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Reading the dental record : a dental anthropological approach to foodways, health and disease, and crafting in the pre-Columbian Caribbean

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CHAPTER 7 TALKIN' TEETH: DISCUSSION

7.1 INTRODUCTION

In this chapter, the results presented in Chapter 6 are discussed within the context of dental anthropological studies worldwide, the individual site contexts, and the broad cultural context of the pre-Columbian Caribbean region. Other lines of evidence for foodways in the region are assessed alongside the results of this study. The chapter is organised along the three major themes of this study: foodways, health and disease, and craft activities. Other aspects that are focussed on and encompass these themes are LSAMAT, dental evidence for individual life histories, and the juvenile role in foodways and crafting. The intra-site chronological differences and the broad scale chronological differences over time throughout the region demonstrated in Chapter 6 are discussed.

7.2 FOODWAYS IN THE PRE-COLUMBIAN CARIBBEAN

7.2.1 Food consistency and preparation techniques

An assessment of the rate of molar wear of the individual sites in this study using the principle axis method shows that there are distinct differences in rate of wear between the seven largest sites in the sample. As the rate of wear is known to be related to food consistency and food preparation techniques, this suggests that diet and/or food preparation techniques differed per site. At some sites, the rate of wear was found to be clearly more rapid than at other sites. Particularly high rates of wear were observed in Anse à la Gourde, Chorro de Maíta, and Escape. The remaining sites of Lavoutte, Maisabel, Punta Candeleró, and Tutu show lower rates of wear. The high rate of wear group interestingly comprises an Early Ceramic Age site (Escape), a Late Ceramic Age site (Anse à la Gourde), and a Late Ceramic Age/Early Contact period site (Chorro de Maíta), which are distant in both space and time. Anse à la Gourde and Escape are both located on the Atlantic coasts of their respective islands, but Chorro de Maíta is located 4 km inland of the northern coast of Cuba, on the slope of a hill. It is possible that the high rates of wear seen at these sites are related to a marine dietary orientation, since largely marine diets are known to be associated with rapid dental wear (Costa 1980; Jurmain 1990; Eshed et al. 2006; Littleton and Frohlich 1993; Macchiarelli 1989; Pedersen 1949; Sealy and van der Merwe 1988; Sealy et al. 1992; Smith 1972; Walker 1978; Turner and Cadien 1969). Despite their differing spatial and temporal distribution, marine foods could have been accessed at all three sites, and for Anse à la Gourde evidence has been found for the consumption of a large proportion of marine and terrestrial protein foods (Laffoon 2012; Laffoon and de Vos 2011; Stokes 1998). At Escape, it is likely that marine and terrestrial protein foods formed the major component of the diet, considering the location of the site and the very low caries rate, and low rates of other dental pathology observed in this study. Marine dominated diets,

which contain lots of grit and other contaminants, are thought to be characterized by a high degree and frequency of chipping (Jurmain 1990; Walker and Erlandson 1986). Comparison of the degree and frequency of chipping of these three sites reveals that while Anse à la Gourde shows a high degree and rate of chipping, Chorro de Maíta shows a low degree and frequency. Escape shows a relatively low degree and frequency of chipping in general, but was excluded from statistical comparisons due to poor preservation of the material.

Caries rates at the three sites differ significantly, with Anse à la Gourde and Chorro de Maíta both showing high rates (particularly the former), indicating a large proportion of carbohydrates in the diet, but Escape showing a very low rate, suggesting cariogenic plant foods comprised a much less important part of the diet. Little is known of the precise food preparation techniques which were used at Anse à la Gourde, Chorro de Maíta, and Escape. Stone grinding tools have been found at Anse à la Gourde (Corinne Hofman, personal communication 2012), and starch grains of maize, beans and cocoyam recovered from the dental calculus of a number of individuals from this site revealed evidence of pressure treatment (grinding) and heat treatment. Similarly, starch grains recovered from dental calculus from a small number of individuals from Chorro de Maíta and Escape showed evidence of pressure and heat treatment (Mickleburgh and Pagán Jiménez 2012, Jaime Pagán Jiménez, personal communication 2013). Based on this information, it is hard to assess whether substantial differences in food preparation techniques would have been present at the three sites. Together, the data discussed above seem to indicate that the cause of the high rates of dental wear observed in Anse à la Gourde, Chorro de Maíta, and Escape, may have been different at each site; spatial and temporal differences, as well as different chipping rates and caries rates, suggest variation in foodways.

The remaining sites of Lavoutte, Maisabel, Punta Candelerero, and Tutu, which show lower rates of wear, show a slightly smaller spatial distribution, and overlap considerably in time. Lavoutte, Maisabel, and Punta Candelerero are situated on or very close to the coast, while Tutu is located slightly further inland. Nonetheless, marine foods were also exploited at Tutu, as evidenced by bone isotope and faunal analyses at the site (Wing et al. 2002; Norr 2002). Caries rates at these four sites do not differ significantly, and all fall within the medium range. These apparent similarities may go some way in explaining the lower rates of wear at these sites, but although the rates of wear are lower than at Anse à la Gourde, Chorro de Maíta, and Escape, they also differ among each other. Punta Candelerero and Tutu show very similar rates, as do Lavoutte and Maisabel. Moreover, chipping degree and frequency differs between these sites too. Thus, although the differences between these low wear rate sites are less distinct, there does appear to be some variation between them, suggesting that foodways differed per site. It appears that the communities at each individual settlement adapted their foodways to their particular surroundings (i.e., local environment and ecology) as previously argued by Newsum and Wing (2004).



Figure 7.1 Map of the Caribbean showing the two groups based on the predominant direction of molar wear and occlusal surface shape (Pepijn van der Linden and Hayley L. Mickleburgh).

Type 1: (1) Chorro de Maíta, Cuba (2) Punta Macao, Dominican Republic (4) Punta Candelero, Puerto Rico (6) Kelbey's Ridge 2, Saba (9) Escape, St. Vincent (10) Manzanilla, Trinidad (11) Canashito, Aruba (12) Savaneta, Aruba.

Type 2: (3) Maisabel, Puerto Rico (5) Tutu, St. Thomas, USVI (7) Anse à la Gourde, Guadeloupe (8) Lavoutte, St. Lucia.

The assessment of the direction of molar wear and occlusal surface shape indicates that there are broadly speaking two types of sites in the sample: those with predominantly horizontal molar wear, with either flat or – less frequently – cupped surface shapes, and those with predominantly oblique molar wear, usually associated with mostly cupped surface shapes. As the direction of molar wear, i.e., the angle of the occlusal surface, is known to become increasingly oblique as the proportion of soft, refined foods in the diet increases (Eshed et al. 2006; Lubell et al. 1994; Smith 1984), and the shape of the occlusal surface is known to become ‘hollowed out’, or cupped, as the result of soft, refined foods containing small particles of grit or stone from grinding tools (Chattah and Smith 2006; Kaidonis 2008; Lubell et al. 1994; Smith 1984)(see also Chapter 2, section 2.2.2), this suggests a broad division in sites where: (1) food was tough, requiring puncture-crushing, but with a substantial component of refined foods which may have been stone ground or contain particles of dust, and where (2) relatively refined foods were consumed, which required little puncture-crushing and predominantly tooth on tooth contact chewing, likely containing dust or small particles from grinding implements. The majority of sites fall in the first category. On inspection of the regional and temporal distribution (Figure 7.1; see also Chapter 5), we see that for both major types of wear site locations would have allowed direct or (relatively)

easy access to marine foods (both reef and pelagic), and often fresh water (riverine) foods too. All have relatively easy access to terrestrial resources, and both groups contain sites that are positioned on exceptionally good (fertile) land for plant cultivation. Both groups contain sites from the Early and Late Ceramic Ages; only the type 2 group contains an Archaic site (Canashito), although with regards to absolute dating this site is contemporary with the Early Ceramic Age. Thus, it appears that the two types of wear are not strictly associated with a particular site setting (e.g., directly on the coast or somewhat inland) or time period. It is likely that the differences in the patterns of molar wear between the sites are the result of differing sociocultural choices, with individual communities choosing to adapt to and exploit the locally available resource in their own way.

The possibility that dental erosion may falsely indicate the inclusion of soft, refined foods with stone particles or grit in the diet, as it similarly produces cupped molar surfaces, was assessed based on criteria outlined by previous studies into the aetiology of dental cupping in archaeological specimens to distinguish between abrasion and erosion (Bell et al. 1998; Ganss 2008; Ganss et al. 2002; Kaidonis 2008; Scheutzel 1996). The dental cupping observed in the sample conforms to the criteria distinguished for cupping caused by abrasion as opposed to erosion. Buccal dental lesions, strongly associated with dental erosion, were not observed in any of the sites, excepting those clearly identified as cement-enamel junction caries. The cupped occlusal molar surfaces were in almost all cases 'shallow'. However, a small number of teeth displays slightly larger, deeper cupping that may reflect an acidic component in the diet. It is known that various fruits, which would have been acidic, were readily available to the indigenous inhabitants of the Caribbean, some of them were even introduced to the archipelago by the first migrants to the area (see Chapter 3). Furthermore, it is known from ethnohistory that cassava and/or maize beer was an important fermented beverage consumed during feasts and ritual occasions (Benzoni 1857). Fermented beverages such as chicha (both maize and cassava variety) and masato generally have low pH levels (Pezo Lanfranco and Eggers 2010), and thus when consumed regularly can damage enamel and eventually dentine through acid erosion. Also, as discussed in detail in section 7.5, a form of LSAMAT distinguished in this study appears to have resulted from dental erosion. Although it is not yet clear whether this pattern of erosion was caused by intrinsic or extrinsic acids, it is clear that this type of acid erosion was an issue for a considerable number of individuals in the sample. Therefore, while the overall evidence indicates that the presence of molar dental cupping in the sample reflects abrasion by relatively refined foods, it is likely that a component of acidic foods in the diet contributed to the rapid wear and cupped surface shapes.

7.2.2 Carbohydrate consumption

Caries rates vary significantly between the site assemblages, suggesting variation in carbohydrate consumption at the sites. The caries rates in themselves – whether tooth count or individual count – do not always offer straightforward indications of

the proportions of carbohydrates in the diet. Population age profiles, ante mortem tooth loss, rate of wear, food consistency and preparation techniques (especially softness and stickiness of carbohydrate foods), differential preservation of dental elements, and oral hygiene practices all influence caries prevalence. Nonetheless, the significant differences based on simple tooth count method that were found in this study in all cases were supported upon further analysis of the caries rates by age group, tooth class, and sex, with the exception of significant differences between males and females at the site of Maisabel, which upon closer examination of the differences were found to be the result of differing population age profiles between the sexes. As such, the simple tooth count method was found to be very effective in the comparisons required in this study.

| Caries ranges | % | | |
|--------------------|-----------------|---------------|-----------------|
| | Low | Medium | High |
| Study | Hunter-gatherer | Mixed economy | Agriculturalist |
| Koca et al. 2006 | 1.00-2.00 | 3.00-5.00 | 5.60-16.00 |
| Milner 1984 | 0.40-7.80 | | 4.50-43.40 |
| Larsen et al. 1991 | < 7.00* | | > 7.00* |
| Turner 1979 | 0.00-5.30 | 0.44-10.30 | 2.30-26.90 |
| This study | 0.00-4.55 | 9.33-14.77 | 19.89-35.29 |

Table 7.1 Example comparison of caries ranges previously established in studies worldwide, and those established in the current study. *Respectively with and without maize consumption.

Based on the caries rates per site, a scale of caries ranges was established for skeletal populations in the region, which is based on statistically significant differences between caries rates observed at the different sites in this study (Table 7.1). The distinguished ranges are 0.00–4.55% (low), 9.33–14.77% (medium), and 19.89–35.29% (high). These ranges were established using the simple tooth count method, and are therefore simple and easy to compare with the results of other or future studies. Other studies of caries rates in the region are relatively sparse. Table 7.2 presents an overview of the caries rates or other information regarding caries frequency from other studies in the Caribbean archipelago. Comparison of these results with those obtained in the current study reveals that the Ceramic Age sites in the Bahamas, Carriacou, the Dominican Republic and Haiti, and Puerto Rico show similarly high caries rates to some of those documented in this study. The Lithic/Archaic Age sites of Canímar Abajo, and Solapa de Sílex, show very high caries rates, while Cienfuegos shows a very low rate, suggesting that in this earlier period (in Cuba at least) starchy, the proportion of consumed cariogenic plant foods varied locally.

| Site | Caries % | | Dating | Source |
|---|---|--|---------------------|--|
| | T.C. | I.C. | | |
| La Caleta, Dominican Republic | Adult: 8.97 Male: 7.00 Female: 12.50 Child: 6.58 | | ± A.D. 1300 | García-Godoy 1980 |
| Manigat Cave, Île de la Tortue, Haiti | Adult: 9.38 | | Meillacoid | Barker 1961 |
| Paso del Indio, Puerto Rico | | Male: 73.90 Female: 71.50 Juveniles: 18.10 Total: 47.30 | | Crespo Torres 2000 |
| Tibes | | Total: 21.00 | | Crespo Torres 2010 |
| Canimar Abajo | "high" | | 4000–1000 B.C.E. | |
| Solapa de Sílex | "high" | | 2987 ±37 B.P. | Crespo and Ji- ménez 2004; Martínez-López et al. 2011 |
| Cienfuegos | 0.86 (adult) | | 2360–1785 B.P. | Rodríguez Montoro 2010 |
| Preacher's Cave, Eleu- thera | 31.60 | 100.00 | A.D. 800–1300 | Schaffer et al. 2012 |
| Grand Bay, Carriacou | 30.80 | | | Cited in Schaffer et al. 2012 |

Table 7.2 Review of caries prevalence in pre-Columbian assemblages from the Caribbean either mentioned in the literature or calculated using published data. T.C. = tooth count. I.C. = individual count.

Comparison of the caries ranges established in this study with caries rates known from studies worldwide (Table 7.1), where subsistence practices have been well-documented both through bioarchaeological research and otherwise, shows that the majority of sites in this study can be characterized as high carbohydrate consumers. In other parts of the globe, groups with such high caries rates would be classed as agriculturalists, i.e., populations with a clear focus on intensive agriculture who obtain the majority of their caloric intake from plant carbohydrates. Only a small number of sites falls into the low range, which is more appropriate for low or moderate carbohydrate consumption. Escape stands out because of its extremely low caries rate in comparison to most other sites in the sample, while the number of individuals in the assemblage is relatively large (thus excluding small sample size as a distorting factor). This indicates that a low proportion of carbohydrates, both starches and sugars, was consumed. When the caries prevalence at Escape is compared to global caries rates, Escape would be classed as a hunter-

gatherer population. Very few faunal remains were recovered at the site and the adjacent sites of Argyle and Argyle 2, most likely due to soil conditions, but the low caries prevalence suggests that the diet was protein oriented. Marine foods would undoubtedly have comprised an important part of the diet, considering the location of the site directly on the coast. The surrounding landscape offers riverine and perhaps small terrestrial fauna. Nonetheless, carbohydrates were not completely absent. The small percentage of caries indicates that they were present in the diet, and a recent study of starch grains trapped in the dental calculus of two of the individuals from Escape revealed starches belonging to Leguminosae (beans), and other unidentified plant starches (Mickleburgh and Pagán Jiménez 2012).

The caries rates in the high range group are indicative of very high proportions of carbohydrates in the diet, including refined, soft, and sticky starches. At these sites carbohydrates would have comprised the staple food, and the manner of preparation would have been of great influence on the overall degree and pattern of dental wear (see section 7.2.1). The medium range group also shows relatively high caries rates (9.33–14.77%), which also indicates a high carbohydrate intake, but may have differed from the high range group in the proportion of carbohydrates consumed, and the manner of preparation. Soft, sticky foods, such as boiled starchy plants, tend to be more cariogenic than tough, abrasive and baked foods (Cohen and Armelagos 1984; Delgado-Darias et al. 2005; Hillson 2001; Klatsky and Klatell 1943; Larsen 1997; Larsen et al. 1991; Lingström et al. 2000; Littleton and Fröhlich 1993; Meiklejohn et al. 1984; Milner 1984; Turner 1979).

Although all of the sites which fall within the high caries range belong to the Late Ceramic Age, the low and medium range consists of both Early and Late Ceramic Age sites. No spatial patterning is apparent in the distribution of low, medium, and high range caries rate sites throughout the archipelago. Moreover, although the majority of the site populations in this study would have consumed a significant proportion of refined (i.e., highly processed) cariogenic plant foods, there is still a considerable degree of variation between the sites. Combined with the variation observed in dental wear and chipping rates observed between the sites (see section 7.2.1), this suggests that foodways varied to some extent locally.

Caries and maize

Studies in other parts of the Americas have demonstrated that caries rates over 7.00% are generally associated with maize consumption, since maize is known to be very cariogenic due to its relatively high natural sucrose content (Larsen 1997; Larsen et al. 1991). Considering the high rates of caries observed in many of the assemblages in this study, the potential contribution of maize to the diet is explored. Maize consumption has recently been established at the sites of Anse à la Gourde, Chorro de Maíta, Escape, Canashito, Juan Dolio, Kelbey's Ridge 2, Malmok, Manzanilla, Point de Caille, Punta Macao, Tanki Flip, and Tutu, through a study of starch grains trapped in dental calculus by the author and palaeobotanist Jaime R. Pagán Jiménez. However, this study also supports previous findings that

a broad spectrum, but locally variable diet was consumed throughout the Caribbean islands between ca. 350 B.C. and A.D. 1600 (Mickleburgh and Pagán Jiménez 2012; Newsom and Wing 2004). A variety of root crops functioned as staple crops in the subsistence economy, although no evidence of a heavy reliance on manioc was found. No evidence was found for restricted access to maize based on status and or age/sex. The crop was mostly eaten ground and baked as bread, instead of in its immature or 'green' state. However, the presence of maize starches in dental calculus does not give any indication of the frequency of its consumption. Since earlier studies indicate that maize was most likely not consumed as a staple crop, maize consumption was concluded to be relatively small-scale, perhaps associated with communal feasting activities, which are currently rarely identified in the archaeological record of the region (Mickleburgh and Pagán Jiménez 2012; Norr 2002; Pestle 2010b; Stokes 1995, 1998).

A recent stable isotope study of human skeletal remains from three Ceramic Age Puerto Rican sites (Punta Candelero, Paso del Indio, and Tibes) revealed that C_4 /CAM plants likely comprised a large portion of the vegetal diet, with an estimated average of $47 \pm 8.1\%$ of dietary energy being provided by C_4 /CAM carbohydrates (Pestle 2010a). However, despite the considerable $\delta^{13}C_{ap}$ enrichment in the majority of individuals, maize was unlikely to have been a staple crop at any or all of these sites, as a number of other C_4 /CAM plants likely contributed to the diet. Similarly, stable isotope analysis of individuals from various sites throughout the Caribbean archipelago found that C_4 plants, including but not limited to maize, contributed relatively little to the overall diet (Laffoon 2012; Laffoon, Valcárcel Rojas, and Hofman 2012; Laffoon and de Vos 2011).

At Tutu, Piperno (2002) found no evidence of maize production or consumption in a study of phytoliths in soil samples. The presence of Marantaceae, Palmae and squash (*Cucurbita* sp.) led her to conclude that the vegetal portion of the diet consisted mainly of tubers and tree crops. A human bone isotopic study revealed a mean bone collagen $\delta^{13}C$ value of $-15.50 \pm 1.80\%$ (s.d. 2), and a mean bone collagen $\delta^{15}N$ value of $12.10 \pm 1.70\%$, predominantly reflecting a large marine component in the protein portion of the diet and the consumption of reef and pelagic fishes (Norr 2002). The mean human bone apatite carbonate $\delta^{13}C$ value is $-10.30 \pm 2.40\%$ (adjusted by Norr to 9.50%), which she interpreted to reflect a diet intermediate between the C_3 plants in the food chain and marine, but based on new evidence for maize consumption at the site (Mickleburgh and Pagán Jiménez 2012), may also reflect a very small component of C_4 plants, such as maize, in the diet.

Stable isotope analysis of human skeletal remains from the site of Grand Bay, Carriacou, revealed that C_4 plants must have comprised a generous proportion of the diet, but maize was concluded not to have comprised a significant proportion of the diet (Stone 2011).

At the Late Ceramic Age site of En Bas Saline, Haiti, maize macroremains were discovered associated with the centrally positioned high-status, elite area of the site, where it is thought that the cacique's residence was situated. The remains

were recovered from what appear to have been feasting pits or communal hearths (Deagan 2004; Newsom 1995; Newsom and Deagan 1994), and the finds were interpreted as evidence for a distinct social significance of (and perhaps restricted access to) maize.

From the above it is clear that the majority of the evidence for maize consumption in the region indicates that although the plant was consumed, access was either restricted based on status, age or gender, or the plant was simply not consumed as a staple food, and consumption may have been associated with feasting and the public domain. Contrastingly, the extremely high caries rates at the some sites in this study, according to research in other parts of the New World, would indicate that maize contributed regularly to the diet. However, it is important to consider the cariogenicity of certain other plant foods and the manner of food preparation (Cucina et al. 2011; Larsen 1995; Tayles et al. 2000). A range of other cariogenic (staple) crops have been identified as important contributors to the diets at sites in this study, including marunguey, sweet potato, cocoyam, arrowroot, and manioc (Newsom and Wing 2004; Mickleburgh and Pagán Jiménez 2012). Once processed, these starchy plants can be highly cariogenic, particularly if consumed in soft, sticky form (Lingström et al. 2000). Furthermore, fruits which naturally contain large amounts of sucrose would have been readily available to most inhabitants of the region throughout the year (see section ‘Starches and sugars’ below). Arboriculture, or the management of trees, including fruit bearing trees such as guava, soursop, papaya (not strictly a tree), star apple (caimito), and genip, is known to become increasingly important during the Ceramic Age (Newsom and Wing 2004). The contribution of fruits to the diet is hard to determine, but even relatively small amounts of sugary fruits, if consumed frequently (i.e., at intervals during the day) may be very cariogenic (Arora and Wendell Evans 2012). Even so, it is unlikely that the high caries rates observed in this study can be predominantly attributed to fruit consumption, since more concrete evidence of dental erosion, particularly in the form of buccal lesions, would be expected in that case (see section 7.2.1).

Recent research by Cucina et al. (2011) has stressed the importance of interpreting caries rates, and dental pathology in general, within the broader archaeological and bioarchaeological context, and refraining from drawing direct (causal) relationships between caries rates and specific foods such as maize. For this reason, and as discussed above, attributing high caries rates in New World assemblages predominantly to maize consumption is therefore not straightforward, and may not always be entirely justified (see also Tayles et al. 2000). The results of this study indicate that at many sites, large amounts of cariogenic plant foods were consumed, which likely included maize, but would have consisted of a large variety of crops and fruits which likely differed locally.

The ‘caries attrition competition’

The rate of dental wear is thought to affect caries prevalence; a phenomenon known

as the 'caries attrition competition'. When the rate of attrition is particularly high, it is thought that carious lesions do not get the opportunity to develop. Such rapid attrition is generally associated with secondary dentine deposition, which may re-mineralize areas where the tooth is compromised and otherwise would have developed a carious lesion (Maat and van der Velde 1987). Other researchers have posited that worn teeth are more susceptible to carious lesions, since the softer, less mineralised dentine becomes exposed (Miles 1969), while yet other researchers argue that caries and attrition are independent variables which are both related to diet (Meiklejohn et al. 1992). In this study, there is no clear association between high rate degree of wear and high caries prevalence. The sites with the highest rates of wear, Anse à la Gourde, Chorro de Maíta, and Escape, show very different caries rates. Anse à la Gourde shows one of the highest caries rates observed in the sample. Chorro de Maíta shows a lower rate than Anse à la Gourde, but the prevalence of caries in this population is by no means low. Escape, on the other hand, shows a particularly low rate, probably associated with a low carbohydrate intake.

Caries inhibiting foods

Fluoride is known to inhibit the development of dental caries, as it helps prevent demineralization and aids remineralization of areas of the teeth where acids produced by bacteria in dental plaque have started to demineralize the enamel and/or dentine (Featherstone 1999). Today, fluoride is added to tooth paste in order to reduce caries rates. A number of natural sources of fluoride were available to populations in the past, including the drinking water, although the fluoride content of natural water sources varies widely. Another major fluoride source is marine food. Only a small marine contribution to the diet is thought to supply enough fluoride to have an effect on caries rate (Elvery et al. 1998; Malde et al. 1997; Spencer et al. 1970). While the proportion of marine foods consumed at the various sites in this study may have differed considerably, it is possible that fluoride from marine foods played a role in caries inhibition at all sites under study, since all have revealed archaeological or isotopic evidence of marine food consumption – with the exception of Tocarón, Venezuela (Atilas 2004; Barker 1961; Bullen and Bullen 1972; Dorst 2000, 2006, 2008; Drewett 1993; Fabrizii-Reuer and Reuer 2005; Grouard 1995, 1998; Hofman et al. 2012; Hoogland and Hofman 1999; Laffoon 2012; Laffoon and de Vos 2011; Norr 2002; Olsen 2004; Ortega 2005; Osgood 1943; Pestle 2010b; Rainey 1935, 1940, 1941; Rímoli et al. 1977; Rouse 1952a, 1952b; Samson 2010; Siegel 1992; Stokes 1998; Versteeg 1991, 1993; Versteeg and Rostain 1997; Versteeg et al. 1990; Wagenaar Hummelinck 1959; Walker 1985; Wing 1999; Wing 2001b; Wing et al. 2002). In addition, marine food is thought to inhibit caries due to the fact that it produces an alkaline environment in the mouth, which prevents the accumulation of bacterial acids responsible for demineralization (Dawes 1970; Dreizen and Spies 1948).

Research has shown that in the Caribbean archipelago, at sites on the smaller islands, the protein portion of the diet was more strongly marine oriented than at

sites on larger islands. This has been attributed to the general lack of terrestrial fauna on these smaller islands, which show an even more impoverished terrestrial fauna than the larger islands (Keegan 2000; see also Keegan et al. 2008; Stokes 1998). This suggests that communities in the Lesser Antilles would be better protected from tooth decay than their Greater Antillean counterparts. However, the results of this study do not corroborate this, since caries rates in the Late Ceramic Age Greater and Lesser Antilles are both considerably high.⁸ Nonetheless, the site of Tutu provides some tentative evidence that increased marine orientation of the diet over time is associated with a decrease in caries frequency (see also Larsen et al. 2002), although potential changes in the composition and consistency of the vegetal component of the diet at this site over time may have influenced the caries rate.

Studies on prehistoric remains indicating that marine food consumption helps inhibit caries by providing elevated fluoride ingestion tend to deal with populations whose diet consisted almost entirely exclusively of marine foods (e.g., Mays 1997; Walker and Erlandson 1986). The majority of the evidence from this study indicates that, although there was a degree of variation in foodways at the different sites in the dataset, most communities represented here consumed a mixed diet in which both carbohydrate rich plant foods and protein rich marine foods were very important. The effect of marine food consumption on caries rates in such mixed diets is hard to estimate. Moreover, some researchers argue that marine food consumption need not necessarily have cariostatic effects at all (Sealy and van der Merwe 1988). Research has shown that the cariogenicity of carbohydrates is increased considerably when foods are consumed frequently, and at regular intervals, since the pH level of the mouth does not have time to recover between consumption (Larson et al. 1962; Walker and Hewlett 1990). It is possible that the frequency of consumption of marine foods similarly affects its cariostatic properties. If marine foods were consumed infrequently (e.g., only as main meals), their cariostatic effects may be limited. Considering the above, it is not possible to precisely ascertain the caries inhibiting effects of marine food consumption in the sample under study, but from the results of this study no clear cariostatic effect of marine food consumption is apparent.

Starches and sugars

The staple plant foods known from archaeological and ethnohistorical studies in the Caribbean, such as sweet potato, cocoyam, marunguey, manioc, maize, and beans, would have provided ample starches for the populations studied here. An important source of sugars in the pre-Columbian Caribbean would have been various types of fruits, which were both naturally available in the environment, and were cultivated by humans. A range of fruits which have high sugar contents have been identified by their macro- and microbotanical remains at sites throughout

⁸ Due to the lack of Early Ceramic Age material from the Greater Antilles, the Early Ceramic Age material from the Lesser and Southern Antilles was excluded from this comparison.

the region (Newsom and Wing 2004). Table 7.3 shows the sugar contents according to contemporary research of some of the important species of fruit and staple crops. This table also shows that the sugar content in sweet potato, an important (staple) food in the region, is relatively high. Squash may also contain relatively large amounts of sugars. Maize contains fewer sugars in comparison, and appears to have more often been consumed as bread, rather than as a stew/porridge, which arguably is a less cariogenic form than boiled or stewed, since the proportion of gelatinized starch grains is smaller (Lingström et al. 2000; Mickleburgh and Pagán Jiménez 2012).

A variety of fruits may have contributed a large amount of natural sugars to the diet, although certain staple food crops such as sweet potato may have been an important source of sugars. While the contribution of fruits to the diet is hard to determine, it is unlikely that the high caries rates observed in this study can be primarily attributed to fruit consumption, since more concrete evidence of dental erosion, in the form of buccal lesions for example, is lacking (see section 7.2.1). Thus, it seems that the high caries rates observed in most assemblages in this study are most likely the result of large proportions of soft sticky starches in the diet, together with regular doses of natural sugars from fruits, sweet potato, squash and perhaps maize.

As discussed in Chapter 2, the location of caries on the teeth is associated with the type and consistency of foods. Some research suggests that CEJ caries are more strongly associated with starches, while occlusal and smooth surface caries are more strongly associated with sugars (Lingström et al. 2000; Waldron 2009). Based on the results of this study, the sites can be divided broadly into three types: (1) sites with predominantly CEJ caries, but with a significant proportion of occlusal caries, (2) sites with a considerably larger proportion of occlusal caries than CEJ caries, and (3) sites with equal proportions of CEJ and occlusal caries, or no caries at all (Table 6.61). The majority of the sites belong to type 1. Interproximal and smooth surface caries are rare, and only occur in some of the type 1 and 2 sites. As such, these results may imply consumption of relatively large amounts of both starches and sugars at all three types of sites, perhaps with type 1 sites leaning more toward starches and type 2 sites leaning more toward sugars.

Calculus

The presence, frequency and degree of calculus formation has a complex aetiology, since calculus is known to be influenced by the alkalinity of the oral environment, which is increased by the consumption of protein rich foods, but conversely has also been documented to be related to poor oral hygiene and the consumption of a carbohydrate rich diet (Ånerud et al. 1991; Hillson 1979, 1996). Calculus forms only when plaque, which also contains the demineralizing bacteria that cause carious lesions, is present on the teeth or roots. Since these bacteria thrive on carbohydrates (particularly sugars), the combination of a high caries rate and high calculus frequency and degree suggests a carbohydrate rich diet with poor oral hygiene

(Belcastro et al. 2007). In assemblages with high calculus frequencies, but low caries rates, the consumption of a larger proportion of protein rich foods may be more likely, along with poor oral hygiene practices. Primary protein sources are meat and fish, although plant foods can contribute large proportions of proteins to the total diet. Beans, for example, are both rich in carbohydrates and protein.

| Fruit/vegetable | Sugar content % |
|--------------------------------|------------------------|
| Cassava bread | 3.18 |
| Genip | 11.15 |
| Guava | 8.91 |
| Maize | 3.33 |
| Mamey Zapote | up to 22.00 |
| Papaya | 7.82 |
| Passion fruit | 11.19 |
| Pineapple | 9.85 |
| Star apple | 14.00–20.00 |
| Sweet potato (baked in skin) | 6.48 |
| Sweet potato (boiled, no skin) | 5.74 |
| Squash | 1.75–7.50 |
| Yellow sapote | 20.64 |

Table 7.3 Sugar contents (by weight ratio) for certain staple crops and fruits native to the Caribbean, or introduced during pre-Columbian times (Sources: U.S. Department of Agriculture 2011, Alia-Tejecal et al. 2007, Bystrom et al. 2008, Parker et al. 2010).

In this study, although some of the sites (e.g., Anse à la Gourde) with high caries rates also show considerable degree and frequency of calculus deposition, the relation between the two pathologies is not very clear. Sites in the medium caries range are associated with either low, medium, or high calculus rates. An important factor in this could be the different conditions of preservation per sample. As discussed in Chapter 6, dental calculus is more fragile and susceptible to certain soil conditions than the teeth, and is often lost during transport, cleaning, or storage of material. The sites studied here differ somewhat with regards to the condition of the dental calculus (see also Larsen et al. 2002). Nonetheless, the presence of dental calculus in 83.67% of the assemblages studied here indicates that, next to poor oral hygiene, carbohydrates – both starches and sugars – formed an important component of the diet.

Unusual calculus deposits

The eight cases of unusual calculus deposits described in section 6.4.3 are significant, since the pattern of calculus deposits clearly differs from the natural pattern of calculus accumulation in the dentition. This natural pattern is largely determined by the location of the salivary ducts in the mouth. Because minerals in the saliva

are responsible for the deposition of the mineral component of dental calculus, the teeth and roots closest to the salivary ducts are affected more frequently and more severely by calculus deposits than the other teeth. Generally, the lingual surfaces of the mandibular incisors and the buccal surfaces of the maxillary molars are most prone to natural calculus build-up (Bergström 1999; Corbett and Dawes 1998; Jin and Yip 2002; Parfitt 1959; Schroeder 1969; White 1997). Apart from naturally occurring minerals in the saliva, calculus has been shown to be – at least in part – influenced by the proportion of carbohydrates and/or protein in the diet, and individual hormonal differences. Also, calculus formation is heavily influenced by oral hygiene, as regular removal of accumulations of dental plaque helps prevent the formation of calculus. Factors that affect the chemical constitution of the saliva or increase salivation may also lead to increased calculus deposition, as in both cases the amount of certain minerals present in the mouth increases (Ånerud et al. 1991; Bergström 1999; Kowalski 1971; Lieveise 1999).

The size of the calculus deposits in the eight affected individuals is remarkable. Despite the fact that the rate of formation of calculus has been shown to be variable (Conroy and Sturzenberger 1968; Gaare et al. 1989), the severity of the calculus accretions suggests an extended period of formation. Even more interesting is the evidence for a lack of mastication in the side of the mouth that is affected by the anomalous calculus deposits in some of the individuals. Some individuals also show more wear on the opposite side of the mouth to the occlusal calculus accretions, indicating that this side of the mouth performed (the bulk of) the food mastication.

Overall, these individuals present a unique pattern of dental calculus formation that is not reflected in the other individuals in the sample. These others are affected by much smaller calculus accretions, which follow the natural pattern of calculus deposition. The possibility that these cases of atypical calculus deposition are the result of a substantially different diet or oral hygiene practices seems highly unlikely, as even then the distribution of the accretions throughout the dentition would be expected to follow a more natural pattern. It is possible that these individuals were engaging in some form of special activity.

Similar unusual calculus deposits have been found in pre-Columbian dental material from Peru and prehistoric dental material from Guam (Leigh 1930, 1937). Leigh suggested that the calculus deposits were the result of coca leaf or betel nut chewing. Although he could not explain the exact relationship between the habitual chewing of plant materials (coca leaves in Peru and the betel nut in Guam) and the formation of anomalous calculus patterns, he suggested that the powdered lime (calcium oxide) that is added to the plant leaves in order to help release the active narcotic ingredients must have somehow been the cause. More recently, research into the chemical composition of dental calculus and lime demonstrated that the two are different substances (Klepinger et al. 1977; Ubelaker and Stothert 2006). Ubelaker and Stothert (2006) conclude that there is no relation between the use of lime in the oral environment and increased or atypical calculus accumula-

tion. Furthermore, other dental evidence of coca chewing in the pre-Columbian Americas has indicated a relation between the practice and cervical-root caries and accompanying root exposure (Indriati and Buikstra 2001), pathological conditions which were not found in association with the unusual calculus deposits documented in this study. As such, the cause of the unusual patterns of calculus deposition in the eight individuals in this study remains unclear. It is possible that while the chemical constitution of dental calculus and lime or other alkali may not be the same, the presence of large amounts of lime in the mouth may affect calculus formation by increasing the amount of available minerals and raising the alkalinity in the oral environment. This warrants further investigation, perhaps through analysis of palaeobotanical remains trapped in the dental calculus (starch grains and phytoliths).

AMTL

Significant differences were observed between the sites with regards to the rates of AMTL. The rates of AMTL observed in this study are generally high when compared to rates observed in populations worldwide (Littleton and Fröhlich 1993; Lukacs 1992; Tayles et al. 2000; Turner 1979). Since AMTL is strongly associated with caries and periodontal disease, and other dental pathologies, high rates of AMTL are often attributed to a high carbohydrate intake, particularly soft, sticky, refined carbohydrates (Larsen 1995; Larsen 1997; Scott and Turner 1988). The high rates observed in this study therefore may be related to a substantial carbohydrate contribution to the diet, with the differences between the sites likely reflecting differences in foodways and preparation techniques.

7.2.3 Sex-based differentiation: *male menus versus female foodways*

This study has brought to light a number of significant differences between males and females from the individual sites, but also in the entire sample assemblage. This contrasts with other dietary (stable isotope) studies, which have found no evidence for sex-based differentiation in dietary practices in the region (Buhay et al. 2012; Keegan and DeNiro 1988; Krigbaum et al. in press.; Laffoon 2012; Laffoon and de Vos 2011; Norr 2002; Pestle 2010a; Stokes 1998, 2005).⁹

With regards to dental wear, males show a slightly higher rate of wear overall than females. Males also show higher rates of dental chipping overall than females. Such differences in rate of wear and chipping between the sexes are frequently reported in various prehistoric populations across the globe (e.g., Benfer and Edwards 1991; Powell 1988). Some researchers have suggested that these differences are the result of the larger jaw and more muscular masticatory apparatus in males, which exert more force on the teeth during mastication (e.g., Chattah and Smith 2006; Chuaje-

⁹ Pestle (2010a) found no significant differences between males and females, although at Tibes the difference was very close to statistical significance, which he argues is most likely the result of a greater consumption of high trophic level terrestrial resources or more marine resources by males, and greater consumption of C₄/CAM foods by females.

dong et al. 2002). However other studies revealed no differences between male and female rates of wear (Kieser et al. 1985; Lovejoy 1985; Molnar 1971a).

Sexual dimorphism, especially in the skull and mandible, in the pre-Columbian Caribbean is relatively limited. Where some populations (particularly north-western European Caucasians) show marked sexual dimorphism affecting the masticatory apparatus between males and females, in the Caribbean islands differences are generally small. The lack of strongly expressed differences is mostly due to the well-developed jaws and muscular attachments in females. A notable exception is the skeletal population from Punta Candeleró, where sexual dimorphism is strongly expressed in the skull and jaw (Anne van Duijvenbode, personal communication 2012; Edwin Crespo Torres, personal communication 2011; Darlene Weston, personal communication 2012). This suggests that sexual dimorphism in the size and strength of the masticatory apparatus is likely of relatively little influence on the rate of dental wear in the region.

In some studies, females have been shown to have a higher rates of wear than males (e.g., Molnar, McKee, and Molnar 1983; Richards 1984). The latter has been interpreted as the result of differing foodways between males and females. For example, males may have selected the most tender meats and refined plant foods, leaving females with the tougher, more fibrous foods (Richards 1984). Another possibility is that females eat more frequently during the day than males, as has been documented ethnographically in some societies, both a potential factor in the higher frequency of caries in females, and presumably could cause higher rates of wear.

The difference observed between males and females in this study, however, is very small, and as such is difficult to interpret. Considering the fact that females show higher caries rates overall than males, it is possible that the slightly lower rate of wear in females is related to a slightly larger component of heavily processed, soft, sticky, starchy foods in their diet. Males, on the other hand, show higher chipping rates, perhaps related to the consumption of tougher, more damaging foods possibly with more inclusions such as grit and sand.

At some sites, and for the sample as a whole, caries rates were found to differ significantly between males and females. As discussed in Chapter 2, studies of sex-based differentiation in caries rates have shown that in different cultures and subsistence systems worldwide females are often more frequently affected by caries than males (Kelley et al. 1991; Larsen 1997). Such differences are explained as either the result of gender-based differences in food processing and consumption (Larsen 1983; Larsen et al. 1991; Lukacs 1992; Lukacs and Pal 1993; Walker and Hewlett 1990), or the result of biological differences, with hormonal fluctuations and reproductive biology in females affecting the immune response to carious attack and dietary preferences (Cheyney 2007; Laine 1988; Lukacs 1996; Lukacs 2008; Lukacs and Largaespada 2006; Vallianatos 2007). Higher caries prevalence among females has also been attributed to their earlier eruption of the permanent teeth. Earlier eruption means earlier and longer exposure to cariogenic foods, potentially leading to

higher caries rates. However, clinical research has shown that early eruption does not lead to significantly different caries rates (Kaur et al. 2010).

Surprisingly few studies have been done on the differences in food preference between males and females, particularly in an ethnographic context. Berbesque and Marlowe (2009) found a clear difference in food preferences between Hadza hunter-gatherer males and females with males rating protein rich foods (meat) highly, and females rating sweet, sugary foods highly. While this difference is very interesting with regards to the potential difference in proportions of cariogenic foods in the male and female diets, this study revealed little of the underlying reasons for the observed difference: i.e., does this concern biological or cultural differences? Do females prefer carbohydrates over proteins because they are biologically programmed to do so, or is this the result of ingrained social practices, where females preside over the acquirement and production of carbohydrate foods and males over protein rich foods? In the case of the Hadza hunter-gatherers, females are responsible for the procurement of carbohydrate foods (berries and tubers) and males for hunting animals and gathering honey. When on hunting trips males may gather and consume tubers and berries, although older men never dig tubers (Berbesque and Marlowe 2009).

Nonetheless, some dental studies have found no significant differences in caries rates between the sexes, and yet others have revealed higher caries rates in males, showing that biological differences related to female fertility do not necessarily determine caries rates (Burns 1979; Clarkson and Worthington 1993; Larsen 1997; Liebe-Harkort 2012; Powell 1988; Walker et al. 1998).

In the current study, when significant differences in the frequency of caries were observed (tooth count), females tend to show a higher caries rate than males. The fact that at most sites under study here, like many others worldwide, females have higher caries rates than males, would appear to indicate a greater intake of cariogenic foods by females than males. This is usually attributed to the female role in staple food processing. Staple foods, often the most starchy and rich in carbohydrates, in many cultures comprise an important aspect of gendered labour divisions, with females being responsible for the entire, or most of, the production process. Sexual division of labour in the pre-Columbian Caribbean has been hypothesised based on iconography and association of certain motifs with either the male or female sex (Boomert 2001, 2003; Waldron 2011). These associations are built on ethnographical analogies with the tropical lowlands of South America, where sex-based differentiation in labour division, particularly when regarding food procurement and processing, is known to be an important organizing principle (Boomert 2001; Heckler 2004; Mowat 1989). Also, based on extrapolation of information from ethnohistoric sources to earlier periods (and various locations), it is thought that labour division was at least partly related to gender in the Caribbean. Ethnohistoric accounts reveal that both males and females tended to crops, fished, were politically active, and engaged in craft activities, although it appears that females were solely responsible for the labour intensive preparation of cassava

bread and cooked meals (Deagan 2004; Deagan and Crucent 2002; De las Casas 1875, 1992; Fernández de Oviedo y Valdés 1851; Lovén 2010; Veloz Maggiolo 1997).

While ethnographically and ethnohistorically documented individuals are separated in both time and space from those incorporated in the current study, the tropical lowlands of South America were not only the homeland of many original migrants to the Caribbean archipelago, but are known to have shared a social and cultural interaction sphere and perhaps (in part) a common cultural identity and worldview with the islands throughout prehistory (Boomert 2000; Hofman and Boomert et al. 2011; Roe 1997; Rouse 1992; Siegel 1992, 1997, 2010). It is not unlikely therefore that the system of gendered labour division regarding food preparation in areas of the mainland was transported to the islands by migrating populations, perhaps resulting in differential access to foods between the sexes. Furthermore, the processing of staple foods in other surrounding mainland areas is also known (ethno)historically and ethnographically to be performed by women (Boomert 2001; Mowat 1989; Perego 2007).

While this could explain the observed differences in caries rates, it does not concur with previous findings in carbon and nitrogen isotope studies that indicate males and females were consuming similar diets (Buhay et al. 2012; Keegan and DeNiro 1988; Krigbaum et al. in press; Laffoon 2012; Laffoon and de Vos 2011; Pestle 2010a; Stokes 1998, 2005). The difference between male and female caries rates is statistically significant in the overall population, and at three sites. At a further eight sites clear differences were observed, but were found not to be statistically significant. At other sites differences are small or not discernible. The difference between males and females is never so great that they could be categorized into different caries ranges (i.e., low, medium, high; Table 7.1), usually comprising only a few percent. When compared to differences documented in other regions of the globe, they could arguable be characterized as 'subtle', since at many sites worldwide female caries rates reach values twice as high or more than male caries rates (Lukacs 1992; Temple and Larsen 2007; Walker and Erlandson 1986; Walker and Hewlett 1990).

Such relatively subtle differences are unlikely to be caused by drastic differences in foodways between the sexes. They are more likely to be the result of slightly different proportions of carbohydrates and proteins in the diet and the effects of hormonal differences between the sexes. It also is possible that males and females were broadly consuming the same foods, but that the frequency and manner of consumption differed. Females may have consumed processed carbohydrates more frequently during the day, as they were involved in the processing of starchy plant foods, or may have eaten small amounts of other cariogenic foods (fruits) procured in home gardens or close to the settlement more frequently during the day (Larson et al. 1962; Walker and Hewlett 1990). Males, on the other hand, while consuming the same foodstuffs, would have eaten larger amounts less frequently, and perhaps may have preferred different manners of preparation of the foods that

were less cariogenic (i.e., less soft and sticky). This scenario fits well with the labour division and food habits documented in ethnographic studies from the tropical lowlands of South America and ethnohistoric accounts of the early contact period (De las Casas 1875; Fernández de Oviedo y Valdés 1851; Heckler 2004). Additionally, carbon and nitrogen studies may be concealing some of the variation in foodways between the sexes, since the consumption of various combinations of different foods may produce similar isotopic signatures, and carbon and nitrogen ratios cannot reveal frequency of food consumption. Other indications, such as the frequency and degree of calculus, may suggest that males consumed larger proportions of protein, or perhaps ate protein rich foods more frequently during the day. Taken together this evidence seems to point toward a combination of the factors discussed above: slight to moderate differences in dietary composition or frequency and manner of consumption which may avoid detection using stable isotope analysis, and which differ per site.

This study has revealed evidence for differing foodways between males and females in the pre-Columbian Caribbean. This is unlikely to have been entirely the result of consumption of different foods; males and females were generally consuming the same foods, perhaps with slight differences in proportions. The manner and frequency of consumption, an equally important aspect of foodways, is likely to have differed somewhat. These differences may have been structured according to differences in daily activity patterns and task divisions between the sexes.

7.2.4 Foodways over time

Intra-site

Intra-site comparisons of dental wear and pathology did not reveal a great deal of variation at individual sites over time. A major hindering factor in this is the size of the assemblages representing the individual occupation periods at these sites. Larger sample sizes would greatly contribute to our understanding of possible intra-site differences over time. At Maisabel, Punta Candeleró, and Tutu, increasing the sample size per occupation phase is not possible, however at Anse à la Gourde, Lavoutte, and Manzanilla expansion of the sample of radiocarbon dated skeletons may allow such comparisons in future.

At Maisabel, there are indications that food consistency in the late phase of occupation was coarser and tougher than in the early phase of occupation, since the proportion of horizontally worn molars increases, and the frequency and degree of chipping rises. The slight (non-significant) drop in caries rate suggests that carbohydrate intake was lower in the later period, or that food was less soft and sticky (processed). But this is paired with a significant increase in AMTL. Overall the results from Maisabel are complex, and chronological changes are rarely backed-up by statistical significance. There is no clear evidence for change in diet over time, although food consistency may have been less refined in the late period.

At Punta Candeleró horizontal and flat wear is the most common molar surface

shape in both periods. No significant differences were observed in the frequency and degree of chipping or calculus. A slight rise in caries rate is seen, but this is also not significant. AMTL rate drops significantly in the late period. In sum the results from Punta Candelero show no clear evidence for dietary change between the middle and late period of occupation. Pestle (2010b) found no significant changes in the enrichment of $\delta^{13}\text{C}$ over time at Punta Candelero, although the proportion of C_4/CAM plants in the diet appeared to increase very slightly over time, a fact that could be correlated with the slight (but also non-significant) rise in caries rate. At Tutu, the proportions of horizontally and obliquely worn teeth are similar for both periods. Occlusal surface shape does also not change significantly over time. Dental chipping increases significantly in the later period. The caries rate drops somewhat in the late phase, although the difference is not statistically significant (see also Larsen et al. 2002). A significant drop is seen in the rate of AMTL in the late phase of occupation. Together, this suggests there was a decrease in the proportion of carbohydrates in the diet, or perhaps less refined processing, over time. This scenario concurs with the findings of previous studies at the site, which indicated that there was a slight shift toward a more marine oriented diet in the late period (Farnum and Sandford 2002; Larsen et al. 2002; Wing et al. 2002). The apparent break in foodways at Tutu contrasts with the relative continuity at Maisabel and Punta Candelero over time. This break also coincides with a potential break in occupation of the site. The early and late burial populations are separated by a gap of 210 years, during which time the site may have been uninhabited (Righter 2002). The re-settlement of the site in the later phase seems to have been done by a group with (slightly) different foodways than their predecessors.

Early Ceramic Age – Late Ceramic Age

Comparisons between the Early Ceramic Age and the Late Ceramic Age revealed great differences between the two groups, both in patterns of dental wear and pathology. The distinctly lower rate of molar wear in the Late Ceramic Age group may be the result of fewer abrasives in the diet of this group in comparison to the Early Ceramic Age group. The abrasivity of the diet is largely the result of food preparation techniques, i.e., how refined the foods are, coupled with the inherent abrasive qualities of the foodstuffs. This suggests that foods consumed by the Late Ceramic Age group were generally more refined, and the diet contained less abrasive foodstuffs overall. The statistically significant difference in caries rate between the two groups is considerable; the simple tooth count caries rate in the Late Ceramic Age groups is almost double that of the Early Ceramic Age group. This suggests at the very least a clear difference in food preparation techniques between the two groups, but far more likely a distinct difference in the amount of carbohydrate intake combined with highly refined food processing techniques. This higher caries rate in the Late Ceramic Age group is paired with a significantly higher AMTL, which also suggests a far more carbohydrate rich and refined diet overall. The slight, but significant increase in the proportion of teeth affected by calculus

in the Late Ceramic Age group is thus likely to be associated with a larger amount of soft, sticky foods which contribute to the formation of plaque.

The smaller number of teeth affected by hypercementosis in the Late Ceramic Age group is not statistically significant, but considering the evidence presented above may be the result of a reduction in the tough, abrasive components in the diet, leading to a reduction of stress on the teeth; heavy dental wear has been suggested as the cause of hypercementosis (Hillson 1996, 2008b).

The individual count rates of caries, AMTL, calculus, and hypercementosis show a similar distinct difference between the two groups to the tooth count rates discussed above. With regards to periapical lesions, the individual count method indicated a slightly higher rate in this group. These differences again support the scenario that the Late Ceramic Age brought more refined, heavily processed, soft, sticky plant foods to pre-Columbian Caribbean diets.

Changing Lesser and Southern Antillean foodways

Comparisons between the Early Ceramic Age and the Late Ceramic Age of the Lesser Antilles and Southern Caribbean Islands also revealed great differences regarding foodways. The distinctly lower rate of molar wear in the Late Ceramic Age indicates that the diet was less abrasive overall in comparison to the Early Ceramic Age, suggesting that food preparation techniques were more refined, and inherently less abrasive foods were consumed. This picture is confirmed by the difference in predominant direction of wear and occlusal surface shapes between the two periods. The Early Ceramic Age shows predominantly horizontal and flat wear, consistent with generally abrasive foods, while the Late Ceramic Age shows a shift toward oblique and cupped wear, consistent with more refined foods.

Again the caries rates of the two periods differ significantly: the simple tooth count caries rate in the Late Ceramic Age group is four times that of the Early Ceramic Age group. The caries rate for the Early Ceramic Age is within the range established globally for hunter-gatherers subsisting on a very low proportion of (refined) carbohydrates, whereas the Late Ceramic Age rate is consistent with the range established for agricultural economies, where refined carbohydrates comprise a very large proportion of the diet (Koca et al. 2006; Larsen et al. 1991; Powell 1985; Scott and Turner 1988; Turner 1979). This demonstrates a clear difference in carbohydrate intake and food preparation techniques over time. The higher caries rate in the Late Ceramic Age group is paired with a significantly higher AMTL (over three times greater than the early group), supporting the interpretation that the diet contained far more refined carbohydrates in the later period (Larsen 1995; Larsen 1997; Scott and Turner 1988). The frequency of calculus also almost doubled in the Late Ceramic Age, similarly indicating a significant increase in the proportion of soft sticky foods consumed (Ånerud et al. 1991; Hillson 1979, 1996). The reduction of tough, abrasive foods in the diet may have contributed to the reduction in the number of teeth affected by hypercementosis in the Late Ceramic Age group, by reducing the stress on the teeth (Hillson 1996, 2008b). The individual count rate

of caries similarly evidences a change in dietary focus in the Late Ceramic Age. Contrastingly, the rate of periapical lesions, often associated with a more refined starchy diet, is slightly lower in the Late Ceramic Age, although the difference is not statistically significant.

Interestingly, the frequency and degree of dental chipping is significantly greater in the Late Ceramic Age, although in both groups the degree of chipping is much lower than that seen for the entire assemblage. Since in both groups, the chipping is mostly found on the occlusal buccal and lingual surfaces, a pattern which has been attributed to the use of the teeth in non-alimentary activities (Belcastro et al. 2007), the difference may not necessarily be related to dietary practices.

Time brings change?

Naturally, the clear and significant differences in foodways observed in this study between the Early Ceramic Age and the Late Ceramic Age groups, both for the entire region and for the Lesser and Southern Antilles alone, call for a detailed investigation of the underlying processes which gave rise to them. However, the relatively coarse-grained division into temporal groups (i.e., Early Ceramic Age versus Late Ceramic Age), together with the current lack of clear, finer-grained intra-site differences, and the large geographical units, constitutes a somewhat crude comparison which may be insensitive to and restrict the ability to comprehensively elucidate the subtle causes of such change (see also Chapter 5). This being said, archaeological research in the region has provided highly detailed information, precisely on the contrasting social and cultural character of the two main phases of Ceramic Age occupation. Furthermore, palaeoclimatological and palaeoecological studies have revealed region wide and localized changes in precipitation rates at certain stages during the Ceramic Age, which could have influenced food procurement activities (Brenner et al. 2001; Curtis and Hodell 1993; Curtis et al. 2001; Higuera-Gundy et al. 2009; Hodell et al. 1991). So, while it is understood here that the interpretation of the observed temporal differences is necessarily constrained by the broad nature of the temporal categories used, through careful contextualization of the results valuable interpretations are deemed achievable.

Sadly, no skeletal material that could be assigned to the Early Ceramic Age period – as defined here – was available from sites in the Greater Antilles, meaning that the evidence for foodways from Late Ceramic Age sites in this region could not be compared to earlier occupation in this part of the archipelago. Nonetheless, it is clear from the observations made during this research that the Late Ceramic Age foodways at sites in this area were heavily agriculture/horticulture oriented, with highly refined, starchy and sugary foods constituting a large proportion of the diet, and with highly cariogenic plant foods functioning as staple crops. This picture is entirely in keeping with previous archaeological studies in this part of the Caribbean, which point toward population growth and increase in the size and density of sites throughout the Late Ceramic Age, together with agricultural intensification (Curet 1992; Curet et al. 2004; Keegan 2000; Siegel 1999, 2004; Torres 2010,

2012). The precise reasons for this agricultural intensification have been debated: had carrying capacity been reached in certain areas, and were people forced to reorganize food production, or did sociopolitical change induce agricultural intensification as a mechanism through which increasing control and power could be exerted by an elite class? While the evidence found in this study cannot shed light on the driving forces behind these issues, the results do not support differentiation in foodways based on social status other than slight differences between the sexes that are equally present in other (less complex) forms of social organization, and which have been theorized for Early Ceramic Age societies (Boomert 1999). Therefore, while the heavy agricultural/horticultural focus of the diet in the Late Ceramic Age Greater Antilles may be the result of sociopolitical organization, any kind of direct association between (increased) social complexity and foodways in the form of status differentiation is not reflected in the human dentitions (see also Pestle 2010b).

For the Lesser and Southern Antilles the picture is different. Since dental material from both major Ceramic occupation periods was available from this region, an assessment could be made of changes in foodways over time. The differences found between the Early and Late Ceramic Age occupation of this area in this study are striking, and reflect a fundamental shift toward more refined, starchy and sugary plant foods in the Late Ceramic Age. Interestingly, the picture presented by the Late Ceramic Age dentitions from this region is one of an equal – or perhaps at some sites (e.g., Anse à la Gourde) even greater – focus on agricultural/horticultural foodstuffs than we have seen at Greater Antillean sites from this period. Dental wear and pathology indicate that during this period in the Lesser and Southern Antilles the communities represented in this study relied heavily on highly cariogenic plant foods, which had been thoroughly and carefully processed prior to consumption.

Previous studies have demonstrated that sites throughout the Lesser Antilles show considerable diversity in faunal food procurement, determined by the local environment and available resources (Carder and Crock 2012; Carder et al. 2007; Fitzpatrick et al. 2008; Newsom and Wing 2004). Whether these differences are limited mostly to the Late Ceramic Age (Serrand 2007), or characterize the entire Ceramic Age is currently less clear. What is clear is that the picture presented by the human dentitions in this study contrasts somewhat with faunal evidence from the region. Particularly in the Late Ceramic Age dental evidence indicates a very large agricultural/horticultural component at all sites in the sample, suggesting some degree of homogeneity (at least regarding this aspect) within the region in this period. Of course dental wear and pathology cannot give the degree of detail regarding precisely which foods comprised the diet that faunal analysis can: a range of cariogenic plants may have given rise to the patterns of wear and pathology observed in this study. Nonetheless the large agricultural/horticultural component reflected in all of these sites is remarkable. It seems that regardless of the rich and diverse marine resources available at most sites in the sample, staple

plant crops formed a steady basis in all communities, and became increasingly important over time. While some studies have suggested that some form of increased agricultural/horticultural practices took place in the Lesser Antilles during the Late Ceramic Age (Newsom and Pearsall 2003; Newsom and Wing 2004), the size of the agricultural/horticultural component in the diet based on dental evidence presented here is still surprising.

This brings up the question whether processes of agricultural intensification hypothesized for the Greater Antilles were similarly at play in the Late Ceramic Age Lesser and Southern Antilles. Perhaps because this agricultural intensification has clearly been attributed to the increasing sociopolitical complexity in the Greater Antilles, and since traditionally such developments are thought not to have affected communities in the Lesser Antilles to such an extent, the question whether foodways underwent similar re-organization in the Late Ceramic Age Lesser and Southern Antilles has not been adequately addressed. Based on decades of research in the Lesser and Southern Antilles, some researchers have suggested that during the Late Ceramic Age (i.e., post-Saladoid) there was a transition toward increased social differentiation with the formation of ranked social classes and a shift from achieved to ascribed leadership. These changes are associated with an increase in the number and size, and greater variety in the location, of settlement sites in this period, and are thought to have affected both the Leeward and Windward Islands. Material culture repertoires show increasing diversity, reflecting the development of individual and local community identities and the participation of individual communities in an intricate network based on kinship and communal ties. These developments may have even had their roots in the late Saladoid period (Corinne Hofman, personal communication 2012; Hofman and Hoogland 2004, in prep.; Petersen 1996). Yet despite the potential evidence for increasing sociopolitical complexity in the Late Ceramic Age Lesser Antilles, I am hesitant to attribute the increase in plant food consumption (and by extension agricultural/horticultural practices) to sociopolitical developments. As discussed in Chapter 3, diet and subsistence practices in pre-Columbian Caribbean archaeology have often been approached from a perspective that prioritizes the explanatory value of sociopolitical organization for most data observed in the archaeological record. In a certain sense, this approach may have restricted our understanding of foodways and their association with sociopolitical organization in the region, since the two are assumed to have an intricate causal relationship (i.e., sociopolitical organization defines foodways, and vice versa). Global studies have indicated that while there is a relation between sociopolitical organization and the organization of food production and consumption, the precise nature of this relation is variable, and caution must be applied when inferring a causal relationship between the two (e.g., Golson and Gardner 1990; Renfrew et al. 1974; Walter et al. 2006). The simple coincidence of increasing sociopolitical complexity throughout the Caribbean and the evidence presented here for a shift toward a greater consumption of agricultural foods is not deemed enough to accept a causal relation between

the two. If such a direct relation was present in the pre-Columbian Caribbean, the question arises why two regions (i.e., the Greater and the Lesser Antilles) with apparently different sociopolitical organization show such a similar picture with regards to dental evidence in the Late Ceramic Age. Other factors at play in the insular Caribbean and surrounding areas of the mainland during the Ceramic Age are considered below.

A number of distinct periods of climatic fluctuation (with increased and decreased precipitation) have been documented for the Holocene in the Caribbean. One important dry period throughout the region, is known to have taken place between roughly A.D. 800–1000 and has been suggested to have been the cause of major sociopolitical upheaval in societies on the Mesoamerican mainland (Brenner et al. 2001). During this time the region was affected by serious drought, with precipitation levels drastically lower than the preceding period (Brenner et al. 2001; Curtis and Hodell 1993; Curtis et al. 2001; Higuera-Gundy et al. 2009; Hodell et al. 1991). Researchers working in the archipelago have attributed changes in sociocultural behaviour to this climate change, and have noted the potential impacts of such change on crop cultivation (Blancaneaux 2009; Fitzpatrick and Keegan 2007; Siegel et al. 2005). After this short period of aridity, however, the subsequent increase in precipitation may have encouraged agriculture. Similar developments have been observed in prehistoric Fiji, where episodic droughts and floods related to the El Niño Southern Oscillation (ENSO) encouraged the development and persistence of competitive strategies and may have led to increased sociopolitical complexity on the island of Viti Levu. This increased sociopolitical complexity was also associated with increased interaction and population growth, and attempts to increase control over agricultural production (Field 2004). Agricultural intensification during the Late Ceramic Age may reflect an attempt by societies to bring the availability of food sources directly under their control, and to be less dependent on the natural availability of resources, after precipitation levels had stabilized. This increased desire for control could perhaps have similarly been a factor in increasing sociopolitical organization, however once again the potential relation with foodways is unclear. In fact, the absence of evidence for status differentiation in foodways between individuals, other than sex-based differences, found in this study could even be construed as an indication that the increased sociopolitical complexity and diet and subsistence were not related, at least at the level of the individual. That is to say, social differentiation was not expressed in individually differing foodways, although the growing power exerted by an elite class may have been consolidated through the control of food production. For the moment, however, it seems that while sociopolitical organization and foodways both went through important changes in the Late Ceramic Age, the precise nature of the possible relation between the two is unclear.

7.3 HEALTH AND DISEASE IN THE PRE-COLUMBIAN CARIBBEAN

7.3.1 Dental health and disease

Ethnohistoric accounts provide conflicting descriptions of oral health and hygiene practices in the early period of contact between Europeans and the indigenous populations of the islands. Gonzalo Fernández de Oviedo y Valdés' description of the physical appearance of the indigenous population of the Caribbean islands agrees with the picture presented by the dentitions included in this study, stating that they did not have good teeth: "tienen muy buen cabello ellas y ellos, y muy negro e llano y delgado: no tienen buenas dentaduras" (Fernández de Oviedo y Valdés 1851:68 [Tomo I, Libro III, Capítulo V]). In contrast, Girolamo Benzoni, who visited the New World between 1541 and 1550 describes a practice that protected the teeth from decay, which he witnessed in the Gulf of Paria region:

They make a certain mixture, to preserve the teeth, with oyster shells, of the sort that produce pearls, burning them with the leaves of the laxi, and then adding a little water, so that the mixture looks like the whitest lime; and this they spread over the teeth, which became as black as coal; but they are thus preserved for good, without pain [Benzoni 1857:9–10].

López de Gómara describes the same custom of blackening and preserving the teeth, which he observed in Cumaná:

Précianse de tener muy negros los dientes, y llaman mujer al que los tiene blancos, como en Curiana, y al que sufre barba, como español, animal. Hacen negros los dientes con zumo o polvo de hojas de árbol, que llaman ahí, las cuales son blandas como de terebinto y hechura de arrayán. A los quince años, cuando comienzan a levantar la cresta, toman estas yerbas en la boca, y tráen las hasta ennegrecer los dientes como el carbón; dura después la negrura toda la vida, y ni se pudren con ella ni duelen. Mezclan este polvo con otro de cierto palo y con caracoles quemados, que parece cal, y así abrasa la lengua y labrios al principio [López de Gómara 1922:188–189].

They pride themselves in having very black teeth, and women who have white teeth, like in Curiana, and those with beards, like the Spanish, they called animals. They make their teeth black with the juice or powder of tree leaves, like they called it there, which are soft as terebinth and the product of myrtle. At fifteen, when they begin to hold their head up [i.e., become adults], they take these herbs in the mouth, and carry them there until the teeth are black as coal; the teeth become black for the rest of their lives and do not rot or ache. They mix the powder with other powders and burnt snail shells, similar to *cal*, which burns the tongue and lips at first [Translation: Hayley Mickleburgh and Adriana Churampi].

De las Casas also describes a custom of chewing herbs (likely coca leaves) which he clearly disapproves of, although the result is whitening of the teeth:

Vieron ellos también, y yo después, que acostumbran los hombres traer en la boca cierta hierba todo el día mascando, la que, teniendo los dientes blanquísimos comúnmente, se les pone una costra en ellos mas negra que la mas negra azabaja que puede ser; traen esta hierba en la boca por sanidad, y fuerzas, y mantenimiento, según yo entendido tengo, pero es muy sucia cosa y engendra grande asco verla, a nosotros, digo; cuando la echan, después de muy bien mascada, lavanse la boca y tornan a

tomar otra, y teniéndola en la boca hablan, harto oscuramente, como quien la lengua tiene tan ocupada” [de las Casas 1875:436 (Tomo II, Capítulo CLXXI)].

They also saw it and after them I did too, that men have the custom of carrying in their mouths a certain herb, which they chew all day long, and they commonly having white teeth they put a herb crust on then and it turns the teeth blacker than the blackest jet that may be; they carry this herb to heal the mouth, and strengthen and protect it, as I understand, but it is a very dirty thing and it is disgusting to see, for us, I say: when they throw it away, after they have chewed it well, they wash their mouth and turn to take another, and carrying it in their mouth, they talk, very wearily, as one who has a busy tongue [Translation: Hayley Mickleburgh and Adriana Churampi].

Of course Benzoni, López de Gómara and De las Casas’ descriptions specifically pertain to the land around the Gulf of Paria, including the Paria peninsula of the South American mainland (currently Venezuela), Cumaná, and western Trinidad. Some sparse descriptions of dental health and hygiene from other part of the Americas during the early colonial period are available in the ethnohistoric sources. López de Gómara, for example explains the damage caused to the dentition by consuming toasted maize and ground maize bread, and the care taken to clean the teeth after consumption:

Comen eso mesmo el grano seco, crudo y tostado; mas de cualquiera manera es duro de mascar y atormenta las encías y dientes. Para comer pan cuecen el grano en agua, estrujan, muelen y amásanlo [...] Ensucia y daña mucho la dentadura, y por eso traen gran cuidado de alimpiarse los dientes [López de Gómara 1922:239–240].

They eat that very grain dry, raw and roasted; but whichever way it is hard to chew and torments the gums and teeth. To eat bread they cook the grain in water, crush, grind and knead it [...] It dirties and damages the teeth, and for this reason they take great care to clean the teeth [Translation: Hayley Mickleburgh and Adriana Churampi].

This example appears to relate mostly to his observations in Peru, although the consumption of toasted maize and ground maize bread has been documented for the early Contact period Caribbean (Benzoni 1857; Fernández de Oviedo y Valdés 1851:266 [Vol. I]).

Although the ethnohistoric descriptions of dental health and hygiene are sparse and variable, the high pathology rates observed in this study indicate that oral hygiene was likely very poor, or even non-existent in all populations under study here. From both clinical dentistry and bioarchaeological studies of past populations we know that the greatest contributing factor in dental disease is the presence and accumulation of dental plaque (Hillson 1996). The formation and growth of plaque and the bacterial communities within it are also closely associated with dietary and oral hygiene practices. Particularly the frequency and degree of calculus deposits – the mineralized remains of dental plaque – and the high rates of other observed dental pathology show a lack of (appropriate) oral hygiene practices.

The most important dental pathology observed in this study, dental caries, is closely related to the composition and consistency of the diet. Other observed dental

pathologies are known to be connected to dietary practices, albeit less directly than caries. AMTL, for example is associated with carious lesions, periodontal disease, periapical lesions, heavy dental wear, and trauma, all of which (except the latter) are individually correlated to dietary practices. In addition, dental pathology in general is known to be associated with age. For these reasons, the interpretation of data on dental pathology is a highly complex matter, since the different pathologies are interrelated and a variety of causes are involved.

The combined types and frequencies of pathology observed in this study repeatedly show associations with a relatively high carbohydrate intake, suggesting that diet was the main factor in their development. As explained above, sex-based differentiation in dental pathology observed here is equally thought to be the result of differences in carbohydrate intake. Adequate proportions of carbohydrates and protein in the diet are essential to nutritional and general health. Globally, the increase in refined carbohydrates from around 10,000 years ago is associated with health and nutrition problems. These health and nutrition problems are not solely the result of changing diet, but also population growth and increased density, leading to the easier and more rapid spread of infectious disease (Larsen 1995; Larsen and Walker 2010). The pathological conditions observed in this study are not only a symptom of health conditions as a result of changing foodways; these conditions would have further impacted the general health and physiology of the affected individuals. Carious lesions, periapical lesions, and of course AMTL, may all be associated with pain, inflammation and restricted ability to masticate and consume food, and may all put a burden on the immune system (Ogden 2008; Waldron 2009).

Dental defects such as linear enamel hypoplasia represent a somewhat different perspective on past health and disease. Since LEH are non-specific indicators of physiological stress, they can indicate a period of poor health, but the precise cause and duration remains indistinguishable (King et al. 2005). Still, LEH are often used to infer population general health and stress, notably weaning stress. The fact that the LEH observed in this study are not restricted to the teeth formed during the younger years of childhood, indicates that physiological stress leading to enamel hypoplasia is not strictly associated with weaning stress in the sample. The most frequently affected elements observed during this study are nonetheless teeth which formed between the ages of six months to six years, suggesting weaning may have been a factor. This has also been inferred for other Caribbean skeletal assemblages, such as Grand Bay, Carriacou, and Paso del Indio, Puerto Rico (Buhay et al. 2012; Crespo Torres 2000; Stone 2011).

Edentulism

Edentulism, or edentulousness, is the loss of all (in in some cases almost all) teeth in the dentition, due to pathology or trauma. Complete or almost complete toothlessness in contemporary populations is known to pose risks to the health; the loss of the teeth is associated with poor nutrition since the intake of particularly fruits

and vegetables decreases. Edentulous patients may lack dietary fiber and essential nutrients (Brennan et al. 2010; Nowjack-Raymer and Sheiham 2003). Furthermore, in modern clinical practice, edentulism is associated with speech complications, mandibular prognathism, and negative self-image due to the prematurely aged appearance (Allen and McMillan 2003; Gordon et al. 2011).

While the emotional and psychological effects of edentulism in past populations is hard to determine, particularly because concepts of health, beauty, and aging may differ drastically from those in modern (western) society, the physiological effects of (near) complete tooth loss would arguably be the same. Reduced nutrient intake is very likely, since the broad range of available foods would be considerably constricted for an individual who was no longer able to chew his or her foods.

Complete edentulism was observed in only five individuals in this study, from the sites of Anse à la Gourde, Manzanilla, and Punta Macao. Other studies have documented edentulism in the region at Cueva María Sosá (Luna Calderón 1982) and La Caleta (Herrera Fritot and Leroy Youmans 1946). Clearly, complete or near complete edentulism was a rare health issue in the pre-Columbian Caribbean, most likely because adults rarely reached the age at which complete tooth loss would have been inevitable considering prevalence of dental pathology and oral hygiene practices. However, large numbers of individuals with extensive AMTL were documented, often to the degree that less than one quarter of the dentition was still present. This indicates that (partial) edentulism is likely to have affected nutritional condition in most populations in the region, making AMTL a significant health issue.

7.3.2 Sex-based differentiation: *his and her health*

The differences in dental pathology between males and females observed in this study, both at individual sites and in the entire assemblage, mirror broad trends observed globally. These trends indicate that social differences based on sex and gender (socially constructed sex) that are reflected in the bioarchaeological record, are also present in the pre-Columbian Caribbean. For example, certain patterns, such as the greater rate of caries and AMTL in females are common throughout history and are reflected here (Larsen 1995; Larsen and Walker 2010).

In this study, the impacts of diet on nutritional condition and general health, discussed above, tend to have affected female oral health more severely than that of males, with the exception of periapical lesions. Males are more frequently and more severely affected by periapical lesions, while females are more frequently affected by caries and AMTL. Males are also affected more frequently and more severely by dental calculus deposits than females. The higher rate of periapical lesions may be related to the slightly higher rate of wear in males, leading to exposed pulp chambers and subsequently to infection of the pulp and alveolus. Overall, however, periapical lesions are relatively infrequent, both in males and in females, and while they can sometimes cause considerable pain and physiological stress, the rates of caries and AMTL suffered by females in this sample would have been

of considerably more strain on the immune system and general health condition. Such differences between the sexes are not reflected in LEH – the developmental defects pertaining to the individual's physiological and especially nutritional condition during childhood – indicating differences were associated with adult life. This could perhaps indicate that gendered differentiation in foodways was not pre-determined at birth and practiced during childhood. Rather, upon reaching adulthood an individual's gendered identity started to influence his or her food choices and consumption patterns, which in turn affected nutritional status and health. The greater consumption of refined carbohydrates in females led to higher rates of certain forms of dental pathology, likely leading to higher physiological stress rates than in males. However, hormonal differences related to fertility may have also predisposed females to higher rates of dental pathology than males (Lukacs 2008; Lukacs and Largaespada 2006)

7.3.3 Health and disease over time

Intra-site

As discussed above (section 7.2.3) intra-site comparisons of dental pathology did not reveal a great deal of variation at the individual sites over time, most likely due to the small size of the assemblages representing the individual occupation periods.

At the site of Maisabel, few clear differences in dental pathology were found between the two occupation phases. Noteworthy is the slight decrease in caries rate at Maisabel over time, together with a slight drop in calculus frequency and a statistically significant increase in AMTL. The latter certainly indicates poorer dental health in the late period. A slight increase in the frequency of LEH was observed in the late phase of occupation at Maisabel, perhaps a symptom of poorer physiological condition in the late period (Goodman and Rose 1991; Hillson 1996; King et al. 2005), however the difference is not statistically significant. Previous osteological analysis of the human remains from Maisabel found in general a low prevalence of skeletal pathology, suggesting the population may have been relatively healthy, although poor preservation of the material may have contributed to this picture. No differences were observed in the prevalence of skeletal pathology between the early and late period of occupation (Weston and Schats 2010).

At Punta Candellero a slight rise in caries rate is seen. AMTL rate drops significantly in the late period. LEH rates for the different periods of occupation at the site could not be compared, since only one individual with LEH could be securely assigned to a period. A previous study of the skeletal and dental remains from Punta Candellero by Crespo Torres (2000), although performed prior to large scale radiocarbon dating of the human remains (Pestle 2010b), found no sub-group differentiation with the entire group with regards to health, suggesting that physiological conditions at the site remained similar over time.

At Tutu, dental health seems to improve slightly over time, with a decrease in the

caries and AMTL rates. In a study of the human remains from Tutu Sandford et al. (2002) found that inflammatory disease affecting the bone was far more prevalent in the late phase of occupation, and that child mortality was higher. Precise patterning of the bone inflammations show that treponemal disease was more prevalent in the later population, perhaps due to greater population density facilitating the spread of infectious disease (Righter 2002; Sandford et al. 2002). The difference in dental pathology rates is thought here to be associated with changes in dietary practices between the two phases of occupation at the site, which are separated by around two centuries, and not with general physiological health, which seems to decline over time. LEH prevalence is generally low in both periods and no differences were observed over time.

Early Ceramic Age – Late Ceramic Age

As discussed above, broad scale differences were found in the rates of dental pathology between the Early and Late Ceramic Age groups. For the greater part, these differences are related to differences in foodways, specifically diet composition and food preparation techniques. The impact of these differences in foodways on dental health can be considered great. The almost doubling of the caries rate and strong increase in AMTL would have affected the ability to consume a varied and healthy diet, thereby affecting the nutritional condition. The increase in frequency and degree of calculus deposits would have affected the condition of the periodontium, leading to inflammation of the gingiva and other periodontal tissues. The infections associated with for example carious lesions, and periodontal disease and ABR (which was proliferous in both periods), would have laid a burden on the immune system (Ogden 2008; Waldron 2009).

The difference in frequency of LEH between the Early and Late Ceramic Age is relatively large, although it was not found to be statistically significant. Nonetheless, in the light of the differences in health between the two groups described above, this difference may be considered another expression of general differences in health and nutrition between the groups. As such, the greater frequency of LEH in the Late Ceramic Age group, suggests that periods of physiological stress due to malnutrition, infectious disease, or other health issues (including weaning stress) were more frequent in this group (Goodman and Rose 1991; Hillson 1996; King et al. 2005). Such conditions have generally been attributed to increasing population sizes, competition over resources and crowding in populations worldwide (Larsen 1997; Smith et al. 1984).

Changing Lesser and Southern Antillean health and disease

Significant differences were observed in the rates of dental pathology between the Early and Late Ceramic Age groups in the Lesser and Southern Antilles. Once again, these differences are related to differing foodways, chiefly with regards to the proportion of carbohydrates in the diet and food preparation techniques. The quadrupling of the caries rate and more than tripling of the AMTL rate would have

had significant implications for food consumption, and would have affected the immune system. The increase in frequency and degree of calculus deposits would have affected the condition of the periodontium, leading to inflammation of the gingiva and other periodontal tissues. The periodontal infections and carious lesions would have further burdened the immune system (Ogden 2008; Waldron 2009).

The difference in frequency of LEH between the Early and Late Ceramic Age is relatively large, since none of the Early Ceramic Age individuals were found to have hypoplasia. Since the differences in dietary practices and resulting dental health between the two periods are so large, it is likely that the Late Ceramic Age LEH are the result of physiological stress associated with changes in health and nutrition, such as malnutrition, infectious disease, or including weaning stress. Population growth leading to the more rapid and easy spread of infectious diseases could have contributed to this picture (Goodman and Rose 1991; Hillson 1996; King et al. 2005; Larsen 1997; Smith et al. 1984).

Time heals?

As discussed in Chapter 3 (section 3.6), previous studies in the pre-Columbian Caribbean have provided inconsistent results on the changes in health and disease over time. With regards to dental health, this study has shown a clear difference between Early Ceramic Age sites and Late Ceramic Age sites from throughout the region. The lack of available Early Ceramic Age dental material from the Greater Antilles sadly means that changes over time within this area could not be assessed, but for the region as a whole, and for the Lesser and Southern Antilles alone, the increase in frequency and changing pattern of dental pathology over time is considerable. The major factor contributing to the picture of deteriorating dental health over time in the region is changing foodways. As the diet became significantly more carbohydrate oriented, and foods substantially more refined, dental pathology became increasingly proliferous. The potential causes for such distinct differences in foodways over time, discussed above (section 7.2.3), include changes in sociopolitical organization, climate change, and population growth, or any combination of these potentially interrelated factors. Population growth is associated with greater pressure on local resources, perhaps differential distribution of nutrients (foodstuffs), and increasingly poor sanitary conditions leading to the spread of infectious disease (Larsen 1997).

7.4 CRAFTING IN THE PRE-COLUMBIAN CARIBBEAN

One of the most distinctive characteristics of fifteenth-century Taino society (at least to the modern observer) is a vibrant sense of artistic creativity and exuberant innovation in material expression [Deagan 2004:601].

7.4.1 Teeth as tools

It is likely that all of the individuals incorporated into this study used their teeth as a tool at some point in their lifetime, as we do nowadays when opening plastic packages or tearing sticky tape. Dental anthropological studies have found that during such activities particularly the anterior teeth are damaged (i.e., chipping), whereas the posterior dentition is more at risk during food mastication (Scott and Winn 2010). The anterior teeth are not intensively used during food mastication (i.e., grinding of the food), since they are adapted to cutting and tearing portions of food for subsequent mastication. A greater rate of chipping in the anterior teeth can therefore be indicative of non-alimentary use. Some studies have found that occlusal buccal and occlusal lingual edge chipping is more strongly related to non-alimentary use of the teeth, whereas interproximal edge chipping is associated with food mastication (Belcastro et al. 2007; Bonfiglioli et al. 2004). Another reason for disparate rates of chipping between the anterior and posterior dentition is AMTL. Greater AMTL in the posterior dentition may put more strain on the anterior dentition, as these teeth must perform all food mastication (Belcastro et al. 2007).

Observations of the rate, degree, and location of chipping made in this study indicate that posterior chipping is both heavier and more prevalent than anterior chipping overall, but not at the sites of Anse à la Gourde and Maisabel, and for the males at Chorro de Maíta. The observed locations of chipping on the tooth crowns of the posterior teeth generally reflect normal use of the teeth in mastication of foods with grit or hard particle inclusions. The observed chipping locations on the anterior teeth are more typical for non-alimentary use of the teeth. Even though posterior chipping is more prevalent in the sample, the rate of anterior chipping can be considered relatively high, suggesting that non-alimentary use of the teeth was commonplace in the daily routine. Particularly at the sites of Anse à la Gourde and Maisabel, and with regards to the males at Chorro de Maíta, it seems that the teeth were used more frequently in simple non-alimentary practices, such as the clamping of materials and objects. Sex differences in anterior dental wear have been previously recorded, including differences in the frequency and degree of dental chipping (Belcastro et al. 2007; Bonfiglioli et al. 2004; Larsen 1997; Richards 1984). The higher frequency of chipped teeth in males overall concurs with the results of previous research in other regions, and has (similar to a higher mean degree of wear in the anterior teeth) generally been attributed to the greater force exerted by the larger muscular masticatory apparatus in males, or alternatively the sex-based division of tasks (Scott and Turner 1988).

Other patterns of dental wear observed in the sample appear to indicate more specific uses of the teeth as tools. For example, the various types of notching and grooving of the anterior teeth, grouped here as Type 3 non-alimentary wear, are consistent with patterns of wear observed in numerous studies worldwide, which have frequently been attributed to the manufacture of cordage, sewing, or basketry. Distinctive features such as striations and polishing of the notch or groove area, or pitting and micro-fracturing, may indicate the cause of the observed pattern of

macrowear. Striations and polishing are mostly associated with the movement of a flexible fibrous material across the tooth surface, while pitting and micro-fractures are associated with the clamping together of the teeth to hold an object (such as a needle, reed, or twig). All cases of Type 3 non-alimentary wear were examined under a stereomicroscope, however in some cases further analysis by SEM is warranted to understand the aetiology of the wear. In the majority of cases, the presence of clear striations, sometimes indicating directionality, showed that fibrous plant materials were drawn across the tooth surfaces, and therefore suggests cordage manufacture and/or basketry. Often such activities are found to be strongly associated with sex and age, both in skeletal and modern populations (Erdal 2008; Larsen 1985; Molnar 1971a, 1972). The proportion of the overall population involved in activities which caused Type 3 non-alimentary wear is small, which may suggest that this activity involved some degree of specialized knowledge. However, although all patterns of wear grouped under Type 3 represent grooving and/or notching of the anterior teeth, there is a great deal of variation in the patterns of wear grouped in this category. The observed notches and grooves show little uniformity with regards to affected dental elements, or size and direction of the notch or groove. This could indicate that the technology of cordage and basket manufacture was not standardized and passed on from teacher to apprentice (i.e., each individual developed his or her own technique), or that each variant represents the manufacture of a different type of item. The latter seems less likely, however, since it is known that similar activities can lead to widely varying patterns of macrowear (Scott and Turner 1988). There is some highly tentative evidence, however, for an association with sex based on the similar appearance of notches in five individuals. These five individuals are all females, and originate from the sites of Anse à la Gourde, Punta Candelerero, and Tutu.

Type 1 non-alimentary wear, lingual wear of the lower incisors, is relatively rare, with only six affected individuals in the entire sample. This pattern of wear involves dentine exposure of the lingual surfaces of the lower incisors, extending from the cement-enamel junction to the incisal edge, and is associated with heavy wear of the teeth in general and the older adult age categories (36–45 and 46+ years). There is no evidence for malocclusion in the individuals concerned, and neither are there any indications of corresponding wear on the upper anterior teeth. The absence of surface striations and ‘exit-grooves’ such as those seen in some cases where the lower incisors are used to manipulate thin strips of material (Littleton and Fröhlich 1993; Molnar 2011), means it is hard to define a non-alimentary cause for this pattern of wear. Overall, this pattern of wear is consistent with patterns of dental erosion identified in clinical dentistry, where loss of lingual enamel due to acid erosion similarly creates a pattern of flat, bucco-lingually angled wear (Bartlett 2005, 2006; Lussi et al. 2004; Ogden 2008). These patterns of erosion are generally associated with individual diet and eating habits, and generally result from extrinsic acids, since intrinsic (stomach) acids introduced when vomiting rarely affect the lower teeth due to the protective position of the tongue. Acids from acidic

fruits consumed by pressing the flesh against the lingual surfaces of the lower front teeth are a possible cause (see also section 7.6 on LSAMAT). It is unclear, therefore, whether this pattern of wear is truly the result of non-alimentary activities.

Type 2 non-alimentary wear, disproportionate wear between anterior and posterior teeth, is the most commonly observed pattern of wear associated with the use of the teeth as tools in this study. In many cases, both the upper and lower anterior teeth are affected, however, in some cases only the upper or the lower anterior teeth are worn disproportionately. This distinction represents clearly different aetiologies for the main category (Type 2) and the two subcategories (Type 2a and Type 2b), since in the latter two the teeth are not used in occlusion. The precise aetiology of this type of wear is hard to distinguish, however, since a great variety of actions may cause rapid and severe wear of the teeth, including the simple clamping and holding of objects as described above, but also the chewing of hide or the peeling of tubers (Berbesque et al. 2012; Scott and Turner 1988). Some individuals incorporated into this category displayed more distinct features however, such as individuals 11 and 13 from Punta Macao (both males, aged 26–35 years and 36–45 years, respectively). These two individuals display severely worn upper central incisors, with complete enamel loss, and a bucco-lingually rounded surface. The upper lateral incisors are heavily worn, to a slightly lesser degree than the central incisors, and show labial wear facets on the mesial incisal edges. The lower incisors are also quite heavily worn. Overall the surfaces appear polished, and SEM analysis of two teeth belonging to individual 11 revealed relatively short surface striations without clear directionality across the incisal surface. Deeper, labio-lingually oriented scratches with clear V-shaped pits on the labial part of the rounded incisal surface may indicate friction of grit or other hard particles across the surface. Pitting and a generally damaged dentine surface suggest pressure fracturing of the enamel, perhaps as the result of the hard clamping of an object between the front teeth. The extremely distinct features of this pattern of wear, which are also seen in individual 3 (B3) and individual 9 from Punta Candelero (a female aged 36–45 years and an adult of unknown sex, respectively), suggest a highly specific task activity. It is tentatively suggested here that the clamping of a mouthpiece for a bow drill may have been the cause. The use of a bow drill mouthpiece has previously been suggested as the cause of disproportionate wear of the anterior dentition, however the precise pattern of wear associated with this activity has never been described in detail (Angel 1968; Erdal 2008; Lukacs and Pastor 1988; Merbs 1983). This aetiology may explain the pitted areas of the exposed incisal dentine observed by SEM, as the high pressure and perhaps vibrations from the drilling action could damage the tooth surface in such a way. It may also explain the short, clearly V-shaped scratches, as grit or small particles trapped between the teeth and the mouthpiece (or even the mouthpiece itself) may scratch the exposed dentine due to vibrations from the drill. The use of a mouthpiece for a bow drill may also explain the labio-lingually rounded wear of the central incisors, and the labial wear facets on the mesial incisal edges of the lateral incisors. Bow drill use has been

inferred for some sites in the Caribbean, such as Anse à la Gourde (Guadeloupe) based on the presence of large numbers of *Strombus sp.* perforated beads of standardized manufacture, and at the bead manufacturing site of Governor's Beach (Grand Turk) based on the fragile nature of the beads which would require a bow drill to make perforations (Carlson 1995; Lammers-Keijsers 2007).

Type 4 non-alimentary wear, buccal wear, is found in a relatively large number of individuals in the sample. This pattern generally affects the anterior dentition, and takes the form of either flat, polished wear facets involving both enamel and dentine, or rough, damaged buccal surfaces in which the enamel and dentine appear fractured, and chipped. The absence of clear striations or striations with uniform directionality in the first type suggests that this pattern of wear was not caused by the (forceful) contact with and movement of material across the affected tooth surface. This pattern of wear is more consistent with the repeated contact between a hard (relatively non-abrasive) material and the tooth surface. Such macrowear has often been attributed to the wearing of lip or cheek ornaments (labrets), which can be made of wood, bone, stone, glass, metal, or shell, and which are known from both clinical studies and analyses of prehistoric material to cause wear facets of this appearance (Cybulski 1974; De Moor et al. 2005; Dietze et al. 2007; Keddie 1989; Santoni et al. 2006; Torres-Rouff 2003). While it is known from ethnohistoric sources that the indigenous societies of the Caribbean islands at the time of the first encounters with Europeans wore various bodily and facial ornaments, including large ear spools, there is no known documentary evidence for labret use in the archipelago (Beckwith and Farina 1990). Body ornamentation is recovered archaeologically, however, the distinction between ear spools or other body decoration and labrets could be hard to make, since both ornaments can take the same round or cone-like shape. Again this category shows little uniformity in the observed wear facets, with each case being unique apart from the fact that there is buccal (or labial) wear of one or more teeth). Body decoration norms, even when practiced by only a small portion of the population, tend to follow clear rules with regards to size and placement of the ornament, iconography, colour, gender and age of the wearer, and so on (Turner 1979, 2009). It is possible that lip and cheek ornaments were used in the pre-Columbian Caribbean, but that the position of the ornament on the face was not uniform, or that such ornaments were worn only by very small numbers of individuals, and the manner of wear was different for each individual. Alternatively, it is possible that Type 4 non-alimentary wear was caused by the repeated holding of a hard object between the teeth and the cheek or lips.

The second type of buccal wear observed in this study was found in only one (juvenile) individual from the site of Esperanza (Vieques), and is associated with severe damage (chipping and fracturing) of the buccal surfaces of the upper central incisors. This type is more consistent with the rubbing of a hard, abrasive material across the upper central incisors with great force, such as the peeling of tubers with the front teeth (Berbesque et al. 2012). This wear pattern may represent a personal habit, or perhaps a site specific activity (this juvenile is the only individual from

this particular site in the sample).

Type 5 non-alimentary dental wear, singular cases, represents a set of unique patterns of clearly non-alimentary dental wear that cannot be assigned to any of the other four categories. These patterns of wear could represent habitual activities which are specific to the individual, since they are not found in any others in the sample. Further study of these dentitions (for example with SEM) is warranted to understand which activities may have caused the observed unique patterns of wear.

Although it is incredibly hard to securely identify the activities that caused the patterns of non-alimentary wear observed in this sample (and many others worldwide), there are some indications for specific task activities, such as basketry, cordage manufacture (e.g., for fish nets), and the use of a bow drill (e.g., to drill stone and shell beads and pendants). These all represent activities which may be considered crafting, i.e., the manufacture of items not related to the daily food production activities, for which a large degree of knowledge, training and expertise was needed. In the following section we will take a closer look at how dental anthropological evidence can contribute to studies of craft activities in the past, and how the individuals in this study may have fulfilled the role of crafts(wo)man in their community.

7.4.2 Teeth and crafting activities

Crafting has been studied through various means in archaeology, often based on the material end product of the crafting process, the refuse material associated with production, or the tools involved in production. Recent years have seen an explosion of research on craft production and specialization, a topic of study which is often used as a tool to understand social structure and socio-political organization. The implicit association between craft production and labour specialization and increasing socio-political and economic complexity was present from the outset of studies on social complexity in the 1950's and 1960's (e.g., Service 1962; see also Peregrine 1991). More recently, however, prominent researchers in the field have called for a focus on the producer as opposed to the consumer of craft products in order to get a better understanding of the social identity and agency of the artisans (Costin 1998). Some have questioned the assumption that specialization and social complexity are inherently associated (Sinopoli 1998), while others have questioned environmental and political models for craft production (Sassaman 1998). One of the main problems signalled by researchers working with craft production systems is the fact that the identity of the producers, or artisans, is hard to define, despite the use of models based on ethnographic analogies. Recently, in the field of bioarchaeology, there is increasing interest in the study of how the human skeleton may reflect past activity patterns, including specialized activities such as crafting, as these may leave permanent modifications on the skeletal frame (Jurmain et al. 2012; Meyer et al. 2011). This type of research has astounding potential for our understanding of who the artisans were. Based on the physical characteristics of the

human skeleton, age and sex of individual skeletal remains can be identified. Although biological sex can arguably be very different to the social gender categories recognized in a particular society, knowing the biological sex of individual artisans can provide important insights into the division of craft labour. Furthermore, the manner and location of burial (mortuary practices) can offer information on individuals' social status. Even diet and provenience (i.e., the location where individuals grew up as opposed to where they were buried) can be inferred using archaeometric techniques. Together with skeletal or dental evidence of (craft) activities, this information can be used to build an informed picture of the identity of artisans in the past.

While many studies in craft specialization struggle to put a face to the anonymous crafts(wo)men, this study has potentially identified a number of individuals who used their teeth to manipulate items, and perhaps to craft objects. It is important to realize here that the use of the teeth as a tool does not automatically amount to craftsmanship. The regular engagement in tasks involving the teeth for other purposes than mastication of food is not always related to craft activities, and does not necessarily require the skill and knowledge involved in crafting. For example, the carrying or clamping of an object between the teeth while the hands are otherwise occupied does not constitute crafting, since no object or material is manufactured. Where dental evidence can reasonably be concluded to evince the manufacture of certain materials or objects which require skill and practice, such as in the case of notches or grooves caused by fibrous plant materials, crafting could be inferred. As explained in the previous section, this study has identified a number of individuals with Type 3 non-alimentary dental wear, and three individuals with a specific subtype of Type 2 non-alimentary dental wear, that likely used their teeth in activities which are often considered crafting or craft specializations: i.e., basketry and/or cordage manufacture, and the use of the bow drill, perhaps to fabricate stone or shell beads, and other ornaments. Yet while the traces of human actions have been found, in the form of notches, grooves, and other patterns of non-alimentary wear on the teeth, the final crafted object is lacking. Based on this information, it is impossible to say whether these individuals engaged in other (food producing) activities or not (i.e., whether they were fulltime specialists), or whether their craft 'specialization' was related to food production (see Chapter 3, section 3.5). For example, one way in which Type 2 non-alimentary wear could have been produced, is through the peeling and scraping of tubers with the anterior teeth in order to prepare them for the production of staple foodstuffs. So for now there is no evidence that certain craft activities involving the teeth as a tool were controlled by a politically elite class and involved specialization. For the early contact period in the Greater Antilles (in particular the modern-day Dominican Republic and Haiti), ethnohistoric accounts describe a system of controlled production and restricted access to certain craft items, within the chiefdom sociopolitical organization established there: "Both of the principal early sixteenth-century chroniclers of the Taino specifically recorded that caciques controlled production of both subsistence and

craft goods by assigning specific tasks to individuals or groups, appropriating the fruits of their labor, and subsequently redistributing goods to community members” (Deagan 2004:600). Other research has similarly argued for the existence of a class of (elite or shamanic) craft specialists who manufactured basketry and wooden objects requiring great skill and knowledge (Berman and Hutcheson 2000; Conrad et al. 2001; Ostapkowicz 1998). Conrad et al. (2001) argue, for instance, that an organized group of craft specialists constituting a class of elite persons, or working for the elite, did not come into existence until Taíno chiefdoms grew in size and power after A.D. 1200. This information, while indicating that craft activities in the Late Ceramic Age and early Contact period in the Greater Antilles were likely organized and controlled by an elite class, and may have involved a class of craft specialists, cannot simply be extrapolated to other parts of the Caribbean, and/or other periods in the occupation history of the region.

Furthermore, the evidence found during this study does not indicate any kind of uniformity in craft activities using the teeth, perhaps suggesting that crafting technology and techniques were highly personal, and not standardized. This argues against craft specialization in general, in which some form of standardized production and the passing on of techniques and skills (to apprentices) is expected. In contrast, the potential crafts(wo)men identified in this study present a haphazard picture of highly idiosyncratic ‘artisans.’ The inference that craftsmen (at least among the Late Ceramic Age populations of the Greater Antilles) belonged to an elite (high status) class remains unsubstantiated after consulting the data on mortuary treatment of the individuals identified here as potential crafts(wo)men. Based on what is known of grave goods, burial position and orientation, and burial type (i.e., primary, secondary, single, multiple, etc.), the ‘crafts(wo)men’ in the sample do not appear distinct in any way from other individuals (Edwin Crespo Torres, personal communication 2011; Menno Hoogland, personal communication 2011; Sandford et al. 2002; Siegel 1992; Tavaréz María 2004). Grave goods were not found to be associated with the inferred crafting practices, although grave goods related to the production of artefacts were found, such as two hammer stones recovered from the grave pit of individual 10 (a female aged 46+ years) from Maisabel (Siegel 1992).

Of course it is entirely possible that there existed a class of (elite) specialized crafts(wo)men in the pre-Columbian Caribbean, who used standardized technology and passed techniques on to their apprentices, and that these practices simply did not involve the use of the teeth as tools. Or alternatively, certain crafting activities may have been socially structured in this way, while others were not. Currently, it is beyond the scope of this research to provide answers to these complicated issues. Further research into the craft activities related to non-alimentary dental wear along with analysis of for example other occupational and activity markers on the skeletal frame, such as musculoskeletal stress markers (MSM), is necessary to further elucidate craft practices in the pre-Columbian Caribbean.

7.4.3 Sex-based differentiation: *craftsmen or craftswomen?*

As discussed above, the individuals identified as potential crafts(wo)men in this study show clear differences in their patterns of non-alimentary wear and potential aetiologies. Significant differences were also found between the sexes: a far greater proportion of males was found to have non-alimentary dental wear than females. Even when taking into account the fact that Type 1 non-alimentary dental wear may in fact have an alimentary cause, the majority of the group is still male (51.67%). In other words: the majority of the population using their teeth as tools is male. As already indicated in Chapter 6 (section 6.3.4; Table 6.19), this difference is not a reflection of discrepancy in the proportions of males and females in the total sample, since numbers are almost equal.

However, for those tasks that are most likely associated with craft activities (the Type 3 category, and the four possible ‘bow drillers’ assigned to Type 2), the proportions of the sexes are the same (male: 40% [n= 10], female: 40% [n= 10]). The fact that of the ten females in the pooled Type 3 and Type 2 ‘bow driller’ categories, five share specific characteristics with regards to the type, size, and directionality of notching, and the affected portion of the dentition, while only one male individual shows a similar pattern, may indicate sex-based task differentiation within the crafting activities related to cordage and basket production. As indicated in the previous chapter, this pattern is consistent with the production and manipulation (spinning and weaving) of (cotton) thread and cordage, or basketry. While numbers are small, and analysis of more dental assemblages is warranted to lend credence to this view, this picture agrees with the sex-based labour divisions recorded by early colonial period chroniclers, who mention that “women spun and wove cotton into clothing and hammocks, made baskets and mats, and carved some ceremonial wooden items” (Deagan 2004:601; Ostapkowicz 1998). The ethnohistorical sources are less specific with regards to male crafting activities, but it is often assumed that males crafted larger wooden items (e.g., houses, canoes), and produced stone artefacts (Deagan 2004; Ostapkowicz 1998). The latter could potentially explain the generally higher frequency and degree of dental chipping observed in males at most sites in the sample, as the manufacture of larger hard-material objects may be more strongly associated with the use of the teeth for grasping, clamping and otherwise manipulating hard materials.

7.4.4 Crafting over time

Since very little dental material dated to before approximately A.D. 600/800 from the Greater Antilles was available for analysis, comparisons between the early and late period of occupation could not be made for this region. Two broad temporal comparisons were made in order to track changes in crafting activities over time. The first compares all dentitions incorporated into this study from the Early Ceramic Age (i.e., before A.D. 600/800), and all dentitions from the Late Ceramic Age (A.D. 600/800–1500/1600). The second compares only the Lesser and Southern Antillean material for the same two periods to each other, since this is the only

region that is represented in this study by sufficient dental material from both main occupation periods.

Both comparisons described above revealed differences between the early and late groups. In the entire region, non-alimentary dental wear patterns become more prevalent in the Late Ceramic Age. Likewise, within the Lesser and Southern Antilles, the frequency of dentitions affected by non-alimentary dental wear increases in the Late Ceramic Age. While these differences were not found to be statistically significant, there is some evidence that they may reflect a true shift in non-alimentary practices using the teeth, since in both comparisons the frequency of non-specific non-alimentary dental wear (such as chipping along the occlusal buccal edge of the crown and anterior chipping) also increases in the Late Ceramic Age. The practice of teeth as tool use increases in the Late Ceramic Age, both for specific task activities, and for non-specific non-alimentary uses of the teeth such as grasping or clamping of objects, for example when the hands are otherwise occupied. The latter type of activity seems to increase particularly in the Lesser and Southern Antilles in the Late Ceramic Age, as in this region the mean degree of chipping increases significantly, together with the frequency of chipping and the frequency of affected individuals. These increases may indicate a more active daily routine involving a greater variety of tasks and activities during the Late Ceramic Age on the part of most adult individuals in the community.

7.5 LSAMAT, LSWMAT, LSEMAT: TERMINOLOGY AND AETIOLOGY

As described in Chapter 2, there has been some debate on the cause of LSAMAT with two main parties divided on the issue whether this pattern of wear is caused by attrition (Irish and Turner 1987, 1997; Turner and Machado 1983; Turner et al. 1991) or erosion (Levitch et al. 1994; Robb et al. 1991). With regards to the former option, both alimentary and non-alimentary explanations have been offered since the pattern was first described (Comuzzie and Steele 1988; Hartnady and Rose 1991; Larsen et al. 2002; Liu et al. 2010; Porr and Alt 2006). Despite this debate on the cause of LSAMAT the past few decades have seen little further research into the aetiology of LSAMAT, even though this pattern of wear has currently been identified in a large number of different geographical and temporal settings throughout the world (e.g., Baker and Moramarco 2011; Berbesque et al. 2012; Consiglio 2008; Liu et al. 2010; Meng et al. 2011; Mickleburgh 2007, 2011; Pechenkina et al. 2002; Saul and Saul 1991; Villotte and Prada Marcos 2010). It has become clear that LSAMAT is not always associated with a high rate of caries (e.g., Consiglio 2008; Meng et al. 2011; Pechenkina et al. 2002), and is now frequently found in regions where manioc – or even sugarcane – did not grow.

Furthermore, comparison of published images of LSAMAT from throughout the world clearly shows that the dental wear patterns nowadays identified as LSAMAT vary in their appearance, and perhaps therefore also in their aetiology. For these reasons, I feel it is time for a re-evaluation of the dental wear pattern LSAMAT and

its aetiology, based on the presence of LSAMAT in numerous settings throughout the world.

7.5.1 A tricky terminology

The term LSAMAT has been criticized by Robb et al. (1991) for its use of the term *attrition*, which in a strict sense refers only to wear caused by contact between teeth. The correct term for wear of the tooth surfaces through contact with a foreign agent is *abrasion*. The use of the term *attrition*, therefore, may be misleading in the sense that it does not concur with the aetiology proposed by Turner and colleagues, and may be more appropriately replaced by *abrasion* or *wear*: lingual surface *wear* of the maxillary anterior teeth (LSWMAT). However, there is another complication associated with the term which has led to a degree of variety in patterns of wear which are currently identified as LSAMAT. The fact that the term itself is a description of the appearance of the pattern of dental wear has led to its use in various cultural and temporal settings, since many forms of lingual wear of the upper front teeth (without corresponding wear on the lower anterior teeth) may comply with the description of LSAMAT. However, Turner and colleagues also list more specific qualities that characterize LSAMAT, such as the associated high caries rate (Turner and Machado 1983; Irish and Turner 1987, 1997). LSAMAT is more than a purely descriptive abbreviation, as the term has become synonymous with the inferred aetiology of this pattern of dental wear (i.e., the use of the teeth to extract nutrition from fibrous and cariogenic plant material, or to prepare the material for the manufacture of goods, by drawing it across the lingual surfaces of the upper front teeth). As a consequence, the broad application of the term in various contexts worldwide has meant that few researchers have attempted to search for the causes and aetiology of the lingual wear they have observed, since lingual wear is assumed to be LSAMAT, which in turn is assumed to result from the drawing of fibrous plant materials across the lingual surfaces of the upper front teeth. The manner in which the term is currently used in dental anthropology and osteoarchaeology in general may in fact be masking a great deal of variety in lingual wear patterns and their causes in the archaeological record.

One final complication associated with the use of the term LSAMAT is the fact that lingual wear of the mandibular anterior teeth, discovered in a small number of individuals in this study and denoted as Type 1 non-alimentary wear, could equally be referred to with the same abbreviation (i.e., lingual surface attrition of the *mandibular* anterior teeth; LSAMAT).

7.5.2 Re-evaluating LSAMAT

One of the main characteristics described as defining the pattern of dental wear known as LSAMAT, according to the original researchers, is the fact that LSAMAT is invariably associated with a high caries rate. The high caries prevalence observed by Turner and Machado (1983) in the Archaic Corondó site in Brazil (4200–3000 B.P.) was of particularly great influence upon their original interpreta-

tion of this pattern of wear, because based on the fact that they were dealing with an Archaic period population (who are traditionally assumed to have consumed a heavily protein oriented diet) they decided that this pattern of anomalous wear of the lingual surfaces of the upper front teeth must have been associated with a highly specific task activity or eating habit associated with a very cariogenic plant. Since Turner and Machado's original investigations in the early 1980's osteoarchaeologists and archaeologists in general have come to understand that the simple dichotomy between protein-eating hunter-gatherers and carbohydrate-consuming agriculturalists is not a true reflection of foodways in past (nor in modern non-western) societies. It is now known that many hunter-gatherer diets consist of large proportions of carbohydrates, next to (in some cases) a considerable proportion of protein foodstuffs (Kubiak-Martens 2002; Lee 1968; Milton 2000). Therefore, the assumption that extremely high caries rates in a hunter-gatherer population must in some way reflect specific task related activities is not necessarily appropriate. Furthermore, even if LSAMAT observed at the Corondó site is considered to have an alimentary cause, there is no evidence that the high caries rate observed in the dental material is in any way related to the patterns of lingual wear observed there. If this were the case, higher caries rates would be expected in individuals displaying LSAMAT, as opposed to individuals without LSAMAT, however such a distinction was not reported by Turner and Machado (1983), nor by Irish and Turner (1987, 1997). So even considering Turner and Machado's dietary explanation for LSAMAT (which they prefer over a non-alimentary cause), in which manioc roots were peeled for consumption and raw peel was consumed, the association between the high caries rate and LSAMAT is far from clear-cut. The results of the present study show that individuals with LSAMAT have a significantly higher caries rate than those without LSAMAT, however, the difference could be an artefact of the different age profiles of the two groups, since the LSAMAT bearing group is generally older. This means that even when a correlation between high caries rate and LSAMAT is apparent, a causal relation between the two cannot simply be assumed. Furthermore, if LSAMAT was caused by repeated contact between a cariogenic plant material (i.e., raw manioc peel) and the maxillary anterior teeth then one would expect the anterior maxillary teeth to be particularly severely affected by caries, due to their direct contact with the cariogenic material. Once again, this is not reported in the originally described cases of LSAMAT.

7.5.3 Types of LSAMAT

In the course of this research, it became clear that the patterns of lingual wear observed in pre-Columbian Caribbean dental material show some degree of variation with regards to their appearance, even though they conformed to the descriptions of LSAMAT as set out by Turner and Machado (1983) and Irish and Turner (1987, 1997). Two different types of LSAMAT were distinguished on the basis of the sample used in this study.

Type 1 LSAMAT

Type 1 LSAMAT consists of maxillary lingual wear which affects the central incisors most severely, particularly the area around the cingulum. The lateral incisors and the canines are worn more evenly across the lingual surface, although the area closest to the cement-enamel junction is usually most severely worn. Characteristically, this type of LSAMAT is associated with lingual wear of the premolars, and (infrequently) the first molars. Wear facets are often circular in shape, and expose the underlying dentine. On the premolars (and often also on the other affected teeth), the circular wear facets are always clearly cupped. This pattern of wear was not found to be associated with a higher rate of caries in general. A review of published cases of LSAMAT, revealed that this particular pattern has been found in other spatial and temporal contexts.

Firstly, based on physical appearance this pattern of wear is practically identical to that observed on a single male individual from the site of Cerro Mangote, Panama, found in a shell midden dated to 5000 B.C. (Irish and Turner 1987). Irish and Turner (1987) describe LSAMAT observed in dental material recovered from Venado Beach, Panama, a late prehistoric site occupied during the second half of the first millennium A.D., as affecting the upper central and lateral incisors, and to a much lesser degree the upper canines. But the image published in this work is of the male individual (32) from Cerro Mangote, who clearly shows cupped, circular wear on the lingual surface of the upper right first premolar. The pattern of wear in this individual corresponds completely to that described in this study as Type 1 LSAMAT. Irish and Turner (1987) indicate that the prevalence of caries at Venado Beach is very high, however they make no mention of the caries rate at Cerro Mangote, perhaps due to the small amount of material recovered from that site.

Secondly, the photo example of an individual affected by LSAMAT provided by Irish and Turner (1997:Figure 1) similarly appears to conform to the pattern described in this study as Type 1 LSAMAT. Here, the authors describe LSAMAT in historic material from Senegal in West Africa, which – as was the case for the original LSAMAT pattern of wear found at the Corondó site in Brazil – was associated with a high caries frequency (Irish and Turner 1997; Turner and Machado 1983). The authors maintain their original interpretation of LSAMAT as most likely resulting from the consumption and/or processing of an abrasive, carbohydrate-rich food, in this case raw sweet manioc root or sugarcane (Irish and Turner 1987, 1997). The example image of a historic female individual from Senegal affected by LSAMAT provided by Irish and Turner shows that the lingual surfaces of the upper incisors and canines are affected only around the cingulum, close to the cement-enamel junction. The remainder of the lingual surfaces appears not to be worn. The wear facets, which expose the underlying dentine, are circular in shape, and appear to be slightly cupped.

Type 2 LSAMAT

Type 2 LSAMAT consists of the lingual wear of the upper central incisors, lateral

incisors, and to a lesser extent the upper canines. The wear is generally flattened and angled in an oblique (downward-labial) direction, and affects the entire lingual surface, except in the early stages of wear when the cingulum is the focus of wear due to its raised relief. The lingual surface often displays (macroscopically observable) labio-lingual striations. This type of LSAMAT was found to be associated with a significantly higher caries rate than that seen in individuals without LSAMAT. This difference may be related to age, however, meaning there is as yet no direct evidence that the presence of LSAMAT and a high caries rate are related. A review of published cases of LSAMAT, revealed that this pattern of LSAMAT has been found in other spatial and temporal contexts.

For example, at the Late Mesolithic site of Bad Dürrenberg, Central Germany, an isolated burial of an adult female (25–35 years) together with the remains of a young child found in the 1930's, was recently found to display “advanced lingual wear of the first incisors, whereas lingual facets are less developed on second incisors [...] the wear pattern of the upper first incisors seems to be due to teeth-as-tool activities of unknown genesis” (Porr and Alt 2006:400). An accompanying image of the lingual wear of the upper central incisors clearly shows enamel loss of the entire lingual surfaces of the upper central incisors and slight lingual wear on the mesial aspects of the lingual surfaces of the lateral upper incisors (Porr and Alt 2006:Figure 3).

The same type of pattern appears at the Xinjiang site in Northwest China where dental material dating to the Bronze-Iron Age (5000–2000 B.P.) was found to have “severe wear on the lingual surface of maxillary anterior teeth [...] expressed as large wear facets on the lingual surface of the upper incisors and canines slightly above the cement-enamel junction” (Liu et al. 2010:110). The published image of the lingual wear pattern (Liu et al. 2010:Figure 6) clearly shows wear and dentine exposure on the entire lingual surfaces of the remaining central and lateral maxillary incisor, and canine. No mention is made of the caries frequency in this population.

Other ‘LSAMAT’

Various recent studies have described patterns of lingual wear of the upper anterior teeth which have subsequently been identified as LSAMAT, although in most cases the researchers do not adhere to the aetiology of LSAMAT as set out by Turner and Machado (1983), and Irish and Turner (1987, 1997).

For example, researchers working on the Jiangzhai site in Northern China have documented a pattern of lingual wear of the upper front teeth which they consider to be LSAMAT in a skeletal population dating to the end of the Chinese Neolithic (7000–4000 B.P.) (Pechenkina et al. 2002). The wear they found was “expressed as large wear facets on the lingual surface of the upper incisors and canines slightly above the cemento-enamel junction” (Pechenkina et al. 2002:22). On close inspection of the published photograph of a maxillary dentition affected by LSAMAT, it is apparent that the lingual surfaces of the central incisors are unevenly affected

by the wear, resulting in a 'stepped' appearance of the lingual surface. The most severe wear is located near the cingulum, close to the cement-enamel junction, where a considerable portion of the dentine is exposed. The other anterior teeth appear to be worn more evenly across the lingual surfaces, although the cement-enamel junctions are also most severely affected. This pattern of lingual wear does not concur with original descriptions of LSAMAT, particularly with regards to the 'stepped' appearance and uneven wear of the lingual surface, which is supposed to be "flattened at all stages and angled appropriately for some sort of material having been drawn across the lingual tooth surfaces" (Turner et al 1991:348). Furthermore, the pattern of wear is described by Pechenkina et al. (2002) as atypical for LSAMAT, since the caries frequency in this skeletal assemblage is generally low, and LSAMAT was found only in dentitions completely lacking carious lesions. They conclude that preparation of fibers from non-sugary plants is the most likely cause of the pattern of wear they found, while ruling out the pressing of cordage to the lingual surfaces of the incisors, as there appears to be no 'exit' location for the cord between the canines and premolars.

At the Medieval/Venetian Period cemetery of Athienou-Malloura, where five of 35 adults were found to display lingual wear of the upper anterior teeth, researchers have found clear exit grooves on the distal edges of the lateral incisors, accompanying a pattern of lingual wear which the investigators identify as LSAMAT (Baker and Moramarco 2011; Harper and Fox 2008). The same pattern was also found in a small number of individuals from two early sixth century basilicas at Polis Chrysochous, north-western Cyprus (Baker and Moramarco 2011).

Another, clearly uneven, 'stepped' pattern of lingual wear of the upper central incisors and flat wear of the lateral incisors was observed by Meng et al. (2011) in a Neolithic population (6700–5600 B.P.) from northern China. Since there is no evidence of manioc or similar plants ever having grown at the site, Meng et al. (2011) conclude that the pattern of lingual wear in their sample is more likely the result of non-alimentary activities, such as the pulling of flexible materials across the anterior teeth, such as the pressing of a cord or sinew against to the lingual surface of the upper front teeth during weaving, cordage manufacture or basketry (Meng et al. 2011).

7.5.4 LSAMAT or LSEMAT?

The examples above of 'LSAMAT' appear to differ considerably from each other, and sometimes from the original description of this pattern of wear. This raises the question whether both Types 1 and 2 LSAMAT, as well as some of the other patterns of lingual wear observed across the globe could possibly share the same aetiology, as the use of a single term to denote these patterns implies.

To reiterate, the original interpretation of the cause of LSAMAT involved the habitual drawing of a fibrous and cariogenic plant material across the lingual surfaces of the upper front teeth, either to extract nutrition or to prepare the material for the manufacture of goods. The action of pulling the plant material across the teeth

is described as similar to the way we nowadays eat artichoke leaves: by clamping the leaves between the upper front teeth and the tongue and pulling them across the lingual tooth surfaces. Could this action have caused the different types of LSAMAT described above? There are some indications that suggest not. Firstly, with regards to Type 1 LSAMAT, the angle and pressure needed to create the wear and dentine exposure of only the area of the tooth around the cingulum would have to be very localized, close to the cement-enamel junction. The absence of wear on the mandibular front teeth and along the incisal edges and rest of the lingual surfaces of the upper front teeth indicates these parts of the dentition were avoided, or at the very least were not the focal point of pressure. Considering the natural position of the upper front teeth in the jaw (nearly vertical to somewhat prognathic), this means the object drawn across the teeth must have been moved in the (almost) vertical plane (up-and-down or down-and-up), with the mouth opened far enough to keep the lower front teeth out of the way. However, such an action would unavoidably put some pressure on the incisal edges of the upper front teeth, as any force applied to a flexible plant material would put the greatest strain on that part of the tooth which obstructs the movement the most (i.e., the incisal edge, since it protrudes the most) (Figure 7.2). Furthermore, it is hard to imagine that the tongue was used to press the fibrous plant material onto the cingulum, as the repeated action of drawing the fibrous material between tongue and teeth (while applying pressure), must be uncomfortable and even damaging to the tongue.

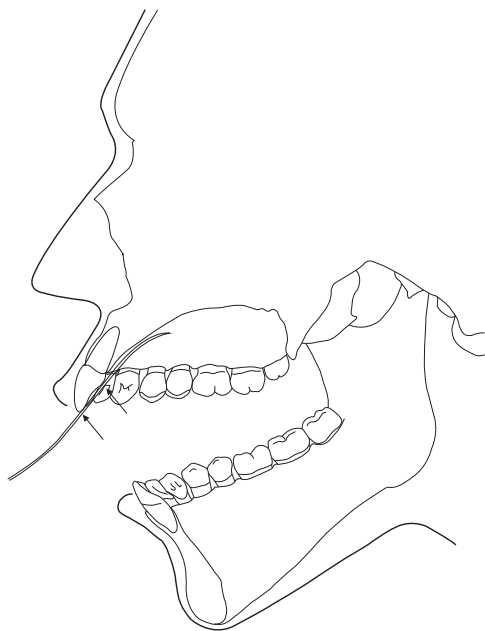


Figure 7.2 The pressure points for dragging a fibrous plant material across the lingual surface of the upper front teeth needed to create forms of LSAMAT described in section 7.5. To create a large exposed dentine patch around the cingulum, the highest amount of pressure would need to be exerted at this location. When using a flexible plant material, and avoiding the lower front teeth, such an action would unavoidably put some pressure on the incisal edges of the upper front teeth (pressure point also indicated). The possibility of a relation between dental erosion and the various forms of LSAMAT described worldwide must therefore be reconsidered.

It seems more likely that Type 2 LSAMAT could have been caused in this manner, as in this type the entire lingual surfaces of the upper front teeth tend to be worn at an angle, without a clear focus on the area closest to the cement-enamel junction. Perhaps, considering the strain which would be put on the tongue if used in such activities, it is more likely that the plant material was pressed against and drawn

across the lingual surfaces of the upper front teeth by the thumb(s) or fingers. The results of SEM analysis of one individual presenting with Type 1, an individual with Type 2 LSAMAT, and a further juvenile individual with LSAMAT of unknown type, indicate that Type 2 LSAMAT is associated with abrasives being dragged across the lingual surfaces, since microwear found on these surfaces consists of relatively large scratches with clear directionality (labio-lingual) and frequent pitting and fracturing of the enamel and dentine. The Type 1 case does not show such a clear picture. Very small striations are present, as well as a clearly damaged enamel and/or dentine surface, however the striations show less directionality, and the surface damage does not show clearly defined pits where enamel or dentine has lifted away, but rather a generally eroded appearance. Comparison with the results of clinical studies of dental erosion shows that the surface characteristics of the exposed, circular-cupped dentine patches and surrounding enamel of Type 1 LSAMAT are typical of acid erosion. Particularly the uniform honeycomb pattern of enamel prisms is associated with acid etching of the tooth surface (King et al. 1999).

This finding is highly significant, since it means we must reconsider the possibility, originally suggested by Robb et al. (1991), that at least some patterns of lingual wear denoted as LSAMAT may have been caused by erosion as opposed to abrasion. In other words, we may in actual fact be dealing with Lingual Surface Erosion of the Maxillary Anterior Teeth (LSEMAT). Based on extensive clinical research in bulimia patients, Robb et al. suggest that the typical circular-cupped dentine exposure of the lingual surfaces of the upper anterior teeth in prehistoric cases could have been the result of intrinsic acid erosion. This suggestion was strongly refuted by Turner et al. (1991), who argue that intrinsic acid erosion – caused by the regurgitation of stomach acids or frequent vomiting – would have been a highly unlikely cause of lingual wear in such a large percentage of the population (85% at Corondó and 57% at Venado Beach). Furthermore, they add that in all cases the wear they have observed in the Corondó, Venado Beach, Cerro Mangote, and later the historic Senegal dental material is flattened at all stages and angled appropriately for some kind of abrasive material being drawn across the surface in to have been the cause. With regards to the latter, we have seen based on published images for a male individual from Cerro Mangote, and a female individual from historic Senegal, that this is not the case (Irish and Turner 1987, 1997). In both images, circular-cupped wear facets are apparent on the lingual surfaces of the upper anterior teeth, which do not extend across the entire lingual surface, and which do not appear angled the manner suggested. Since based on their general descriptions of LSAMAT in these populations it is not clear whether these images are typical of the entire population, it is plausible that at these sites various factors were at play which caused different patterns of lingual wear: i.e., both abrasion and erosion. The same picture is apparent based on the patterns of lingual wear observed in pre-Columbian Caribbean dental material. Here, the majority of LSAMAT could have been caused by the forceful dragging of fibrous plant materials across the lingual

surface (Type 2), however a small portion of the overall LSAMAT is more consistent with acid erosion (Type 1). This smaller percentage of individuals (6.94% in this study), is a more acceptable figure for individuals suffering from intrinsic acid erosion, or in other words regular regurgitation of stomach acids or vomiting. Estimates of the proportions of modern populations suffering from such disorders range up to 65% of all adults (Bartlett 2006). Even assuming that various modern dietary and behavioural habits (i.e., eating disorders, alcoholism, the use of narcotics, and smoking) may be at the root of many of these cases, this high percentage could indicate that intrinsic acid erosion may have been a relatively common disorder in past populations too.

Alternatively, for the Caribbean region, there is some ethnohistoric evidence suggesting that people took part in voluntary purging through vomiting. Such activities could have been related to concepts of purity and contamination, and it is known that self-induced vomiting was carried out in preparation for ritual activities and/or shamanistic activities (De las Casas 1875; Mickleburgh 2007; Pané 1999). For *behiques*, or shamans, the act of purification through sneezing, fasting, and vomiting was an important preparation for communication with *zemís* and spirits during trances. Vomiting was induced by an emetic or by the use of an oblong object thrust down the throat, such as the well-known highly decorative vomiting spatulas found mainly in the Greater Antilles (Roe 1997). The friar Ramón Pané, who spent a couple of years living in indigenous settlements in Hispaniola (1494–1496), describes the snuffing of the hallucinogenic drug *cohoba* (*Anadenanthera peregrina*) and the use of certain herbs to induce vomiting by the *behique* (Pané 1999). Father Raymond Breton witnessed the use of tobacco juice as an emetic during ritual fasting and purification by Island Carib in the 17th century (Taylor 1950).

La fruta es cuasi como avellanas y así blancas; es la que llaman los medicos ben, de manera que está escripta, y hace mención della la medicina. Es de gran eficacia para purgar, de cólera principalmente, según se cree por los no médicos por lo que se ha visto por la experiencia [de las Casas 1875: Capítulo XII].

The fruit is a bit like hazelnuts and is white; the doctors call it *ben*, as written, and they mention it as a medicine. It is highly effective for purging, mostly of cholera, according to those who are not doctors who know this from experience [Author's translation].

Tenían otro uso nuestros indios, que parecía vicio, pero no por vicio, sino por sanidad lo hacían, y éste fué que acabando de cenar (cuya cena era harto delgada), tomaban ciertas yerbas en la boca, de que arriba dejamos parecer a las hojas de nuestras lechugas, las cuales primero las marchitaban as huego, envolvíanlas en una poca ceniza, y puestas como un bocado en la boca sin tragallo, les revuelve el estómago e idos al río, que siempre lo tenían cerca, les provocaba echar lo que habían cenado, y después de lavados volvíanse y tomaban a hacer colación. Y como todo el comer dellos fuese siempre, de día y de noche, tan poco y pocas cosas, parece claro que no lo hacían por glotonía, sino por hallarse más ligeros y vivir mas sanos [de las Casas 1875: Capítulo CCIV].

Our Indians had another custom, which seemed to be a vice, but was not a vice, they only did it for

health, and it was that upon finishing dinner (the dinner was terribly little), they took certain herbs in the mouth, we mentioned that they resemble our lettuce leaves, which they first withered and then wrapped in a little in ash, and put a morsel in the mouth without swallowing it, turning their stomachs, and went to the river, which was always nearby, and it caused them to expel what they had eaten, and after washing they returned and took a light meal. And because their food was always, day and night, so very little, it seems clear that they did not do it out of gluttony, but to be lighter and to live healthier [Translation: Hayley Mickleburgh and Adriana Churampi].

In the two excerpts above Las Casas describes how most community members partook in regular purging activities, which they deliberately brought on by the use of certain emetic herbs. In the first excerpt, it is explained how these herbs were used as a medicine in order to cleanse a sick individual of slime or gal. In the second excerpt, Las Casas describes self-induced vomiting as a daily activity for all members of the community, in order to maintain good health. In the light of this evidence, it seems clear that voluntary regurgitations of stomach contents (including acids) may often have been a very conscious and deliberate choice, perhaps indicating that Type 1 LSAMAT was the result of ritual cleansing activities.

Another possibility is the presence of dietary (i.e., extrinsic) acids in the mouth, which can have the same erosive effect on the teeth as non-dietary acids. Clinical studies have shown that the consumption of large amounts of sugary soft drinks, or fruit (juices) can cause severe erosion of the teeth due to the high acidity of such foodstuffs. Research has shown that the manner of consumption of such acidic foods is an important factor in the resulting pattern of erosion. For example, so-called fruit-mullers, who gently masticate (mull) fruit between the molars for extended periods of time often show severe erosion of those teeth (Abrahamsen 2005; Bartlett 2005). Therefore, Type 1 LSAMAT, if caused by extrinsic erosion, would involve exposure of the lingual surfaces of only the upper anterior teeth to acids. Since the tongue is known to protect the lower anterior teeth from acid erosion in bulimia patients, it is possible that the lack of erosion in the lower teeth in Type 1 LSAMAT is similarly due to the protective action of the tongue. We may envisage a scenario in which the tongue is used to press some kind of acidic food against the lingual surfaces of the maxillary anterior teeth, perhaps for extended periods of time. As described in Chapter 3, the pre-Columbian inhabitants of the Caribbean had at their disposal a wide variety of fruits. According to ethnohistoric accounts by De las Casas and Fernández de Oviedo y Valdés a variety of fruits were available to indigenous populations of the Caribbean (De las Casas 1875: Tomo III, Capítulo XII; Fernández de Oviedo y Valdés 1851: Tomo I, Libro VII-XI). Some of these fruits are still consumed in the region today, and are very astringent or acidic. Based on observations of the author during fieldwork in the region, a tentative suggestion for an extrinsic cause for Type 1 LSAMAT is put forth here. The genip (*Melicoccus bijugatus*), a large fruit bearing tree which was introduced to the Caribbean archipelago by Archaic Age people from the South American mainland (Newsom and Wing 2004), produces a fruit which resembles the lychee in the fact that it has a tough, leathery skin, which when removed reveals a soft,

juicy flesh surrounding a hard seed. The flesh is generally sour to semi-sweet, and the seed is also edible. Measured pH values for the flesh range between 3.4 and 3.8, certainly acidic enough to demineralize dental tissues (Lussi 2006; Manzano-Méndez and Damaso Bautista 1999). The fruit is generally eaten raw, although sometimes jam is made from the flesh. The leathery skin is broken with the teeth and discarded, and the juicy fruit including seed is sucked upon and moved around with the tongue to extract the juices. This movement presses the acidic juices and the seed against the palate and the lingual surfaces of the maxillary anterior teeth. Once the juice has been extracted, the seed is spat out, with some remaining flesh still covering it. The manner of consumption of this fruit is highly specific and based on the acidity of the fruit and the involvement of the lingual surfaces of the maxillary anterior teeth, could perhaps lead to acid erosion of the teeth resembling Type 1 LSAMAT. Currently, this is merely a tentative suggestion, and future work with Caribbean individuals who regularly consume genip, and local Caribbean dentists, is needed to verify this possibility.

7.6 INDIVIDUAL LIFE HISTORIES: DENTAL EVIDENCE

The bioarchaeology of individual life histories is a field of research within the (bio) archaeological sciences and human osteology, which has developed rapidly over the past decade or two. The development of increasingly accurate dating techniques, stable isotope analyses, and tools for palaeoenvironment reconstruction, allows us to reconstruct prehistoric lifeways (i.e., human social, cultural, and biological behaviour) to a level of detail that was hitherto impossible (Zvelebil and Weber 2012). This development follows broader trends in bioarchaeology and archaeology in which researchers increasingly emphasize the variability in individual human behaviour which gave rise to the intricate patterns of social and cultural expressions observed in the archaeological record. Dental anthropological contributions to the developing field of individual life history approaches include, for example, the study of differences in caries prevalence between males and females as a result of fluctuating hormone levels throughout a female's life (Lukacs and Largaespada 2006). Generally, however, the study of dental wear and pathology requires the analysis of large numbers of individuals for example for the reconstruction of dietary patterns and health and disease, and has little interpretative value on the individual level. A great exception is dental wear related to task or occupational activities, which may give insights into individual craft activities, and potentially their social role. As discussed in section 7.4, some individuals incorporated in this study revealed dental evidence of crafting activities, potentially giving insight into their social identity (as crafts(wo)man) in life. Other cases discussed above, such as the case of ECC described in section 7.5, equally show the value of dental evidence in shedding light on important events in individual life courses. In this case, the young child (2–3 years) was affected by a severe case of rampant caries, which may have been related to disease processes and a compromised immune

system which led to this person's untimely death. This at once potentially gives insight into the course of the disease and the cause of this child's death, and mortuary treatment of juveniles who had been ill for long periods of time. Alternatively, the rampant caries in this individual could have been entirely the result of dietary habits, i.e., the child was fed large amounts of sugary foods and drinks, which since this was not found to be the case in juveniles in general at this site may perhaps be evidence for special dietary treatment of sick juveniles. Either way, this unique case demonstrates that next to exceptional patterns of dental wear, exceptional dental pathology may also reveal aspects of life histories at the individual level. Below I discuss the one other case of evidence for individual life histories in the form of intentional dental modification.

7.6.1 Intentional Dental Modification

Individual 72B from the site of Chorro de Maíta, a young female (18–25 years), displays Intentional Dental Modification (IDM) of the upper incisors and canines. The teeth appear to have been filed extensively. The precision and symmetry of the modification suggests a skilled individual performed the modification using special tools. The practice of IDM has a long history in various cultures across the globe for aesthetic, religious, ritual and sociocultural reasons. A range of techniques for dental modification are known, such as filing, chipping, cutting, drilling, incising, inlaying with stone materials, and extraction or ablation (Alt and Pichler 1998; Vukovic et al. 2009).

A small number of cases of IDM has previously been documented in the Caribbean region, however in all cases these individuals were identified as enslaved Africans (Crespo Torres and Giusti 1992; Handler 1994; Handler et al. 1982; Jay Haviser, personal communication 2010; Rivero de la Calle 1974; Schroeder et al. 2012; Stewart and Groome 1968). As most of these burials were accidental discoveries, with the exception of the Zoutsteeg three, little information is available on their precise archaeological context. However, what is clear is that the dental modifications in these cases are significantly different in appearance and aetiology from the Chorro de Maíta case. The African modifications tend to be achieved by rough chipping or cutting of the enamel, although more refined chipping also occurs. Furthermore, most African modifications resulted in a sharp, pointed appearance of the anterior teeth. The general appearance and degree of craftsmanship displayed in individual 72B is more consistent with Mesoamerican types. When compared to known types of dental modification from Mesoamerica as documented and organized in a typology by Romero Molina, the central incisors can be classed as category C2 or C3, and the lateral incisors and canines as category A4 (Romero Molina 1986). No previous cases of this type of dental modification are known for the pre-Columbian Caribbean islands, suggesting a non-Caribbean origin. Descriptions of dental modification are also conspicuously absent from early ethno-historical accounts pertaining to the Caribbean islands, although cranial modification is mentioned. A study of cranial modification in the skeletal population

from Chorro de Maíta revealed that this individual has fronto-occipital vertical modification, while the other persons displaying intentional cranial modification interred at Chorro de Maíta all show modification of the fronto-occipital parallel type. The fronto-occipital vertical type of modification is relatively rare in the Antilles, but is the predominant type of cranial modification in mainland Mesoamerican and Central American populations (Anne van Duijvenbode, personal communication 2012; Valcárcel Rojas et al. 2011). Strontium isotope analysis of dental enamel from a premolar belonging to this individual revealed a signature that is clearly not local to the site of Chorro de Maíta, but is not necessarily foreign to the Antilles or Cuba. Carbon and nitrogen stable isotope analysis revealed that this individual likely consumed elevated amounts of C₄ plants, which is uncharacteristic for individuals in the Antilles, but is common in certain areas of the surrounding mainland, where maize formed the dietary staple (Laffoon, Valcárcel Rojas, and Hofman 2012). Individual 72B also shows an uncharacteristic mortuary treatment for the Antilles. She was buried prone (i.e., face down), with the head resting on the left cheek, the arms flexed with the hands placed beside the shoulders, and with the lower legs semi flexed with the lower legs to the left. A large rock was placed on the back of the thighs. This type of burial position is unique at the site, and is very rare in the Caribbean islands in general. While a very small number of prone burials have been reported, particularly for the Greater Antilles, none were found in this particular position with a rock placed over the body.

Based on the results of isotope analyses, it is clear that individual 72B did not originate from Chorro de Maíta, and came from another part of Cuba or perhaps even an area of the Mesoamerican mainland (Laffoon 2012; Laffoon, Valcárcel Rojas, and Hofman 2012; Valcárcel Rojas et al. 2011). The cranial and dental evidence indicate a Mesoamerican origin of this individual. Recent studies on Mesoamerican sites in Belize, Guatemala, Honduras and Mexico have highlighted regional and temporal differences in both style and technique of dental modification. Results point to the use of dental modification as a manner of expressing identification with a lineage, polity, ruler or region (Havill et al. 1997; López Olivares 1997; Tiesler Bloss 2001; Williams and White 2006). Based on current data, the type of dental modification present in the dentition of individual 72B (C2/C3 and A4) is most commonly found in the Mesoamerican regions of Belize and Guatemala (Williams and White 2006). In particular, this type of modification has been documented for Postclassic sites in Belize (Williams and White 2006). This area falls within the region identified as the potential origin area based on isotope studies for this individual. Furthermore, recent research at the site of Lamanai Belize has uncovered a series of Postclassic period burials in which the individuals are all buried prone, with the legs either tightly or semi-flexed (Elizabeth Graham, personal communication 2012). While much more research on the regional association of dental modification styles is needed, based on the combination of the evidence laid out above I tentatively suggest that individual 72B originated in Belize. The presence, and particularly the mortuary treatment, of this person at Chorro de Maíta is of

great significance to our understanding of this late pre-Columbian – Early Contact period site. Her mortuary treatment implies that the living population at the site had highly detailed knowledge of the mortuary practices which were appropriate for an individual from the mainland area of Belize, potentially meaning that a small community of Mesoamerican individuals lived at Chorro de Maíta, and were able to uphold their spiritual, ritual and sociocultural beliefs, at least regarding the burial of this young female. The presence of mainland peoples at the site is highly interesting, and raises the question whether they migrated there voluntarily, or perhaps were introduced to Cuba through European colonial actions: it is known that forced migration of mainland populations to the Caribbean islands took place in the early colonial period, when Europeans were looking to supplement their diminishing enslaved labour force (Valcárcel Rojas 2012; Valcárcel Rojas et al. 2011). However, the dating of this individual (cal. A.D. 1465–1685, 1σ [Valcárcel Rojas 2012]) is not precise enough to distinguish whether she was buried prior to or after European contact (Europeans entered Cuba in 1511).

7.7 CARIBBEAN KIDS

Infant and juvenile foodways vary widely across the globe, although it is often thought that pre-industrial populations breastfed for a longer period, weaning later or weaning for an extended period of time. Likewise, it is often assumed that females in hunter-gatherer subsistence communities breastfeed for long periods of time, sometimes until the child is five or six years old, which decreases fecundity. The average weaning age in humans in non-industrial, ‘traditional’ societies is 2.5–3 years. The introduction of agriculture and a complete sedentary lifestyle is thought to have led to shorter breastfeeding periods, and more rapid weaning, allowing for increased fecundity. Particularly in industrial societies of the last two centuries, weaning age and duration decreased drastically (Buikstra et al. 1986; Dettwyler 1995; Herring et al. 1998; Lewis 2007). The duration of breast feeding and the length of the weaning period have a huge influence on fecundity and the demographic profile of a population (e.g., Waters-Rist et al. 2011), as breast feeding acts as a natural contraceptive by drastically reducing the chance of a new pregnancy, a condition known as lactational amenorrhea. Lactational amenorrhea takes effect in females when they are fully or almost fully breastfeeding their child, day and night, without intervals greater than 6 hours, within the first six months of nurturing. This type of lactation induced infertility may extend beyond six months, however the chances of a new pregnancy then rise from under 2% to 6–8% (Labbok et al. 1997).

Analysis of juvenile dental wear in this study shows that children were consuming solid foods from the age of 1–2 years onward, indicating the weaning process must have already started by this age. The duration of the weaning period can of course not be established by the presence of dental wear. In this case, analysis of bone collagen carbon and nitrogen ratios can produce estimations of the ages at which the

proportion of breast milk in the diet decreased or ceased entirely, since the elevated carbon and nitrogen levels introduced through the mother's milk drop. As bone collagen has a relatively slow turnover rate there is a significant lag in the expression of the individual's trophic level in his/her bone collagen. The length of this lag is not fully understood, and is thought to be affected by individual variation and metabolic condition. Another tissue in which to track weaning ages in skeletal populations is the permanent dentition, since the dental elements are formed during childhood at well documented intervals, and show little to no turnover. The main advantage of this approach is that individuals who survived the weaning process, which is generally understood to be an emotionally and physiologically stressful period, are studied as opposed to those who perished during this period. This means that the results of potential biases introduced due to poor health, such as metabolic disorders, or even the consumption of a different diet during sickness, are avoided (Dupras and Tocheri 2007; Fuller et al. 2006; Herring et al. 1998; Lewis 2007).

Few of such studies have been done on pre-Columbian Caribbean material, however two studies on Ceramic Age Caribbean material indicate a weaning age and duration that is compatible with those known from global studies in non-industrial societies, i.e., weaning between 2.5–3 years of age (Dettwyler 1995). A stable isotopic study of human remains from the site of Tibes, Puerto Rico, revealed that weaning must have taken place between the ages of two and four years at this site (Pestle 2010a). Research on human remains from Grand Bay, Carriacou, found almost half of the individuals were affected by LEH formed between the ages of 2.5 and 4 years, which was interpreted as the result of weaning stress (Stone 2011). A third stable isotope study on Archaic Age skeletal material from the site of Canimar Abajo, Cuba, found children were being weaned at a relatively young age (16 ± 6 months). At this site, root crops and other plants were used as weaning foods (Buhay et al. 2012). Similar work in the future should shed more light on the duration and age at complete cessation of breast feeding in the pre-Columbian Caribbean. Currently, the results of dental wear analyses in this study have shown that the age at which solid foods were introduced and regularly consumed by juveniles in the sample is between 1–2 years: slightly earlier than the stable isotope studies on Puerto Rico and Carriacou indicate. This difference may be the result of the significant lag in the expression of the individual's trophic level in his/her bone collagen due to its relatively slow turnover rate. Therefore, the study of presence and patterns of dental wear in juvenile individuals, including very young infants, is very important in reconstructing weaning practices in the past.

Once solid foods were introduced, the juveniles included in this study were exposed to cariogenic substances, since 28.99% of all juveniles are affected by carious lesions. The presence of caries in these juveniles indicates that carbohydrates constituted a (large) part of their diet. With the exception of one case of rampant caries at Anse à la Gourde, only children aged over three years were affected by caries, suggesting that by this age non-breast milk carbohydrates (particularly sug-

ars) had become a substantial part of the diet.

Caries rates in juveniles are considerably lower than in adults, although this is generally the case in pre-19th century agricultural populations (Hillson 2008a). Globally speaking, it is not until the 19th century, when diets changed significantly, that juveniles show equal or even higher caries rates than adults. A study by Larsen et al. (1991), based on dental material from a number of sites on the south-eastern Atlantic coast of the United States, consistently shows lower caries percentages in juveniles than in adults, even in the populations with the highest caries rates. This indicates that in these cases caries is not a childhood disease, but is rather mostly age and diet related. Not surprisingly, the predominant caries location in juveniles in the current study differs from that seen for their adult counterparts at the individual sites. Where in adults from most sites there is a significant component of CEJ caries, in juveniles this location on the tooth is least frequently affected. The reason for this difference is the fact that juveniles tend not to be affected by alveolar bone resorption, a condition which is heavily age-related, and which exposes the cervical area of the tooth to cariogenic bacteria. Liebe-Harkort (2012) relates the high rate of CEJ caries in adults versus the low rate in juveniles from the Iron Age burial site of Smörkullen at Alvastra (Sweden), to the lack of root exposure in juveniles as dietary practices did not differ by sex or age. The three juveniles affected by cervical caries in the current study show no evidence of root exposure either due to alveolar bone resorption or other causes.

The case of Early Childhood Caries (ECC) or rampant caries in a young child (2–3 years) from Anse à la Gourde (377) presents an interesting singular case within the dataset. Today, ECC is a global health problem affecting babies and children from impoverished backgrounds most frequently. The disease is known to be associated with feeding and drinking habits. Prolonged exposure to sugars, particularly in the form of liquids is known to be a main risk factor. Other causes include poor nutrition or malnutrition, physical or emotional stress, and the presence of other (immune deficiency) diseases. A study of the effect of rampant caries on body growth showed that rampant caries are associated with smaller body size, indicating that having rampant caries has an adverse effect on child body growth (Ayhan et al. 1996; Berkowitz 2003; Hallet and O'Rourke 2003). No other evidence of pathology was found on the remains of individual 377 (Weston 2011b). However, if this child's untimely death was the result of a condition or disease which does not manifest in the skeletal frame, or simply progressed very rapidly (the 'osteological paradox'), such evidence is not to be expected (Wood et al. 1992). The precise cause(s) of the rampant caries in individual 377 can of course not be ascertained, but it is likely that a combination of large amounts of refined, soft and sticky carbohydrates (especially sugars) and compromised health, either due to infectious disease or some other malady, lay at the root of this condition.

The relatively small number of adult individuals and teeth affected by enamel hypoplasia in the overall population is an indication that (metabolic) disorders and nutrient deficiency was not a common health issue during their childhood. Enamel

hypoplasia occur when the normal growth of the dental elements and particularly the formation of enamel is disrupted. The cause(s) of such a disruption vary widely, but often involve metabolic disorders, including nutritional deficiency, infectious disease, and physical and emotional trauma. Enamel hypoplasia is a non-specific stress indicator, meaning that a large variety of metabolic disorders can result in defects in the enamel (Goodman and Rose 1991). The permanent (upper) central incisors and the (lower) canines are usually most frequently affected, as they are formed during the earliest years of a child's life. Most enamel defects occur before the child is three years old, although they will not become apparent until the permanent dentition erupts, with only 2% of recorded hypoplasia forming between the ages of three and seven years (Langsjoen 1998).

In the sample studied here, linear enamel hypoplasia (LEH) were observed most frequently in the upper canines, but were found in all other dental elements. This suggests that LEH in this sample are not simply associated with for example the physical and emotional stress of weaning or other early childhood maladies, but may indicate recurring infectious disease or nutritional deficiencies in older childhood years, and even up to the age of fourteen. Still, the numbers of affected individuals are small, suggesting that this type of condition was not common.

