

1 **Colonialism, Slavery and ‘The Great Experiment’: Carbon, Nitrogen and**
2 **Oxygen Isotope Analysis of Le Morne and Bois Marchand Cemeteries, Mauritius**

3
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24
25 **Highlights**

- 26 • Isotopic analyses of two 19th century cemeteries give insights into Mauritian
27 diets
- 28 • A wide range of diets was consumed, particularly in terms of C₄ consumption
- 29 • People buried at Le Morne consumed more C₄ foods than those at Bois
30 Marchand
- 31 • The individuals from Le Morne had different childhood diets but similar adult
32 diets
- 33 • This is consistent with Le Morne’s interpretation as a post-emancipation
34 cemetery

35
36 **Abstract**

37
38 Slavery, colonialism and emancipation are important aspects of archaeological
39 research in the Atlantic region, but the lifeways of colonial populations remain
40 understudied in the Indian Ocean World. Here, we help to redress this imbalance by
41 undertaking stable isotope analysis (C, N and O) on human remains from Mauritius, a
42 location which played an important role in the movement of people across the Indian
43 Ocean and beyond. The results indicate that a wide range of diets was consumed in
44 Mauritius during the nineteenth century, varying with location and circumstances of
45 birth such that while a range of resources would have been available on the island, the
46 proportions of the different resources consumed was different for different people.
47 Most people consumed some C₄ resources, likely maize, although the proportion of
48 the diet that this represented varied widely. There is some evidence for the use of
49 marine resources, with one individual consuming a very high proportion of marine
50 foods. In general, the people buried at the post-emancipation cemetery Le Morne

51 consumed a higher proportion of C4 foodstuffs and a lower proportion of animal
52 protein and/or marine resources than those individuals buried at the formal public
53 cemetery Bois Marchand. The data from La Morne are consistent with a population
54 that lived separately as children and then came to live, and eat, together during
55 adulthood. This study has shown a much more nuanced picture of diet in Mauritius at
56 this time than was previously known. The research complements and enriches the
57 historic narrative, adding dimensions to small islands that would otherwise remain
58 obscure in the absence of rigorous scientific assessment of archaeological finds.

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Key words: Indian Ocean, indentured labour, palaeodiet, collagen, enamel carbonate

62
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1. Introduction

76
77 Archaeological aspects of slavery, colonialism and emancipation have been well-
78 studied in the Atlantic region, but comparatively little research has been undertaken in
79 the Indian Ocean area (Seetah, 2016). In particular, the lifeways of colonial
80 populations, especially bondmen and women, freed slaves and indentured labourers
81 remains under-studied. Mauritius formed an important node in the movement of
82 people in the Indian Ocean and beyond, and was the home of the ‘Great Experiment’,
83 when the British replaced slavery with ‘free’, indentured, labour. This research
84 examines the diet of various groups residing in Mauritius in the years following
85 emancipation. Using carbon, nitrogen and oxygen isotopic evidence from dentine
86 collagen, enamel carbonate and bone collagen, we assess the diet and life histories of
87 individuals buried in two cemetery sites in Mauritius (Fig. 1).

88



89
 90 *Figure 1: Map of Mauritius with analysed sites (generated with ArcGIS version*
 91 *10.2.2).*

92
 93 Le Morne ‘Old Cemetery’ is thought to be a post-emancipation cemetery and is
 94 located within the buffer zone of a UNESCO World Heritage site that commemorates
 95 slave resistance. At the time of writing, it appears to be the only post-emancipation
 96 cemetery excavated from the Southwestern Indian Ocean (Seetah, 2015a). Bois
 97 Marchand is a formal cemetery dating from 1867 with extensive burial records
 98 indicating that a cross-section of society was buried there (Pike 1873; Seetah 2015a).
 99 By comparing the individuals buried at these two sites, this study presents a better
 100 understanding of what life was like for nineteenth century Mauritians and how this
 101 varied with circumstances of birth and life history.

102
 103 **2. Background**

104
 105 **2.1. Historical Background**

106
 107 Detailed accounts of the history of Mauritius are provided by Allen (1999, 2003,
 108 2014a), Teelock (2009) and Vaughan (2005), and only a brief outline will be
 109 presented here. Mauritius was colonised by the French in AD 1721, although the
 110 Dutch had made two short-lived previous attempts, and runaway enslaved people
 111 most likely stayed on the island following the latter attempt. The island was under
 112 French jurisdiction until 1810 when the British seized it for its strategic significance,
 113 and it remained a British colony until 1968 when it gained independence.

115 Between the late seventeenth and mid-nineteenth centuries c. 280,000 to 322,000
116 enslaved people were brought to Mauritius and neighbouring Réunion (Allen, 2004).
117 Although the British Empire banned the slave trade in 1807, the practice continued
118 well into the 1820s. Most enslaved people were from Madagascar (45%) and
119 Mozambique (40%), with smaller numbers from India (13%) and West Africa (2%;
120 Allen, 1999, Filliot, 1974). Resistance was a significant problem for the French and
121 British colonists (Peerthum, 2006); during the first half of the 1820s approximately
122 11% of the enslaved population absconded (Allen, 1999). In 1835, a Proclamation
123 was issued that gave all slaves their freedom after a four to six-year apprenticeship
124 (Nwulia, 1978).

125
126 The rapid expansion of the Mascarene sugar industries in the late 1820s, coupled with
127 the decline and eventual demise of the slave trade, led to shortages of agricultural
128 labour. Attempts were made in the 1820s to take free indentured labourers from China
129 and India to Réunion, but there was heavy resistance from the labourers to the poor
130 conditions, and the scheme eventually failed. The indentured labour system began in
131 earnest in 1835 and continued until 1910 (Allen, 2014b). By 1861 there were 193,000
132 South Asian people, mainly from Indian subcontinent, in Mauritius, representing 62%
133 of the island's population at that time (Allen, 1999). The indentured labourers were
134 subject to many of the same harsh treatments as slaves: recruitment through deception
135 and tracking, diseased ship-board passage, travel restrictions within Mauritius and
136 poor treatment, including corporal punishment and imprisonment on estates. They
137 also resisted this oppression using many of the same tactics the enslaved people had,
138 including absconding (Allen, 1999). Even so, the indentured labours were legally free
139 and the small salary that they received set them apart from slaves; they were part of
140 labour commodification in the post-slavery colonial empire system. Genetic analysis
141 of the modern population of Mauritius has evidenced the multicultural nature of this
142 region (Fregel et al., 2014). Today, most mtDNA lineages in Mauritius are of Indian
143 origin (58.76%), with also significant contributions from Madagascar (16.60%),
144 East/Southeast Asia (11.34%) and Sub-Saharan Africa (10.21%).

145
146 Historical evidence suggests that the diets of enslaved people were based upon maize
147 and manioc. Baron Grant, a French planter who lived in Mauritius from 1740 to 1758,
148 reports that enslaved people consumed ground maize boiled in water, or manioc
149 loaves, and that owners were required to give enslaved people meat once a week,
150 although this law was not observed (Grant, 1801). In 1825, Governor Sir Lowry Cole
151 notes that daily slave food rations were no more than 1.25lb of maize or 3lb of manioc
152 (Allen, 1999). There is evidence, however, that enslaved people owned pigs, goats
153 and chickens and produced enough fruits, vegetables and other products to sell the
154 surplus (Allen, 1999). After abolition, the vast majority of previously enslaved
155 individuals left the plantations. They worked instead in a variety of occupations,
156 including craft production, trade, agriculture and domestic service. Many previously
157 enslaved individuals became smallholders, acquiring plots of land which they used to
158 grow bananas, maize, manioc, sweet potatoes and other fruits and vegetables, and to
159 raise poultry or swine (Allen, 1999). According to their contracts, indentured
160 labourers had to receive rations of rice, dal, oil, chilli, salt, salt fish, and so on which
161 were often poor and inadequate. Through time, both in the camps and in newly
162 acquired plots of land, labourers could supplement their modest diets by growing food
163 (Sain, 1980).

164

165 Historical records also indicate that food shortages were a problem throughout the
166 eighteenth century, which increased in the early nineteenth century when more land
167 was given over to sugar production, and again with Indian immigration (Allen, 1999,
168 Ly-Tio-Fane, 1968). Rice and cattle had to be imported to Mauritius from India and
169 Madagascar in order to prevent famines (Allen, 1999).

170

171 **2.2. Le Morne Cemetery**

172

173 This study examines two sites, Le Morne and Bois Marchand cemeteries. Le Morne is
174 located on a peninsular on the south-western tip of Mauritius. The area is isolated
175 from the rest of the island by a 545m high inselberg with only a single, precarious
176 access point. Oral history describes this region as a last resort for runaway slaves
177 (Seetah, 2016). The cemetery itself lies at the foothill of the inselberg and is thought
178 to be a post-emancipation cemetery. It has become a symbol of slave resistance,
179 recognized by its inscription on the UNESCO World Heritage List in 2008 as Le
180 Morne Cultural Landscape (<http://whc.unesco.org/en/list/1259>).

181

182 Archaeological investigations of the area, undertaken by the Mauritian Archaeology
183 and Cultural Heritage (MACH) project and in close association with the Le Morne
184 Heritage Trust Fund, commenced in 2009. The initial survey revealed 45 surface
185 features thought to be burial structures, eight of which were excavated in 2010. The
186 human remains found in these eight graves are included in this analysis (Seetah,
187 2010). The graves were delineated by basalt rocks, with the size of the graves
188 proportional to the size of the interred. All graves contained evidence for well-
189 constructed coffins but very few additional objects were found, although notable
190 exceptions include a series of mother-of-pearl buttons, a small number of French
191 coins dating from 1812 to 1828 (grave 7, Fig. 2) and seven clay tobacco pipes,
192 manufactured in Britain in the first half of the nineteenth century (graves 23, 24 and
193 42). Radiocarbon dating has proved problematic; however, the evidence from coins
194 and pipes suggests that the cemetery dates to the mid 1830s, around the period of
195 emancipation (Seetah, 2015b, Seetah, 2015a). The burial traditions do not reflect
196 Christian religious practices; the absence of any kind of religious building or any
197 other sign of ‘delimited sacred space’, the orientation of the bodies to the west, the
198 burial of neonatal and newborn individuals (i.e. individuals unlikely to have been
199 baptized), and the inclusion of grave goods would suggest African traditions were
200 being followed (Seetah, 2010). In particular, the tobacco pipes could be interpreted as
201 ‘slave material culture’ as they are often found in slave cemetery graves in the
202 Atlantic region but are not documented in cemeteries associated with people of
203 European descent (Katz-Hyman and Rice, 2011). The burials themselves appear to
204 reflect a population of some means, at least to the extent to which they could
205 provision their deceased: the dead were buried in well-constructed coffins; the
206 mother-of-pearl buttons suggests that they were dressed in relatively fine clothes; and
207 they were placed in clearly delineated graves, which were maintained and cared for.
208 This would seem to indicate that they were free people, but whether they had
209 previously been enslaved remains unclear (Seetah, 2010).

210



211
212 *Figure 2: Le Morne Cemetery: skeletal remains of an individual in the grave 7, with*
213 *bronze coins in-situ; 2010 excavation (MACH archive).*
214

215 Eleven skeletons were recovered from eight graves and were available for analysis.
216 All were primary inhumations, with six juveniles (three perinatal and three under 5
217 years at death), four females or possible females and one male individual (Appleby et
218 al., 2014, Appleby in Seetah, 2010). The presence and the position of a foetus
219 between the legs of the female in grave 1 suggests that she may have died in
220 childbirth. There were few osteological indications of dietary stress suggesting that
221 nutrition was adequate, however the stature of the individuals was relatively small,
222 fitting with the documentary evidence for slaves' heights recorded in the 1817 census
223 (Allen pers. comm.). The presence of caries and abscesses in the mouth suggest that
224 the diet was highly cariogenic and that dental hygiene was poor; 12% of teeth had
225 caries and antemortem tooth loss is observed in 18% of alveoli (Santana pers. com.).
226 Pathological conditions present include periosteal bone lesions which are frequent in
227 individuals with compromised immunity and chronic illnesses, such as malnutrition
228 and immune-deficiency diseases. Preliminary genetic analyses on the same
229 individuals using mitochondrial DNA, suggests that nine of the individuals were most
230 probably of East African (possibly Mozambican) descent while two were Madagascan
231 (Seetah, 2015a), but it does not necessarily follow that these individuals had
232 themselves been enslaved. Given the available evidence, Seetah (2015a) has
233 tentatively concluded that the cemetery contains the remains of the first generation of
234 freeborn Mauritians.

235 236 **2.3. Bois Marchand Cemetery** 237

238 Bois Marchand is a formal, public cemetery located in the northern part of the island,
239 approximately 50 km from Le Morne. It was inscribed in 1867 in response to the tens
240 of thousands of people who died from malaria (Pike, 1873). The cemetery was
241 divided into large parcels, with different religious ascriptions including Christian,
242 Hindu and Muslim, and occupational plots for police, firefighters, soldiers, criminals,
243 and so on. Our research focuses on one such parcel (section “R”) which was in use
244 from 1867 to 1868. The parcel has 42 rows of graves, with c. 500 individuals buried
245 here. We anticipated finding the remains of indentured laborers, however the public
246 cemetery was open to all and the excavated individuals represent a cross-section of
247 the Mauritian population, including many indentured workers. The extensive burial
248 records indicate that the individuals buried here were from as far as England, Jamaica,
249 ‘Arabia’ and ‘America’ (Bois Marchand Cemetery Archive, burial registers (BR) No.
250 2: June 6th to July 26th 1898; BR no number: August 23rd to October 1st 1903; BR No.
251 19: May 6th to July 9th 1901).

252
253 The archaeological research of the MACH project in Bois Marchand commenced in
254 2011. Here we are presenting the data from the seasons 2011 when we excavated six
255 graves with eight individuals, and from 2015, when we excavated eight graves with
256 fourteen individuals. The red ferrallitic soil in the area causes all organic material to
257 decompose extremely quickly, thus the human remains and other organic materials
258 are very poorly preserved, preventing an in-depth osteological study of the skeletons
259 (Fig. 3).

260



261

262 *Figure 3: Bois Marchand cemetery: an individual buried in a corrugated iron coffin,*
263 *grave 1, 2011 excavation (MACH archive).*
264

265 All the graves in Bois Marchand cemetery follow an established protocol: NE-SW
266 orientation; similar size (c. 1.80 x 0.90m) and depth (c. 1.60–1.70m); and c. 0.90m
267 spacing between the graves. Out of 14 graves uncovered, nine were double and four
268 single skeletal burials, with one grave empty; in total 22 interments with 17 adults,
269 two adolescents and three infants. All 22 burials were interred in coffins made out of
270 wood, corrugated iron or in corrugated iron lined wooden coffins, with two wooden
271 coffins also lined with lead. Infants were buried wrapped in a shroud: the fabric
272 decomposed, while silver pins that held the textile, remained as testimony. The burials
273 contained various personal objects such as rings, toe-rings, earrings, and belt buckles.
274 The double burials are intriguing, as they are not recorded in the cemetery's burial
275 registers, except a few cases of mother dying with a new-born child. Seven
276 individuals (three infants and four adults, representing four graves) were buried in
277 atypical positions, mostly with the opposite orientation, that is SW-NE. The presence
278 of these 'deviant' burials is highly unusual and calls for further research.
279

280 Due to the poor preservation of remains osteological analysis is limited and likely
281 biased. However, the preserved remains showed evidence for osteoarthritis of the
282 axial skeleton, hip and knee, and a high prevalence of dental caries and calculus. This
283 poor preservation also has implications for collagen isotope analysis, as diagenesis
284 could cause changes in the stable isotope ratios of bone and dentine collagen. Indeed,
285 dentine samples were taken, in part, as a precaution against poor collagen
286 preservation, because teeth tend to show better preservation than bone. Nevertheless,
287 Dobberstein and colleagues (2009) have shown that the collagen triple helix and
288 polypeptide chains remain intact until 99% of collagen is lost. Therefore, bone
289 samples with collagen yields greater than 1% can reliably be used for stable isotope
290 analysis. This and other collagen preservation criteria – a ratio of carbon to nitrogen
291 atoms between 2.9–3.6 (De Niro, 1985), and final carbon and nitrogen yields of at
292 least 13% and 4.8%, respectively (Ambrose, 1990) – are applied to our samples,
293 below.
294

295 Ancient DNA analyses on the Bois Marchand individuals are ongoing. Preliminary
296 results indicate a demographic shift compared with Le Morne, with some individuals
297 having clear South Asian mtDNA lineages, which is congruent with archaeological
298 findings and historical record. However, some individuals have an African/Malagasy
299 origin, indicating that the population buried at Bois Marchand was admixed (Fregel et
300 al., 2015).
301

302 **2.4. Scientific Background** 303

304 The individuals excavated from Le Morne and Bois Marchand were sampled for
305 carbon, nitrogen and oxygen stable isotope analysis. Carbon and nitrogen stable
306 isotope analysis is a quantitative method for studying palaeodiet. When foods vary in
307 their isotopic composition individuals consuming these different diets can be
308 identified via their body chemistry. Stable isotope ratios in adult bone protein
309 (collagen) reflect diet over a period of years, the precise period varying between
310 different skeletal elements (Hedges et al., 2007). Collagen extracted from tooth
311 dentine reflects the diet at the time of tooth formation, that is from a number of years

312 during childhood (Gage et al., 1989). As body protein is primarily constructed from
313 the dietary protein intake, the stable isotope ratios of collagen reflect mainly the
314 protein portion of the diet (Ambrose and Norr, 1993, Howland et al., 2003, Jim et al.,
315 2006, Tieszen and Fagre, 1993). Stable carbon isotopic values in tooth enamel also
316 reflect the diet at the time of tooth formation but reflect the whole diet (Ambrose and
317 Norr, 1993, Tieszen and Fagre, 1993).

318
319 Carbon isotopic ratios can be used to distinguish between marine and terrestrial
320 protein (Schoeninger and DeNiro, 1984) and between C₃ and C₄ plants (Vogel and
321 van der Merwe, 1977). These two plant groups use different methods to take in
322 carbon dioxide from the atmosphere during photosynthesis, resulting in different
323 carbon isotopic ratios in the plant (Vogel and van der Merwe, 1977, Smith and S,
324 1971, O'Leary, 1988). Most staple plants are C₃, including wheat, barley and rice,
325 while maize, sugar cane, millet and sorghum are C₄. Nitrogen isotope ratios provide
326 an indication of trophic position, as there is an increase in $\delta^{15}\text{N}$ of between 3 to 5‰
327 per trophic level (Bocherens and Drucker, 2003, Hedges and Reynard, 2007). As
328 marine and freshwater foodchains tend to be longer than terrestrial ones, nitrogen
329 isotopes can be used to identify fish and aquatic predator consumption, and
330 distinguish between C₄ and marine consumption (Schoeninger and DeNiro, 1984).

331
332 Oxygen isotopic analysis can be utilised as a method for the identification of non-
333 local individuals. Oxygen isotope ratios in precipitation reflect the local climate and
334 vary mainly with temperature and distance from the source of the water (Dansgaard,
335 1964, Rozanski et al., 1993, Rozanski et al., 1992). The oxygen isotope signal in tooth
336 enamel carbonate is derived mainly from ingested water and thus reflects the local
337 climate (Allen, 1999, Longinelli, 1984, Luz and Kolodny, 1985). As tooth enamel
338 does not remodel during life, the isotopic ratios in the carbonate reflect the water
339 drunk at the time of tooth formation. Individuals whose oxygen isotope ratios are
340 notably different from that of the local precipitation are identified as migrants. The
341 identification of migrants using this method is not straightforward; the reader is
342 referred to Lightfoot and O'Connell (2016), Pollard et al. (2011) and Pryor et al.
343 (2014) for a full discussion.

344
345 Both nitrogen and oxygen isotope values are affected by breastfeeding. Infants tend to
346 have higher $\delta^{15}\text{N}$ values than adults as breastfeeding effectively increases the trophic
347 level of the infant (Mays et al., 2002, Fuller et al., 2006, Fogel et al., 1989). Oxygen
348 isotope values are affected as the breastmilk is enriched in ¹⁸O relative to local water
349 due to the producer's higher body temperature (Wright and Schwarcz, 1989, Roberts
350 et al., 1988, Lin et al., 2003). Food deprivation can also affect human isotope values,
351 with $\delta^{15}\text{N}$ values increasing and $\delta^{13}\text{C}$ values decreasing with body mass in modern
352 studies (Mekota et al., 2006, Neuberger et al., 2013). This has been seen
353 archaeologically in incremental samples of human hair and dentine (Beaumont et al.,
354 2013, Beaumont and Montgomery, 2016). With bulk collagen samples, which
355 represent an average diet over many years, however, the influence of food deprivation
356 is most likely seen through lower $\delta^{15}\text{N}$ values, related to low animal protein
357 consumption, and potentially through the use of famine foods where these are
358 isotopically distinct (Beaumont et al., 2013).

359
360
361

3. Methodology

362

363 **3.1. Collagen Isotopic Analysis**

364

365 Bone and dentine samples were taken from eight human skeletons from Le Morne.
366 Bone samples only were also taken from the two peri-natal individuals in grave 6.
367 From Bois Marchand, bone samples were taken from six individuals excavated in
368 2011, with dentine samples also taken from three of these individuals. No bone was
369 available for sampling from the 2015 excavation; however, dentine samples were
370 taken from 11 individuals. Ribs and molars were preferentially sampled, where
371 possible; full sample details are given in Appendix 1.

372

373 The sample preparation was carried out in the Dorothy Garrod Laboratory for Isotopic
374 Analysis, University of Cambridge using the standard laboratory protocol based upon
375 Richards and Hedges (1999). *c.* 0.5g of bone was sampled using a drill and cleaned
376 via sand-blasting. Samples were demineralized in *c.* 10mL 0.5M aq. HCl at 4°C for
377 up to two weeks and then gelatinized at 75°C for 48 hours in pH 3 water. The
378 ‘collagen’ was then lyophilized before weighing for isotopic analysis.

379

380 Each sample was run in triplicate using a Costech elemental analyser coupled in
381 continuous flow to a Finnigan isotope ratio mass spectrometer at the University of
382 Cambridge. Stable carbon and nitrogen isotopic compositions were calibrated relative
383 to the VPDB and AIR scales using international standards. Repeated measurements
384 on international and in-house standards (L-alanine, IAEA-600, USGS-40, Protein 2
385 and EMC) showed that the analytical error was $\pm 0.2\%$ for both carbon and nitrogen
386 (see Appendix 2).

387

388 Measured collagen is deemed to be of good quality if it fulfills the following criteria:
389 an atomic C:N ratio of 2.9–3.6 (De Niro, 1985); a ‘collagen’ yield of 1% by mass;
390 final carbon yields of 13%; and final nitrogen yields of 4.8% (Ambrose, 1990). All
391 collagen data fulfilled these criteria, despite the poor bone preservation observed at
392 Bois Marchand.

393

394 **3.2. Tooth Enamel Carbonate Isotope Analysis**

395

396 Enamel samples were taken from all individuals analysed for dentine, described
397 above, plus two extra individuals from the 2011 Bois Marchand excavation
398 (Appendix 1).

399

400 The teeth were cleaned with a tooth brush to remove adhering dirt and the surface
401 abraded with a carbide drill bit. *c.* 6-8mg of tooth enamel powder was then taken
402 using a diamond drill bit. The pretreatment method was based on Balasse et al.
403 (2002). 0.1mL of 2–3% aqueous sodium hypochlorite was added per mg of sample
404 and left for 24 hours at 4 °C. They were then rinsed five times with distilled water.
405 0.1mg of acetic acid was added per mg of sample and left for four hours at room
406 temperature. The samples were then rinsed with distilled water. The samples were
407 freeze-dried to remove any remaining liquid and transferred to a vial with a screw cap
408 holding a septa and PCTFE washer to make a vacuum seal. The samples were reacted
409 with 100% orthophosphoric acid at 90 °C using a Micromass Multicarb Sample
410 Preparation System and the carbon dioxide produced was dried and transferred
411 cryogenically into a VG SIRA mass spectrometer for isotopic analysis. Carbon and

412 oxygen isotopic ratios were measured on the delta scale, in comparison to the
413 international standard VPDB calibrated using the NBS19 standard (Coplen, 1995,
414 Craig, 1957). Repeated measurements on international and in-house standards show
415 that the analytical error is better than $\pm 0.08\%$ for carbon and $\pm 0.10\%$ for oxygen.
416

417 **3.3. Statistical Analyses**

418
419 Statistical analyses were performed using SPSS version 23 for Mac. Samples were
420 tested for normality using histograms, Kolmogorov-Smirnoff and Shapiro-Wilks tests
421 and for equality of variance using Levene's tests. For parametric data independent
422 samples t-tests were used, while Kolmogorov Smirnov Z tests were used for non-
423 parametric data. Outliers are identified as samples that lie more than 1.5 times the
424 interquartile range (IQR) below quartile 1 (Q1) or above quartile 3 (Q3) (following
425 Lightfoot and O'Connell, 2016).
426

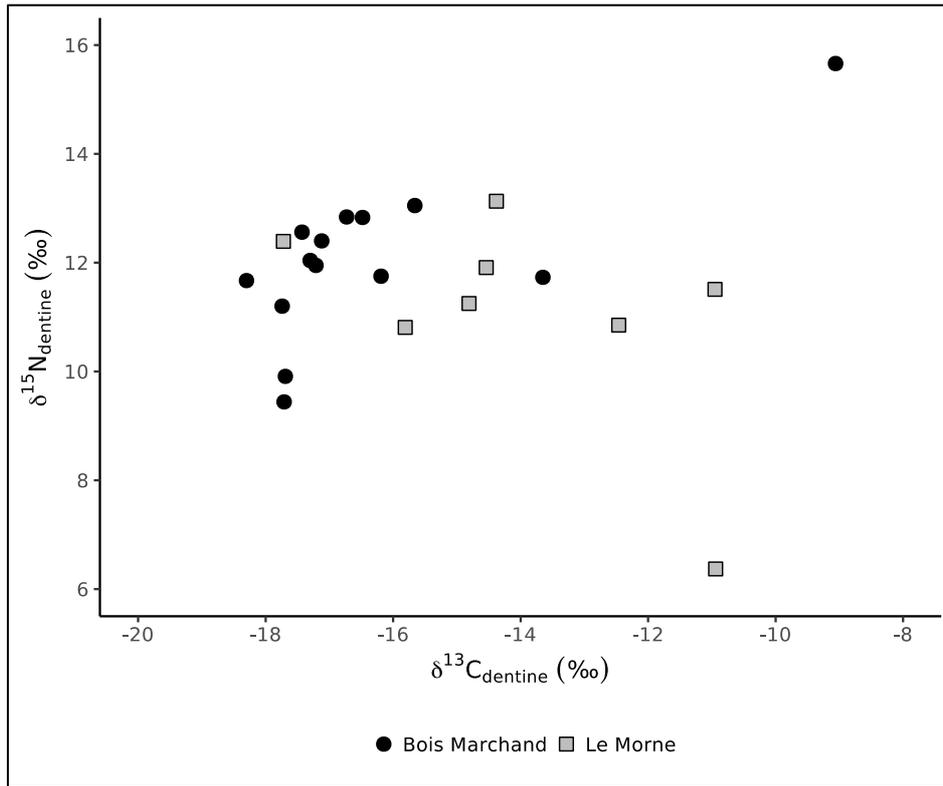
427 **4. Results**

428
429 The results are summarized in Table 1 and given in full in Appendix 1. The dentine
430 results are shown in Figure 4, the enamel carbonate results in Figure 5 and the bone
431 collagen data in Figure 6. The difference between the dentine and bone collagen
432 results for individuals where both samples were analysed are shown in Figure 7.
433

		$\delta^{13}\text{C}$ (VPD) (‰)						$\delta^{15}\text{N}$ (AIR) (‰)					$\delta^{18}\text{O}$ (VPD) (‰)				
		n	Mean	St Dev	Maximum	Minimum	Range	Mean	St Dev	Maximum	Minimum	Range	Mean	St Dev	Maximum	Minimum	Range
Le Morne	Bone collagen	10	-13.9	1.2	-11.4	-14.8	3.4	11.0	0.6	11.8	10.1	1.7					
	Dentine Collagen	8	-14.0	2.4	-10.9	-17.7	6.8	11.0	2.0	13.1	6.4	6.8					
	Enamel Apatite	7	-8.1	2.7	-3.7	-10.9	7.2						-4.2	0.4	-3.7	-4.9	1.2
Bois Marchand	Bone collagen	6	-17.3	0.6	-16.6	-18.3	1.8	11.9	0.5	12.3	10.8	1.4					
	Dentine Collagen	14	-16.3	2.4	-9.1	-18.3	9.2	12.1	1.5	15.7	9.4	6.2					
	Enamel Apatite	16	-10.8	3.0	-0.7	-13.6	13.0						-4.3	0.7	-2.9	-5.1	2.2

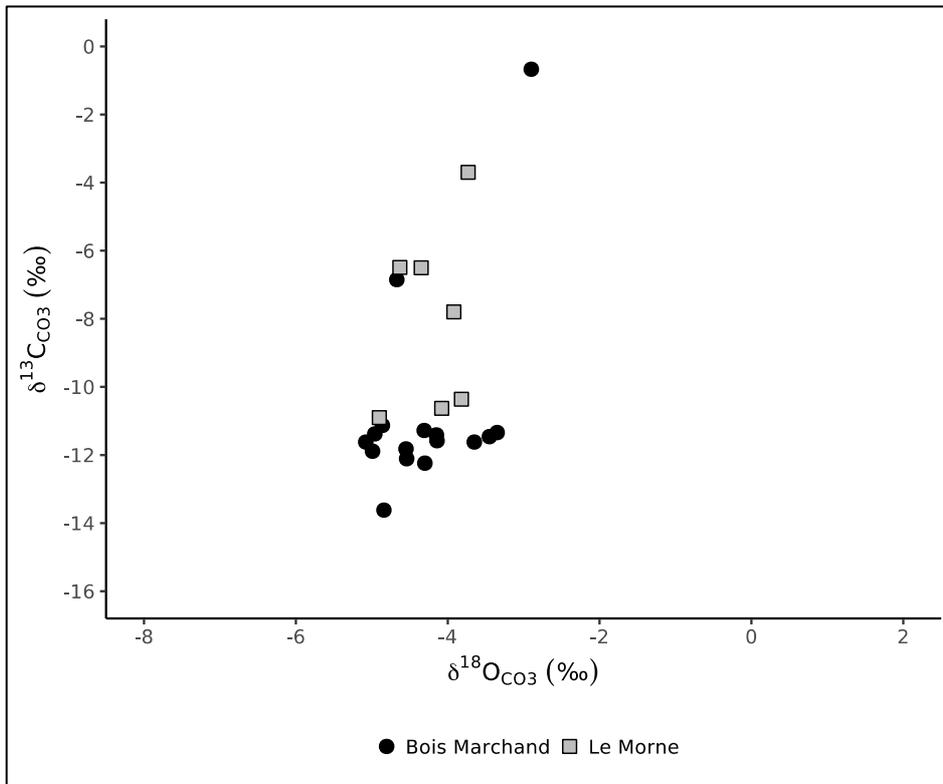
Table 1: Summary of stable isotope results from Le Morne and Bois Marchand

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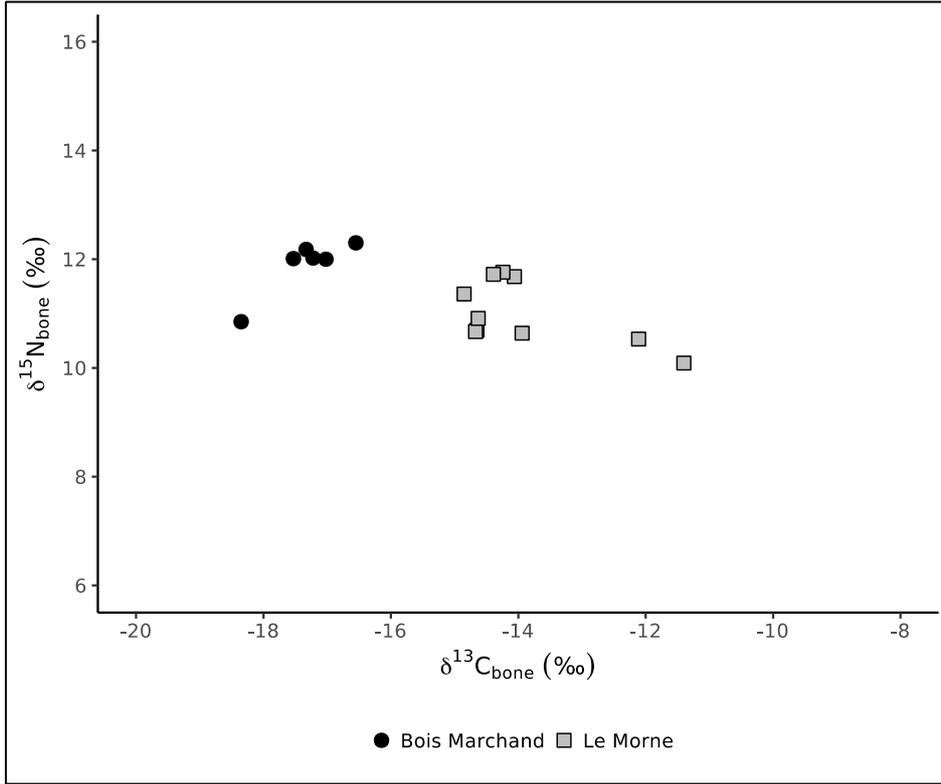
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Figure 4: Scatter plot of human dentine collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values from Le Morne and Bois Marchand



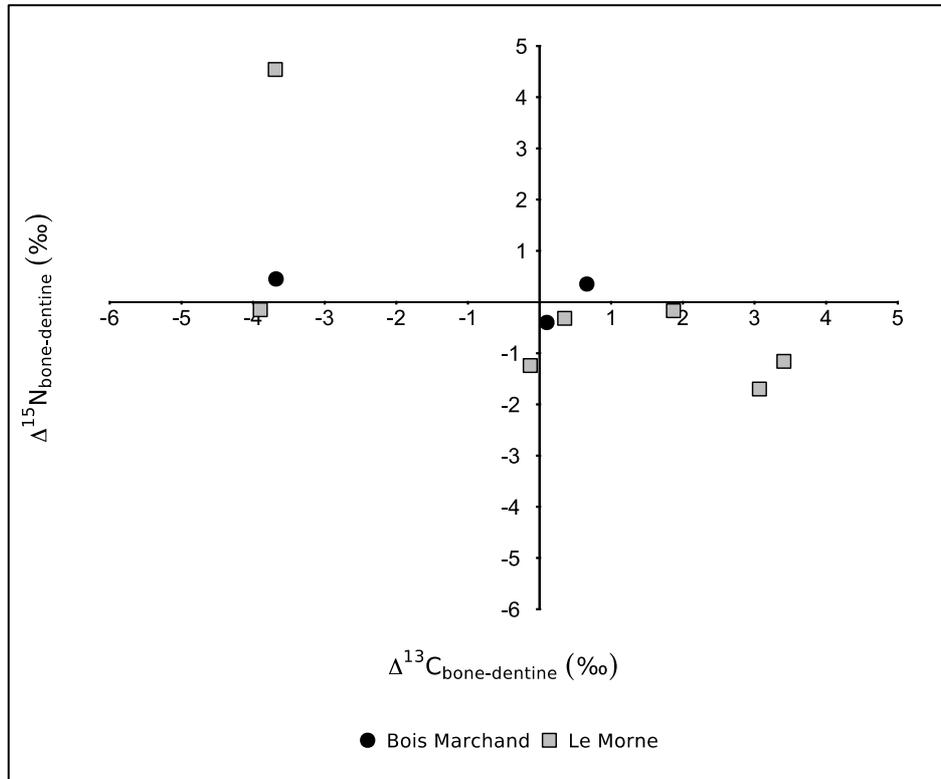
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Figure 5: Scatter plot of human tooth enamel carbonate $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values from Le Morne and Bois Marchand



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Figure 6: Scatter plot of human bone collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values from Le Morne and Bois Marchand



19
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21
22

Figure 7: Scatter plot of the difference between human dentine and bone collagen isotope data from Le Morne and Bois Marchand

23 4.1. Le Morne

24

25 The dentine collagen $\delta^{13}\text{C}$ results from Le Morne range from -17.7 to -10.9‰, while
26 the $\delta^{15}\text{N}$ results range from 6.4 to 13.1‰ (n = 8). One outlier can be identified
27 (STR33/L) with a very low $\delta^{15}\text{N}_{\text{dentine}}$ value, despite this sample being taken from a
28 canine and thus likely to have been affected by breastfeeding which should increase
29 their $\delta^{15}\text{N}$ value. When this individual is excluded, the $\delta^{15}\text{N}_{\text{dentine}}$ results range from
30 10.8 to 13.1‰, with a mean of 11.7 ± 0.9 ‰ (range = 2.3‰, n = 7). There is no
31 correlation between $\delta^{13}\text{C}_{\text{dentine}}$ and $\delta^{15}\text{N}_{\text{dentine}}$ ($r = -0.568$, $p = 0.142$).

32

33 The enamel $\delta^{13}\text{C}_{\text{CO}_3}$ results from Le Morne range from -10.9 to -3.7‰ (n = 7). No
34 outliers were identified.

35

36 The bone collagen $\delta^{13}\text{C}$ results range from -14.8 to -11.4‰, while the $\delta^{15}\text{N}_{\text{bone}}$ results
37 range from 10.1 to 11.8‰ (n = 10). Two outliers can be identified (STR33/U and
38 STR25) who have high $\delta^{13}\text{C}_{\text{bone}}$ values. When these outliers are excluded, the $\delta^{13}\text{C}_{\text{bone}}$
39 results range from -14.8 to -13.9‰ with a mean of -14.4‰ (range=0.9‰, n=8). There
40 is no correlation between $\delta^{13}\text{C}_{\text{bone}}$ and $\delta^{15}\text{N}_{\text{bone}}$ ($r = -0.584$, $p = 0.076$).

41

42 The difference between dentine and bone collagen results from individuals where
43 both samples were analysed (n=8, including 3 children), range from -3.9 to 3.4‰ in
44 $\delta^{13}\text{C}$ and -1.7 to 4.6‰ in $\delta^{15}\text{N}$. Seven individuals have a difference of at least 1‰ in
45 carbon and/or nitrogen isotope values, with one individual (STR025, 3-5 years old)
46 having differences of *c.* 0.3‰ in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$.

47

48 The enamel $\delta^{18}\text{O}_{\text{CO}_3}$ results from Le Morne range from -4.9 to -3.7‰ (n = 7). No
49 outliers were identified.

50

51 4.2. Bois Marchand

52

53 The dentine collagen $\delta^{13}\text{C}$ results range from -18.3 to -9.1‰, while the $\delta^{15}\text{N}$ results
54 range from 9.4 to 15.7‰ (n = 14). Four outliers have been identified. BM35/L is an
55 outlier with high $\delta^{13}\text{C}_{\text{dentine}}$ and $\delta^{15}\text{N}_{\text{dentine}}$ values (from a premolar, and thus unlikely
56 to have been affected by breastfeeding). BM04 is an outlier with a high $\delta^{13}\text{C}_{\text{dentine}}$
57 value. BM33/L and BM36/L are outliers with low $\delta^{15}\text{N}_{\text{dentine}}$ values. When the four
58 outlying individuals are excluded the $\delta^{13}\text{C}_{\text{dentine}}$ results range from -18.3 to -15.7‰,
59 with a mean of -17.0 ± 0.8 ‰ (range = 2.6‰, n = 10) while the $\delta^{15}\text{N}_{\text{dentine}}$ results range
60 from 11.2 to 13.1‰, with a mean of 12.2 ± 0.6 ‰ (range = 1.9‰, n = 10). While there
61 is a correlation between $\delta^{13}\text{C}_{\text{dentine}}$ and $\delta^{15}\text{N}_{\text{dentine}}$ ($r = 0.731$, $p = 0.003$), there is no
62 correlation between $\delta^{13}\text{C}_{\text{dentine}}$ and $\delta^{15}\text{N}_{\text{dentine}}$ when the outlying individuals are
63 excluded ($r = 0.629$, $p = 0.051$).

64

65 The enamel $\delta^{13}\text{C}_{\text{CO}_3}$ results range from -13.6 to -0.7‰ (n = 16). There are two outliers
66 (BM35/L and BM04) with high $\delta^{13}\text{C}_{\text{CO}_3}$ values. BM38 is also an outlier, with a low
67 $\delta^{13}\text{C}_{\text{CO}_3}$ value. When these individuals are excluded the $\delta^{13}\text{C}_{\text{CO}_3}$ results range from -
68 13.6 to -11.1‰, with a mean of -11.8 ± 0.6 ‰ (range = 2.5‰, n = 14).

69

70 The bone collagen $\delta^{13}\text{C}$ results range from -18.4 to -16.6‰, while the $\delta^{15}\text{N}_{\text{bone}}$ results
71 range from 10.9 to 12.3‰ (n = 6). There is one outlier with low values for both

72 $\delta^{13}\text{C}_{\text{bone}}$ and $\delta^{15}\text{N}_{\text{bone}}$. While there is a correlation between $\delta^{13}\text{C}_{\text{bone}}$ and $\delta^{15}\text{N}_{\text{bone}}$ ($r =$
73 0.893 , $p = 0.017$), when the outlier is removed there is no correlation ($r = 0.666$, $p =$
74 0.220). This, combined with the small sample size, suggests that the correlation
75 should be treated with caution.

76

77 The enamel $\delta^{18}\text{O}_{\text{CO}_3}$ results from Bois Marchand range from -5.1 to -2.9‰ ($n = 16$).
78 No outliers were identified.

79

80 **4.3. Comparison between the sites**

81

82 The dentine results show a wide variation at both sites, and they overlap substantially
83 in $\delta^{15}\text{N}_{\text{dentine}}$ values (there is no statistical difference in $\delta^{15}\text{N}_{\text{dentine}}$: $D(21) = 0.411$, $Z =$
84 0.927 , *n.s.*). In $\delta^{13}\text{C}_{\text{dentine}}$, there is notable overlap, but this mainly relates to an outlier
85 from each site. In general, there is a tendency for the individuals buried at Le Morne
86 to have higher $\delta^{13}\text{C}_{\text{dentine}}$ than those from Bois Marchand, with a statistically
87 significant difference between the two sites ($D(21) = 0.661$, $Z = 1.491$, $p = 0.023$,
88 outliers included).

89

90 With the exception of the two high $\delta^{13}\text{C}_{\text{CO}_3}$ outliers from Bois Marchand, the results
91 from the two sites show no overlap in enamel $\delta^{13}\text{C}_{\text{CO}_3}$ values and the means of the
92 two sites are statistically different ($D(22) = 0.875$, $Z = 1.931$, $p = 0.001$, outliers
93 included).

94

95 The bone collagen results from the two sites are clearly and statistically different in
96 both $\delta^{13}\text{C}_{\text{bone}}$ ($D(15) = 1.00$, $Z = 1.936$, $p = 0.001$) and $\delta^{15}\text{N}_{\text{bone}}$ ($D(15) = 0.833$, $Z =$
97 1.614 , $p = 0.011$).

98

99 The enamel $\delta^{18}\text{O}_{\text{CO}_3}$ data from the two sites are very similar and there is no statistical
100 difference between them ($t(21) = -0.337$, *n.s.*). While there is a larger range in values
101 at Bois Marchand than Le Morne (2.2‰ as compared to 1.2‰), this is likely related
102 to the differences in sample size.

103

104 **5. Discussion**

105

106 **5.1. Le Morne**

107

108 The dentine and enamel $\delta^{13}\text{C}$ results indicate that during childhood the people buried
109 at Le Morne ate a wide range of diets in terms of the proportion of C_3 and C_4
110 resources; some individuals (e.g. STR008) consumed a diet primarily based on C_3
111 resources, while others (e.g. STR033/L) consumed large proportions of C_4 or marine
112 foodstuffs – although individuals that died as children are included in these analyses,
113 we note that none of these individuals have either the highest or lowest values in
114 terms of $\delta^{13}\text{C}_{\text{dentine}}$ or $\delta^{13}\text{C}_{\text{CO}_3}$. Given that the $\delta^{13}\text{C}_{\text{CO}_3}$ data suggests the consumption
115 of C_4 carbohydrate, it is reasonable to conclude that these individuals were consuming
116 C_4 plants, as opposed to consuming primarily animals fed upon C_4 plants or marine
117 foods. Given the historical evidence it is likely that this reflects maize consumption
118 (Grant, 1801; Allen 1999). It is also possible, however, that some or all of the C_4
119 consumption reflects sugar cane both directly consumed and animals fed on waste
120 products from sugar production. Indeed the high prevalence of caries and abscesses,

121 noted above, may support the human consumption of sugar cane, as high sugar use
122 may be connected to poor dental health. The $\delta_{15}\text{N}_{\text{dentine}}$ data also shows a wide range
123 of values; one individual's (STR33/L) $\delta_{15}\text{N}_{\text{dentine}}$ values were sufficiently low
124 ($\delta_{15}\text{N}_{\text{dentine}} = 6.4\text{‰}$), and indeed, substantially lower than the other individuals (4.6‰
125 lower than the mean), that they must have consumed little or no animal protein during
126 childhood (note that no animals were included in the batch during processing)
127 (Bocherens and Drucker, 2003, Hedges and Reynard, 2007, O'Connell et al., 2012).
128 While the remaining individuals certainly did consume animal protein during
129 childhood, there is variation in the proportion they consumed, although some of this
130 variation likely relates to the trophic effect of breastfeeding.

131
132 The bone collagen stable isotope data shows a different pattern, with a main group of
133 individuals who consumed similar diets that included a significant proportion of C₄
134 resources and less variation in the proportion of animal protein in the adult diet. This
135 group includes four out of the five children. Two outlying individuals (STR025, 3–5
136 years, and STR33/U, an adult) consumed diets that were predominantly based on C₄
137 resources.

138
139 These results, combined with the generally large differences between dentine and
140 bone isotope results from the same individuals, are consistent with a population that
141 lived separately as children and then came to live, and eat, together during life. When
142 one considers the life histories of the adult individuals, we can see that there are some
143 individuals who ate a higher proportion of C₄ foods during childhood than later in life
144 (STR007, STR033/L), while others who consumed little C₄ during childhood but a
145 higher proportion later in life (STR001, STR008). Individual STR33/U also shows an
146 increase in the proportion of C₄ foods they consumed during life, and during
147 adulthood their diet contained more C₄ than most of the other individuals. It is
148 possible that this individual was a recent arrival to Le Morne who died before their
149 bone had had enough time to remodel and reflect the new dietary conditions in this
150 region.

151
152 Individual STR33/L (mid to old adult, female; biological sex confirmed by aDNA
153 analysis: Fregel, unpublished results) stands out as having had the most pronounced
154 change in diet during life; during childhood they ate a diet very low in animal protein
155 but very high in C₄ plants (presumably maize), while during adulthood the proportion
156 of animal protein in their diet increased, and their consumption of C₄ plants
157 decreased. The aDNA results from this individual suggest that they are most probably
158 of Mozambican ancestry (Fregel et al 2014; Seetah 2015b). It is tempting to speculate
159 that this individual was enslaved during childhood, but came to live at Le Morne
160 some years before death.

161
162 In general, the children's $\delta_{13}\text{C}$ results show consistency in the proportion of C₄
163 consumed between dentine and bone collagen, as would be expected. The individual
164 with outlying $\delta_{13}\text{C}_{\text{bone}}$ data (STR025), also showed relatively high $\delta_{13}\text{C}$ enamel and
165 dentine results. This suggests either that they were born and lived locally but
166 consumed a diet different from that of the rest of the population, or that they were
167 brought to Le Morne close to or after death. The latter scenario fits with the oral
168 history tradition that Le Morne was a safe location for burial (Seetah 2016). There is
169 some intra-individual variation in the children's $\delta_{15}\text{N}_{\text{dentine}}$ and $\delta_{15}\text{N}_{\text{bone}}$ values, likely
170 related to the varying timing of tissue formation, different amounts of turnover and

171 differences in breastfeeding practices. The peri-natal twins buried in STR006 show
172 indistinguishable isotope results (bone only) that reflect the diet of their mother
173 during her pregnancy, which was typical of the population buried at Le Morne.
174

175 The $\delta_{18}\text{O}_{\text{CO}_3}$ results provide no evidence for migrants within this group, however we
176 note that there is significant overlap in $\delta_{18}\text{O}$ values of rainfall in Mauritius and
177 Madagascar (IAEA/WMO 2019). It is therefore not possible to distinguish between
178 these individuals being enslaved people born in Madagascar, and these individuals
179 being free-born Mauritians.
180

181 **5.2. Bois Marchand**

182

183 The dentine and enamel $\delta_{13}\text{C}$ results indicate that during childhood the people buried
184 at Bois Marchand ate a fairly wide range of diets. The $\delta_{13}\text{C}_{\text{CO}_3}$ results form a tighter
185 main cluster of data than the $\delta_{13}\text{C}_{\text{dentine}}$ dataset. This suggests that while this main
186 $\delta_{13}\text{C}_{\text{CO}_3}$ group consumed relatively little C_4 carbohydrate, they also ate varying
187 proportions of C_4 protein (i.e. animals fed on C_4 foods) or marine resources. This
188 main group also shows a fairly large range in $\delta_{15}\text{N}_{\text{dentine}}$ results, with some individuals
189 consuming more animal or marine protein than others (note that the teeth analysed
190 here are unlikely to have a trophic effect from breastfeeding). It is therefore likely that
191 a combination of C_4 protein and marine resources were consumed, with individuals
192 consuming different proportions of these two resource types.
193

194 There are four individuals who consumed different diets to this main group.
195 Individuals BM33/L and BM36/L have outlying $\delta_{15}\text{N}_{\text{dentine}}$ results, suggesting that
196 they consumed a lower proportion of animal and marine protein than the other
197 analysed individuals. Both of these individuals were the lower individuals in double
198 burials and both buried in corrugated iron coffins. BM04 has high and statistically
199 outlying $\delta_{13}\text{C}_{\text{enamel}}$ and $\delta_{13}\text{C}_{\text{dentine}}$ values but typical $\delta_{15}\text{N}_{\text{dentine}}$ values indicating that
200 during childhood they consumed a higher proportion of C_4 resources than the other
201 individuals analysed from Bois Marchand. Individual BM35/L has extremely high
202 $\delta_{13}\text{C}_{\text{CO}_3}$, $\delta_{13}\text{C}_{\text{dentine}}$ and $\delta_{15}\text{N}_{\text{dentine}}$ values (all of which are statistical outliers),
203 suggesting that they consumed a diet largely based on marine resources combined
204 with C_4 or marine carbohydrate, presumably maize. We note that high $\delta_{15}\text{N}$ values
205 can also be caused by prolonged starvation (Mekota et al., 2006), however given that
206 the enrichment is seen in both collagen carbon and nitrogen and therefore likely
207 reflects the protein component of the diet, and that the magnitude of the enrichment is
208 large, a marine diet is a more parsimonious explanation. This individual was buried in
209 a manner inconsistent with the other excavated individuals. The body was orientated
210 with the head towards the west, rather than the east; furthermore, the head was
211 separated from the rest of the body and placed in the south-western corner of the
212 grave, with the mandible and teeth scattered over the upper part of the skeleton. While
213 it is difficult to form a conclusion about what this represents, it is clear that this
214 individual was different in life and in death (cf. Parker Pearson, 1999, Reynolds,
215 2009, Gregoricka et al., 2017).
216

217 Very few bone samples were available for analysis due to the poor preservation
218 conditions. In general, the analysed bone isotope results are consistent with the
219 dentine data in that most individuals consumed a small proportion of C_4 protein, and

220 one individual (BM03/L, adult, unknown sex, bone collagen data only) consumed a
221 diet that had less C₄ than the other analysed individuals. It is likely that the
222 differences in ranges between dentine and bone $\delta_{13}\text{C}$ and $\delta_{15}\text{N}$ relates to the difference
223 in sample size.

224

225 As with Le Morne, the $\delta_{18}\text{O}_{\text{CO}_3}$ results provide no evidence for migrants within this
226 group. This is surprising given the historical evidence for the wide range of origins for
227 the people buried in the cemetery. When one compares the modern precipitation
228 oxygen isotope values from Mauritius to those from India and South Asia, these data
229 indicate that, although there is overlap, the range of values found in South Asia is
230 notably greater than would be expected for Mauritius (IAEA/WMO 2019). One
231 would not therefore expect to be able to identify all migrants, but migrants from some
232 areas of South Asia should in theory be identifiable, if present.

233

234 **5.3. Comparison between Le Morne and Bois Marchand**

235 The isotopic data from Le Morne and Bois Marchand show that a wide range of diets
236 were consumed on Mauritius in the nineteenth century. Most people consumed some
237 C₄ resources, although the proportion of the diet that this represented varied widely.
238 There is some evidence for the use of marine resources at Bois Marchand, but there is
239 only one individual (BM35/L) from either site who consumed significant quantities of
240 marine resources, despite the historical evidence for fishing. The historical evidence
241 discussed above indicates that the diet was likely quite poor and subject to shortages.
242 The isotopic evidence for the consumption of a range of isotopically distinct diets on
243 Mauritius, fits well with the idea that people had differential access to the limited
244 available resources based upon, presumably, where and when they lived, their
245 occupation and their social status.

246

247 The people buried at the two sites clearly consumed different diets during life – the
248 sites are statistically different in $\delta_{13}\text{C}_{\text{dentine}}$, $\delta_{13}\text{C}_{\text{CO}_3}$, $\delta_{13}\text{C}_{\text{bone}}$ and $\delta_{15}\text{N}_{\text{bone}}$. While there
249 are exceptions, the people buried at Le Morne generally consumed a higher
250 proportion of C₄ foods during childhood and adulthood than the people at Bois
251 Marchand. The two sites also differ in the proportion of animal protein consumed,
252 with the people buried at Bois Marchand tending to have a higher proportion of
253 animal protein and/or marine resources in their diet than individuals buried at Le
254 Morne. We note, however, that due to the lack of faunal samples it is not possible to
255 exclude the possibility that isotopic baselines varied through time and space.
256 Nevertheless, the isotopic difference is consistent with the osteological evidence
257 noted above that the individuals buried at Le Morne had compromised immunity and
258 chronic illnesses, and were relatively short in stature.

259

260 The Le Morne cemetery is approximately 30 years earlier in date than Bois
261 Marchand, so it may be that the Mauritian diet changed through time with decreasing
262 maize (or other C₄) consumption and increased access to animal protein and/or marine
263 resources. It is likely that with the end of slavery the consumption of maize would
264 have declined, as former enslaved people had more time and land available post-
265 emancipation to grow a range of crops and raise animals, rather than being forced to
266 rely on maize for sustenance. The isotopic data also fit with the historical evidence for
267 increased use of animals for traction as sugar production expanded, as these animals
268 would eventually have been consumed as meat (Joglekar et al., 2013).

269

270 Nevertheless, given the archaeological context of the sites, issues of time and identity
271 cannot be clearly separated; it also seems likely that these dietary differences reflect
272 the social circumstances of the buried individuals. Le Morne is a community cemetery
273 representing people who lived at or near the site, although it remains possible that
274 other former enslaved people or their descendants were buried here if it was seen as a
275 haven for burial. The stable isotope results from Le Morne are consistent with a
276 population including individuals who spent their childhoods in different groups,
277 consuming different foods and who later came together and consumed similar diets
278 (see above). Bois Marchand, on the other hand, was used as a burial ground for a
279 much wider area of the island and for a cross-section of the population. Although
280 hampered by the lack of bone samples available for analysis, this dataset is consistent
281 with a burial population drawn from different social groups with access to the same
282 suite of resources but utilizing them in different ways.

283

284 It is likely that a combination of both chronology and circumstances of birth explains
285 the differences between the two sites. Further research is needed, particularly in terms
286 of numbers of individuals available for analysis, before more firm conclusions can be
287 drawn. Nevertheless, it is clear that the subsistence strategies undertaken by
288 nineteenth century Mauritians varied through time, with location and with
289 circumstances of birth, such that although a range of resources were, in theory,
290 available to people on the island, the proportions of the different resources actually
291 consumed was different for different people.

292

293

6. Conclusion

294

295 Isotopic analyses of people buried in two Mauritian cemeteries have revealed
296 interesting insights into lifeways in nineteenth century Mauritius. Although sample
297 size is small, it is clear that the people buried at Le Morne consumed different diets
298 during childhood and adulthood to the people buried at Bois Marchand. It is likely
299 that these differences relate both to the date of the cemeteries and to the circumstance
300 of birth of the people buried in them. This study has shown a much more nuanced
301 picture of diet in Mauritius at this time. The research complements and enriches the
302 historic narrative, adding dimensions to small islands that would otherwise remain
303 obscure in the absence of rigorous scientific assessment of archaeological finds.

304

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321

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Appendix 1

Sample	Site Code	Grave	Context	Tooth	Bone	Age	Sex	Dentine $\delta_{13}C$ (‰)	Dentine $\delta_{15}N$ (‰)	Dentine C:N ratio	Dentine collagen yield (%)	Dentine mean $\%C$	Dentine mean $\%N$	Enamel $\delta_{13}C_{org}$ (‰)	Enamel $\delta_{15}N$ (‰)	Bone $\delta_{13}C$ (‰)	Bone $\delta_{15}N$ (‰)	Mean bone C:N ratio	Bone collagen yield (%)	Bone mean $\%C$	Bone mean $\%N$	Single or multiple burial	Grave goods	Coffin*	Comments
STR001	LEM10	STR1	SU08	ULC	Rib	17-19	Female	-15.8	10.8	3.1	16.0	47.1	17.6	-7.8	-3.9	-13.9	10.6	3.2	12.4	46.0	17.0	Single burial	4 mother-of-pearl buttons; 1 porcelain fragment	Wooden coffin with iron nails	
STR006_7	LEM10	STR6	SU12	no teeth	Rib	peri-natal	Juvenile (twins)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-14.1	11.7	3.3	3.2	38.5	13.7	Double burial	No grave goods found	Wooden coffin with iron nails - both infants were buried in one coffin	
STR006_8	LEM10	STR6	SU13	no teeth	Rib	peri-natal	Juvenile (twins)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-14.2	11.8	3.4	4.7	40.5	14.1	Double burial	No grave goods found	Wooden coffin with iron nails - both infants were buried in one coffin	
STR007	LEM10	STR7	SU19	URM1	Rib	25-30	Female	-10.9	11.5	3.1	11.5	43.7	16.2	-6.5	-4.6	-14.8	11.4	3.2	3.9	41.9	15.2	Single burial	1 fabric bag of 4 silver coins	Wooden coffin with iron nails	
STR008	LEM10	STR8	SU25	ULM2	Rib	40+	?Male	-17.7	12.4	3.1	15.9	45.1	16.7	-10.9	-4.9	-14.7	10.7	3.2	4.9	43.6	15.8	Single burial	5 mother-of-pearl buttons	Wooden coffin with iron nails	
STR025	LEM10	STR25	SU29	LLM2	Rib	3-5	Juvenile	-12.5	10.8	3.2	6.2	43.7	15.8	-6.5	-4.3	-12.1	10.5	3.2	5.4	44.5	16.0	Single burial	No grave goods found	Wooden coffin with iron nails	
STR029	LEM10	STR29	SU34	I	Rib	2-4	Juvenile	-14.4	13.1	3.2	14.3	43.1	15.9	n.d.	n.d.	-14.4	11.7	3.2	18.4	47.0	17.2	Single burial	2 mother-of-pearl buttons	Wooden coffin with iron nails	
STR030	LEM10	STR30	SU37	LRM2	Rib	3-4	Juvenile	-14.5	11.9	3.2	9.5	42.4	15.6	-10.4	-3.8	-14.7	10.7	3.3	2.0	44.3	15.8	Single burial	2 mother-of-pearl buttons	Wooden coffin with iron nails	
STR033_U	LEM10	STR33/upper	SU41	LLM3	Rib	25-30	?Female	-14.8	11.3	3.1	15.8	46.7	17.3	-10.6	-4.1	-11.4	10.1	3.2	4.7	33.8	12.4	Double burial	1 green glass bottle	No coffin	
STR033_L	LEM10	STR33/lower	SU42	LLC	Rib	mid/old adult	?Female	-10.9	6.4	3.2	15.9	46.3	17.1	-3.7	-3.7	-14.6	10.9	3.3	4.6	39.5	14.2	Double burial	1 iron object	No coffin	
BM01	BM11	G1	SU26	Left P	Rib frag	16-18	Unobservable	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-11.8	-4.5	-17.5	12.0	3.3	3.3	31.5	11.3	Single burial	1 bone button, 2 bronze rings, 1 silver ring	Metal lined wooden coffin	
BM02/U	BM11	G2Upper	SU29	LLP 17	rib frag	Adult (7older adult)	Female	-17.2	12.0	3.2	14.2	46.9	17.3	-11.1	-4.9	-16.6	12.3	3.2	5.6	43.1	15.8	Double burial	No grave goods found	Wooden and lead lined coffin with iron nails and decorative metal bosses	
BM03/L	BM11	G3Lower	SU37	No suitable teeth	rib frag	Adult	Unobservable	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-18.3	10.8	3.2	5.0	42.2	15.2	Double burial	No grave goods found	Metal lined wooden coffin	
BM03/U	BM11	G3Upper	SU25	UP	Vert	13-15	Unobservable	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-12.2	-4.3	-17.2	12.0	3.2	1.0	27.7	9.8	Double burial	1 metal (iron) key	Metal lined wooden coffin	
BM04	BM11	G4	SU20	LLP2	L rib	Adult	?Male	-13.6	11.7	3.2	15.7	48.0	17.7	-6.8	-4.7	-17.3	12.2	3.3	1.5	29.8	10.6	Single burial	No grave goods found	Wooden coffin with iron nails	
BM05	BM11	G5	SU24	ULP2	Rib frag	18-25	Unobservable	-17.1	12.4	3.1	15.8	47.9	17.8	-11.3	-3.3	-17.0	12.0	3.2	14.2	48.0	17.7	Single burial	1 bronze coin, bottom of grave, under the coffin	Metal lined wooden coffin	
BM033	BM15	G33	SU393	Molar	No bone	Young adult	Male	-17.7	11.2	3.2	10.5	44.2	16.4	-11.4	-5.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Single burial	1 bronze belt buckle above the head area (a hat?), 1 glass fragment, 1 lead bead at the bottom of the coffin, glass fragment, 1 bone button	Wooden coffin with 145 iron nails	
BM033L	BM15	G33L	SU415	Molar	No bone	Adult	Unobservable	-17.7	9.9	3.2	14.9	43.5	16.0	-11.6	-5.1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Double burial	1 glass fragment, 1 bronze pin.	Metal coffin	
BM034L	BM15	G34L	SU424	Premolar	No bone	Mature adult (>30)	Unobservable	-16.2	11.7	3.1	16.9	45.9	17.1	-11.5	-3.4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Double burial	No grave goods found	Wooden coffin with 60 iron nails	
BM035	BM15	G35	SU395	Molar	No bone	Mature adult (>40)	Male	-17.4	12.6	3.1	18.2	61.5	22.7	-11.6	-3.6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Double burial	10 bone buttons, 2 earrings, 1 metal button, 1 glass bead	Wooden coffin with 77 iron nails	
BM035L	BM15	G35L	SU412	Premolar	No bone	Adult	Unobservable	-9.1	15.7	3.1	14.3	44.4	16.5	-0.7	-2.9	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Double burial	No grave goods found	Wooden coffin with 80 iron nails	Unusual burial - see text
BM036	BM15	G36	SU397	Molar	No bone	Adult	Male	-16.5	12.8	3.2	16.1	44.2	16.4	-11.3	-4.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Double burial	1 bronze pin	Metal coffin	
BM036L	BM15	G36L	SU417	Incisor	No bone	Adult	Unobservable	-17.7	9.4	3.2	11.4	43.1	15.8	-11.4	-4.2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Double burial	1 metal bead	Metal coffin	
BM037	BM15	G37	SU407	Molar	No bone	Adult	?Female	-17.3	12.0	3.1	15.7	45.9	17.1	-11.6	-4.1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Single burial	1 metal chain with white beads - probably a rosary, 1 copper object, 1 bronze pin	Metal coffin	
BM037L	BM15	G37L	SU421	Molar	No bone	Adult (<40)	Unobservable	-15.7	13.1	3.1	17.2	46.2	17.2	-12.1	-4.5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Double burial	1 bone button	Wooden coffin with 76 iron nails	
BM038	BM15	G38	SU408	Molar	No bone	Adult (<40)	?Female	-18.3	11.7	3.1	12.9	46.9	17.5	-13.6	-4.8	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Single burial	1 glass bottle, 2 bronze pins in the chest area, 4 bone buttons	Wooden coffin with 94 iron nails	
BM039	BM15	G39	SU413	Molar	No bone	Adult (<40)	Female	-16.7	12.8	3.1	14.3	45.8	17.0	-11.9	-5.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Single burial	1 bone button, 1 metal coffin boss	Metal coffin	

526 **Appendix 2**

527 Carbon and nitrogen isotopic and elemental compositions were determined using
 528 Costech elemental analyser coupled in continuous flow to a Finnigan isotope ratio mass
 529 spectrometer in the Godwin Laboratory (University of Cambridge). Stable carbon and
 530 nitrogen isotope compositions were calibrated relative to VPDB ($\delta^{13}\text{C}$) and AIR ($\delta^{15}\text{N}$)
 531 using the standards listed in Table S1.

532 **Table S1.** Standard reference materials.

Standard	Material	Mean $\delta^{13}\text{C}$ (‰, VPDB)	Mean $\delta^{15}\text{N}$ (‰, AIR)
L-alanine	Alanine	-26.9	-1.4
IAEA-600	Caffeine	-27.5	+1.05
USGS-40	Amino acid	-26.2	-4.5
Protein 2	Protein standard OAS	-26.95	6.0
EMC	Caffeine	-35.85	-2.5

533

534 Table S2 presents the means and standard deviations of the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for
 535 standards as well as the number of standards included in each analytical session.

536 **Table S2.** Mean and standard deviation of all check and calibration standards for all
 537 analytical sessions containing data presented in this paper.

538

Session ID	Standard	n	$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{15}\text{N}$ (‰, AIR)
Session 1	Alanine	3	-26.90 ± 0.06	-1.50 ± 0.06
Session 2	Alanine	3	-26.89 ± 0.00	-1.48 ± 0.03
Session 3	Alanine	3	-26.96 ± 0.05	-1.43 ± 0.02
Session 4	Alanine	10	-26.91 ± 0.05	-1.47 ± 0.03
Session 5	Alanine	10	-26.93 ± 0.06	-1.46 ± 0.05
Session 6	Alanine	7	-26.89 ± 0.11	-1.44 ± 0.04
Session 7	Alanine	6	-26.89 ± 0.04	-1.47 ± 0.03
Session 8	Alanine	9	-26.90 ± 0.04	-1.44 ± 0.04
Session 9	Alanine	6	-26.88 ± 0.04	-1.42 ± 0.13
Session 1	Caffeine	3	-27.48 ± 0.05	1.11 ± 0.03
Session 2	Caffeine	3	-27.48 ± 0.05	1.13 ± 0.02
Session 3	Caffeine	3	-27.48 ± 0.03	1.19 ± 0.01
Session 4	Caffeine	6	-27.62 ± 0.07	1.13 ± 0.07
Session 5	Caffeine	6	-27.59 ± 0.07	1.12 ± 0.07
Session 6	Caffeine	6	-27.55 ± 0.05	1.08 ± 0.08
Session 7	Caffeine	6	-27.54 ± 0.05	1.06 ± 0.07
Session 8	Caffeine	6	-27.53 ± 0.04	1.06 ± 0.03
Session 9	Caffeine	3	-27.55 ± 0.08	1.02 ± 0.18
Session 1	USGS-40	3	-26.12 ± 0.04	-4.56 ± 0.01
Session 2	USGS-40	1	-26.13	-4.49
Session 3	USGS-40	3	-26.14 ± 0.03	-4.43 ± 0.06
Session 4	USGS-40	6	-26.17 ± 0.07	-4.43 ± 0.08
Session 5	USGS-40	5	-26.10 ± 0.07	-4.43 ± 0.13
Session 6	USGS-40	6	-26.12 ± 0.03	-4.51 ± 0.05

Session 7	EMC	3	-35.87 ± 0.04	-2.54 ± 0.01
Session 8	EMC	3	-35.87 ± 0.03	-2.58 ± 0.05
Session 9	EMC	3	-35.94 ± 0.05	-2.57 ± 0.14
Session 7	Protein 2	7	-26.98 ± 0.04	6.05 ± 0.04
Session 8	Protein 2	7	-26.98 ± 0.03	6.08 ± 0.06
Session 9	Protein 2	4	-26.94 ± 0.06	6.08 ± 0.28

539

540 All of the samples were analyzed in triplicate, the results of which are presented in
541 Table S3.

542 **Table S3.** Triplicate stable carbon and nitrogen isotopic compositions for all samples.

Sample	$\delta^{13}\text{C}_a$	$\delta^{13}\text{C}_b$	$\delta^{13}\text{C}_c$	$\delta^{15}\text{N}_a$	$\delta^{15}\text{N}_b$	$\delta^{15}\text{N}_c$
BM05	-17.01	-16.94	-17.10	12.00	11.95	12.04
BM04	-17.35	-17.33	-17.31	12.14	12.16	12.23
BM03L	-18.32	-18.34	-18.38	10.84	10.83	10.87
BM03U	-17.12	-17.22	-17.33	12.03	12.00	12.02
BM02U	-16.52	-16.44	-16.70	12.25	12.33	12.31
BM01	-17.58	-17.43	-17.57	11.96	12.01	12.08
BMD02	-17.28	-17.14	-17.21	11.92	12.06	11.89
BMD04	-13.71	-13.61	-13.62	11.66	11.79	11.74
BMD05	-17.13	-17.15	-17.09	12.39	12.42	12.40
BMD33	-17.77	-17.74	-17.73	11.20	11.29	11.11
BMD33L	-17.73	-17.64	-17.71	9.94	9.98	9.81
BMD34L	-16.22	-16.15	-16.21	11.79	11.80	11.66
BMD35	-17.52	-17.50	-17.28	12.57	12.58	12.52
BMD35L	-9.05	-9.01	-9.12	15.70	15.76	15.53
BMD36	-16.52	-16.43	-16.49	12.96	12.98	12.57
BMD36L	-17.73	-17.68	-17.72	9.46	9.53	9.34
BMD37	-17.37	-17.20	-17.32	12.07	12.05	11.98
BMD37L	-15.72	-15.65	-15.62	13.04	13.13	12.99
BMD38	-18.30	-18.29	-18.32	11.67	11.74	11.59
BMD39	-16.78	-16.71	-16.70	12.84	12.94	12.74
STR001	-13.94	-13.90	-13.99	10.68	10.57	10.66
STR006_7	-14.05	-14.02	-14.10	11.60	11.71	11.73
STR006_8	-14.38	-14.13	-14.21	11.70	11.75	11.82
STR007	-14.89	-14.82	-14.83	11.33	11.32	11.43
STR008	-14.66	-14.64	-14.65	10.68	10.60	10.79
STR025	-12.10	-12.12	-12.10	10.47	10.56	10.58
STR029	-14.41	-14.40	-14.35	11.71	11.71	11.73
STR030	-14.69	-14.66	-14.66	10.62	10.69	10.71
STR033_U	-11.43	-11.39	-11.40	10.13	10.00	10.13
STR033_L	-14.65	-14.66	-14.57	10.89	10.93	10.92

STRD01	-15.90	-15.78	-15.76	10.72	10.79	10.90
STRD07	-11.02	-10.91	-10.91	11.40	11.48	11.66
STRD08	-17.70	-17.75	-17.70	12.37	12.52	12.28
STRD25	-12.51	-12.51	-12.36	10.83	10.91	10.79
STRD29	-14.44	-14.34	-14.35	13.11	13.16	13.12
STRD30	-14.53	-14.53	-14.57	11.98	11.90	11.84
STRD33_U	-14.92	-14.77	-14.75	11.31	11.25	11.19
STRD33_L	-10.99	-10.96	-10.88	6.60	6.57	5.93

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