adaptations to tropical rainforest environments from 48-45,000 years ago through to 3,000

915   years ago. This is not to say that coasts were irrelevant to late Pleistocene human occupations

916   in this part of the world (Blinkhorn et al. 2017, 2019), and indeed future work on Sri Lankan

917   coastal sites is likely to reveal prehistoric settlements in these parts of the island as well

918   (Deraniyagala, 1992). It is now clear that the peopling of South Asia was far more complex

919   than a coastal highway that rapidly brought uniform populations and technological strategies

920   throughout this diverse region.

921

922   Research in South Asia over the past two decades points to a complex pattern of cultural and

923   technological change following the initial *H. sapiens* colonization of the region. In western

924   India, the Son Valley of north-central India and in the Jurreru Valley of southern India, it has

925   been argued that Late Palaeolithic and microlithic toolkits transitioned from Middle

926   Palaeolithic technologies (Sali 1989, Clarkson et al., 2009; Petraglia et al., 2012; Blinkhorn

927   2018; Clarkson et al. 2018). This can be clearly seen in the Jurreu Valley, where Middle

928   Palaeolithic occupations span 77-38ka, with the younger assemblages sharing features that

929   become central to subsequent Late Palaeolithic industries from 35ka onwards (Petraglia et al.,

930   2007; Clarkson et al. 2012). It also appears that microlithic and osseous tool technologies

931   were utilized by communities occupying a diverse range of terrestrial environments far from

932   the South Asian coast. Bone tools were recorded in the Jwalapuram Locality 9 site alongside

933   Late Palaeolithic stone tools (Clarkson et al., 2009). Likewise, bone technology including

934   projectile points presumed to have been utilized to hunt arboreal fauna, alongside quartz

935   microliths, has been recorded in the earliest phase of occupation of the rock shelter sites in Sri

936   Lanka's Wet Zone region (Deraniyagala, 1992; Perera, 2010; Perera et al., 2011; Wedage et

937   al., 2019a; Langley et al., 2020). The sophisticated microlithic and osseous technologies, as

938   well as ochre and symbolic beads, documented in these sites would not be out of place in the

939   caves of western Europe 45,000 years ago (Conard, 2010) or in southern Africa from 100,000

940   years ago (Henshilwood et al., 2011), perhaps causing us to reorient our ideas of which

941   ecological adaptations accompanied symbolic, technological, and economic hallmarks of our

942   species.

943   Evidence for Late Pleistocene rainforest occupation and resource utilization, akin to evidence

944   from Sri Lanka's Wet Zone sites, has also been documented in Southeast Asia and Melanesia.

945   The most comprehensive evidence for Late Pleistocene rainforest subsistence foraging

946   strategies in the region comes from Niah Caves in Sarawak, Borneo. Niah Caves produced

947   one of the earliest human fossils in Southeast Asia, dated to c. 44,000–40,000 cal. years BP

948   (Barker et al., 2007; Higham et al., 2008; Reynolds and Barker, 2015). Results of detailed

949   analyses looking at a wide range of archaeological materials including fauna, pollen,

950   pytholiths, starch grains, and macrobotanical remains, point to complex foraging behaviours

951   tailored to take full advantage of the rainforest environment (Barker and Farr, 2016). These

952   include exploitation of an array of plant resources for food and possibly clothing, processing

953   of toxic plants such as taros and yams, specialized targeting of wild boar, hunting of arboreal

954   taxa including monkeys and civet cats, as well as collection and processing of freshwater

955   molluscs (Barker et al., 2007; Barton et al., 2009; Barton, 2016; Hunt et al., 2012; Piper and

956   Rabett, 2014; 2016; Szabó, 2016). These activities were facilitated by some of the earliest

957   bone tools found in Southeast Asia (Rabett and Piper, 2012; Rabett, 2016) in addition to flake

958   based stone tool technologies (Reynolds, 2016; Barton, 2016). The earliest human occupation

959   of Melanesia is also associated with rainforest foraging. Sites in the Ivane Valley region of

960   Papua New Guinea produced evidence for processing of *Dioscorea* yams and *Pandanus* nuts

961   as early as 49,000–43,000 cal. years BP (Summerhayes et al., 2010). Human occupation of

962   rainforests have also been recorded in the Bismarck Archipelago at sites in New Ireland dated

963   to c. 40,000 cal. years BP (Leavesley, 2005) and in West New Britain c. 35,000 cal. years BP

964   (Pavlides, 2004; Summerhayes et al., 2017).

965

966   It is now becoming increasingly apparent that what truly characterises our species is its

967   emergence at a time of increasing climatic and environmental variability in Africa (Potts et

968   al., 2018). Not only did this act as the background for the evolution of diverse human

969   populations in different parts of this continent (Scerri et al., 2016), but it is also the situation

970   that met members of *H. sapiens* moving into Europe, Asia, Australasia, and the Americas

971   during the Late Pleistocene (Roberts and Stewart, 2018). While in some cases coastal

972   environments or savannah settings may have been significant to human populations utilizing

973   new projectile technologies, and developing novel symbolic networks (Shea, 2011; Marean,

974   2016), these behaviours also supported the movement of populations into more 'extreme'

975   environments including high-altitude settings (Stewart et al., 2016), desert settings (Hiscock

976   and Wallis, 2005; Nash et al., 2016), the arctic (Pitulko et al., 2016), and tropical rainforests

977   (Barker et al., 2007; Roberts and Petraglia, 2015; Roberts et al., 2017a; Westaway et al.,

978   2017). While research focus on these latter environments was for long lacking in contrast to

979   temperate and grassland parts of Europe and Africa, two decades of research has revealed a

980   vast wealth of information into human subsistence, technological adaptations, and symbolic

981   behaviours (Hunt and Barker, 2014; Aubert et al., 2014; 2018; Langley et al., 2020).

982   Increased multidisciplinary excavation, and analysis in parts of the world dominated by these

983   more 'extreme' habitats in the present, as well as the past, has the possibility to enable us to

984   build a more complete picture of the ecological and social adaptations that make us human,

985   and enabled us to colonize nearly the entirety of the planet by the end of the Pleistocene.

986

996   addition, we appreciate the cooperation of Mr. Sunil Kannangara (District Sectary of

997   Colombo).

998
999   **Author contributions**

1000   OW, PR, SD, NB, MP and NA designed the study with AP and JB in collaboration with PF,

1001   AC and KD. OW, AP, JB and NA conducted the site excavation and the recording of

1002   stratigraphy and artefact distribution with supervision from PR, SD, NB and MP. The lithic

1003   materials were analysed by AP and OW. AC looked at the archaeobotanical remains.

1004   Molluscan remains were studied by PF. NA studied the vertebrate faunal remains and the

1005   bone tools. KD was responsible for the radiocarbon dating. OW, PR, PF, AC, KD, AP, JB,

1006   SD, NB, MP and NA wrote the paper.

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