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**Title:** Reading the dental record: a dental anthropological approach to foodways, health and disease, and crafting in the pre-Columbian Caribbean  
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This study aims to investigate how evidence from human dentitions contributes to knowledge of the lifeways and cultural practices of the pre-Columbian Amerindians of the insular Caribbean. As such, it focuses on traces of daily lifeways left on the human dentition in the form of patterns of dental wear and pathology, and their temporal and spatial variation in the region. The study is divided into three key aspects of lifeways and cultural practices: foodways, health and disease, and certain (gender-related) craft activities. These three aspects are explored by integrating information from dental wear and pathology into current knowledge from studies of palaeodiet, palaeopathology, and craft production in the region. At the basis of this work is a multi-disciplinary approach, combining archaeological, bioarchaeological, ethnohistoric, and ethnographic data, as well as evidence from clinical dentistry in order to provide a sophisticated understanding of the dental anthropological data produced in this study.

During the 1960's dental anthropology was established as an important sub-discipline of physical anthropology and human osteology. Broadly speaking, dental anthropology is defined in this research as 'the study of teeth in order to understand the biology and behaviour of past and living hominid populations'. The association between dental pathology and diet and subsistence strategies is an important research focus in dental anthropology. The increase in caries rates over time, observed worldwide, has been attributed to a shift toward a more carbohydrate rich diet. In most areas this shift coincides with important sociopolitical and cultural developments often associated with the adoption of agriculture, however, research has shown that less pronounced changes in diet can result in differences in caries rates. Food processing techniques have also been shown to be influential in the formation of carious lesions. Soft, boiled foods with a sticky consistency tend to facilitate bacterial growth in areas of the mouth where food remains are easily retained. Research on sex differences in caries prevalence has demonstrated that in various cultures and subsistence systems females tend to be significantly more frequently affected by caries than males. These differences are often explained as the result of gender-based differences in food processing and consumption. Studies of social status in various cultural settings have found that high-status individuals often have very different caries rates than lower class individuals. Other dental pathologies such as calculus and ante mortem tooth loss (AMTL) are also indicative of prehistoric diets. Often they are closely linked with the formation and aetiology of dental caries, which means the complete picture of dental pathology, or the 'pathology load', should be taken into account in reconstructions of prehistoric diets. Dental wear in humans is for a large part related to age, as the older an individual becomes, the longer the teeth will have been used in mastication, and the more worn they will be. Next to the age-related component in degree of dental wear, the degree of molar wear has been attributed to food preparation techniques, the physical properties of the food, and the inclusion of sand and grit in the food, for
example in marine diets or in sandy environments. The decline in mean degrees of molar wear over time has been attributed to the transition from hunter-gatherer subsistence to agricultural subsistence practices. This difference is the result of both changing diet composition and changing food preparation techniques, which shift from tough, abrasive foods to soft, refined, sticky foods. Some research has found high mean degrees of molar wear associated with marine food consumption. Developmental defects of the dentition most frequently consist of defects in the (surface of) the enamel. Enamel defects that are macroscopically observable are divided into hypoplasia, opacities, and discolouration. Hypoplasia are disparities in enamel thickness across the crown, which change the appearance of the crown surface.

Apart from ‘natural’ modifications of the teeth as the result of food mastication or disease, modifications as the result of cultural practices are an important category of study in dental anthropology. These types of modification, sometimes referred to as ‘artificial modification’ or ‘non-alimentary use’, can drastically alter the appearance and functioning of the teeth. Artificial modifications can for example result from the use of the teeth as tools, or intentional alteration. In the latter case, the teeth are modified by filing, chipping, in-laying with stone or metal, or even extraction, for aesthetic reasons. The use of the teeth as tools was common in many prehistoric populations.

Dental anthropology is a well-established sub-discipline of bioarchaeology and human osteology and is recognized by many archaeologists as a valuable contribution to their discipline. The application of dental anthropological research in archaeology can still be further explored, however. Being able to incorporate data on for example, mortuary practices, site environment, faunal and botanical remains, and archaeometric analyses enables a far more informed interpretation of the behavioural patterns which gave rise to the condition of the dental remains. Dental anthropological studies have rarely been done in the Caribbean region. Some researchers have however highlighted the potential of pre-Columbian Caribbean human dentitions to reveal past patterns of biology and behaviour in this region. A total of 458 human dentitions from 49 sites from throughout the Caribbean region were analyzed. Broadly speaking, the majority of the material pertains to the Late Ceramic Age (A.D. 600/800–1500), although a significant proportion pertains to the Early Ceramic Age (400 B.C. – A.D. 600/800). However, the skeletal remains incorporated into this study vary with regards to the size of the site assemblages and the amount of available contextual information. Some materials have been radiocarbon dated, while others have been dated using general site dating and associated material culture. In dividing the sample into temporal groups, this research was constrained by differences in resolution of contextual data and the lack of available Archaic Age material. In light of this, and the fact that in the past years researchers have been critically reassessing the established cultural chronology in the region, the assemblages were divided into two large temporal groups. One represents the Early Ceramic Age, and incorporates sites that based on their
absolute and/or relative dating can be assigned to the period between 400 B.C. and A.D. 600/800. The other group represents the Late Ceramic Age, and similarly incorporates sites that based on their absolute and/or relative dating can be assigned to the period between A.D. 600/800 and 1500/1600.

The results of the dental analyses of this study indicate that dental pathology was common among the pre-Columbian inhabitants of the Caribbean. Comparison of the caries ranges established in this study with caries rates known from studies worldwide, 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.

Differences were found between male and female foodways at a few of the sites, and for the overall sample. Where differences were found, they are relatively subtle, and imply very slight differences in proportions of carbohydrates and proteins, and slight differences in the abrasivity of foods. 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. It is possible that men ate slightly more protein, probably marine foods which were more abrasive to the teeth. Females would have eaten slightly more refined carbohydrates, probably soft, sticky, boiled staple foods, and perhaps more fruit, and they may have eaten more frequently during the day than males. The subtlety of the differences found between the sexes is interesting, particularly in the light of other studies worldwide, where differences between the sexes are often relatively large, reflecting sexual division of labour, task activities, or gender-based status differentiation.

No other evidence was found for status differentiation in foodways in this study. While it is possible that differentiation in food consumption was practiced in ritual and ceremonial activities, as suggested in previous studies in the region (Curet and Pestle 2010; Mickleburgh and Pagán Jiménez 2012), and there is some evidence for slight differences between the sexes, no indications were found for the expression of status differentiation in daily (staple) food consumption throughout the Ceramic Age occupation of the region.

Temporal comparisons of dental wear and pathology within individual sites did not reveal significant differences. However, 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 sig-
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 dif-
fERENCE 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 carbohy-
drate rich and refined diet overall.
This study supports the findings of earlier research, that the Late Ceramic Age
brought a distinct increase and intensification of agricultural practices in the
Greater Antilles. Moreover, the results of this study indicate that there was a shift
of equal, if not greater, magnitude in the Lesser Antilles during the Late Ceramic
Age. In a region that has been assumed not to have developed the type of intensi-
fied agriculture traditionally associated with Late Ceramic Age chiefdom societies
of the Greater Antilles, evidence from the dentitions of its inhabitants demon-
strates that highly refined starchy and sugary plant foods comprised a major part
of the diet.
The reasons for this shift in foodways are not clear. In the Greater Antilles intensi-
fied agriculture has been associated with the rise of chiefdom societies in the Late
Ceramic Age. But the similar shift in foodways in the Lesser Antilles, where this
kind of social complexity did not develop, indicates that the relation between so-
ciopolitical organization and foodways in the Caribbean is not straightforward. It
is possible that the shift is related to climatic changes. Perhaps the overexploitation
and resulting depletion of various resources, coupled with a lengthy dry period
after the Early Ceramic Age (400 B.C. – A.D. 600/800) prompted communities
to adapt their subsistence economies and attempt to find solutions for unpredict-
able and decreasing resources by bringing the food economy more directly under
human control, i.e., through increased and intensified agriculture, which could
potentially offer a more reliable and steady supply of food. Also, the increased
precipitation after the dry period may have been conducive to agricultural/hor-
ticultural practices. Whatever the reasons for this change in foodways over time,
subsistence practices throughout the region in the Late Ceramic Age were able to
support growing populations, with the number and size of sites increasing signifi-
cantly during this period.
Oral health and hygiene in the pre-Columbian Caribbean was generally poor. In
all larger assemblages studied here, high rates of dental and oral pathology were
observed in the majority of the adult population and in a substantial portion of the
juvenile population. Although the sparse ethnohistoric accounts indicate that oral
health and hygiene practices were upheld by some Amerindian populations, the
results of this study show that oral hygiene must have been very poor or lacking
entirely. Most individuals suffered from carious lesions and associated inflamma-
tion, and most adults would have suffered from inflammation of the gums and
periodontal ligaments, ante mortem tooth loss, and sometimes from abscesses.
Based on the occurrence of dental wear in infants and juveniles, it seems that children in the Ceramic Age Caribbean started eating solid foods from the age of 1–2 years onward. Women generally suffered higher rates of dental disease than men. The increase in frequency and changing pattern of dental pathology over time is considerable, and indicates that dental health deteriorated over time. Dental defects such as linear enamel hypoplasia also increased over time. 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 prolific. The potential causes for such distinct differences in foodways over time 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, and increasingly poor sanitary conditions leading to the spread of infectious disease.

A total of 66 individuals show evidence of non-alimentary or occupational use of the teeth, amounting to 14.41% of the entire sample. These individuals displayed patterns of dental wear which could not be caused by normal food mastication. The proportion of individuals with such wear in the individual site sample sets varies widely.

Five types of non-alimentary dental wear were distinguished in this study. Each is related to different types of the use of the teeth as tools, although it is possible that Type 1 is the result of acid erosion as opposed to non-alimentary uses of the dentition. Type 2, the most commonly observed type, is a non-specific type, involving differential wear of the anterior and posterior dentition, which could have resulted from a range of non-alimentary activities. However, within this category, a small number of individuals display a more specific pattern of wear which is interpreted here as the result of the use of the teeth to hold the mouthpiece of a bow drill. Ethnohistoric accounts and previous studies of gender and craft activities from the region suggest that tasks involving drilling, such as bead manufacture, were performed by men. Although numbers are very small, the results of this study do not entirely support this, since potential bow drill wear was also observed in a female individual. Type 3, which consists of various types of notching and grooving of the anterior teeth, is most likely related to the manufacture of cordage, sewing, or basketry. The number of individuals displaying this type of non-alimentary wear in the sample is small, perhaps indicating that this activity involved some degree of specialized knowledge. Interestingly, in this group there is some tentative evidence of gender-based task differentiation. While the observed grooves and notches show a large degree of variation in size, shape, affected teeth, and orientation, five female individuals (from various sites) show a very distinct pattern of notching of the anterior teeth, which could have resulted from the production and manipulation (spinning and weaving) of (cotton) thread and cordage, or from basketry. Further analysis with SEM is needed in order to understand the precise aetiology...
of this pattern of wear. Type 4 may represent tentative evidence for the wearing of labrets in the pre-Columbian Caribbean. In one case, this pattern of wear may have been caused by an activity such as the peeling of tubers with the front teeth. Type 5 represents a set of unique patterns of clearly non-alimentary dental wear, probably representing habitual activities that are specific to the individual, since they are not found in any others in the sample.

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. A smaller yet substantial portion of the population would have used their teeth in specific crafting activities. These activities are more strongly associated with males than with females, perhaps indicating gender-based task differentiation in craft activities that involved the use of the teeth. Alternatively, this may be the result of the use of different techniques (i.e., with or without the teeth) by men and women to perform the same or similar crafting activities. Although it is incredibly difficult to identify the specific activities that caused the types of non-alimentary wear observed in this sample, some indications were found for highly 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 crafting activities would have required a great degree of knowledge, training and expertise.

Large numbers of individuals were affected by a pattern of wear known as LSAMAT. This study has shown that patterns of lingual wear currently identified as LSAMAT need further investigation, since various activities may be associated with the loss of lingual surface enamel of the upper front teeth. It is likely that a considerable portion of the individuals with LSAMAT consumed acidic foods, or suffered from gastric acid regurgitation, causing loss of lingual enamel in the upper anterior dentition (Type 1 LSAMAT). Type 2 LSAMAT corresponds more clearly with the action of pulling some form of fibrous (plant) material across the tooth surfaces, either for alimentary or non-alimentary reasons.

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 Intentional Dental Modification of her teeth is consistent with Mesoamerican types, particularly those documented for the Postclassic skeletal remains from the site of Lamanai, Belize. This type of dental modification is unique in the pre-Columbian Caribbean islands, and together with other evidence in the form of stable isotope analysis, analysis of cranial modification, and the unusual mortuary treatment of this individual, suggests that she migrated to Cuba from the Mesoamerican mainland. Considering the site context, it is possible that she was brought to Cuba through European slave transport in the early colonial period. Evidence from human dentitions has revealed hitherto unexplored aspects of lifeways and cultural practices in the pre-Columbian Caribbean. Individuals, com-
communities, and regional populations in the Caribbean were physically affected by their foodways and cultural practices, leaving permanent traces on their teeth. Differences were observed between sites, indicating that foodways varied per community, likely due to local environmental conditions and sociocultural preferences. Most communities represented in this study consumed large amounts of cariogenic plant foods. Sex-based labour division, perhaps related to agricultural/horticultural practices and food preparation, may have resulted in slightly differing foodways between males and females. These slightly varying foodways also differentially affected the health of both sexes, with females more severely and frequently affected by dental disease associated with carbohydrate consumption. Despite these small differences, no evidence for status differentiation in foodways was found in this study. Furthermore, children appear to have consumed the same or a very similar diet to adults after weaning. As such, it appears that status differentiation was not expressed in daily foodways, although restricted access to certain foods may have existed in ritual or ceremonial contexts.

Communities adapted their foodways over time, increasingly focusing on the production of more refined, processed plant foods, and consuming larger proportions of agricultural/horticultural produce. This resulted in drastically contrasting dental wear and pathology profiles between the Early Ceramic Age (400 B.C. – A.D. 600/800) and the Late Ceramic Age (A.D. 600/800–1500), which coincide with broad scale social and environmental changes during the transition between these two periods. While it is possible that the changes in foodways over time observed are related to increasing social complexity, population growth, and/or changing precipitation levels, caution must be applied in drawing direct causal relationships between them.

Future directions for the research include incorporating Archaic Age dental material and attempting to gather more radiocarbon dated materials to get to grips with the temporal shifts demonstrated in this study.