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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 1 INTRODUCTION

Before the historian can judge wisely the political skills of human groups or the strength of their economies or the meaning of their literatures, he must first know how successful their member human beings were at staying alive and reproducing themselves (Crosby 2003:XXV–XXVI).

1.1 BACKGROUND

This study was designed to investigate human foodways, health and disease, and certain (gender-related) craft activities in the pre-Columbian Caribbean archipelago, through integrated analyses of patterns of dental wear and pathology in a large

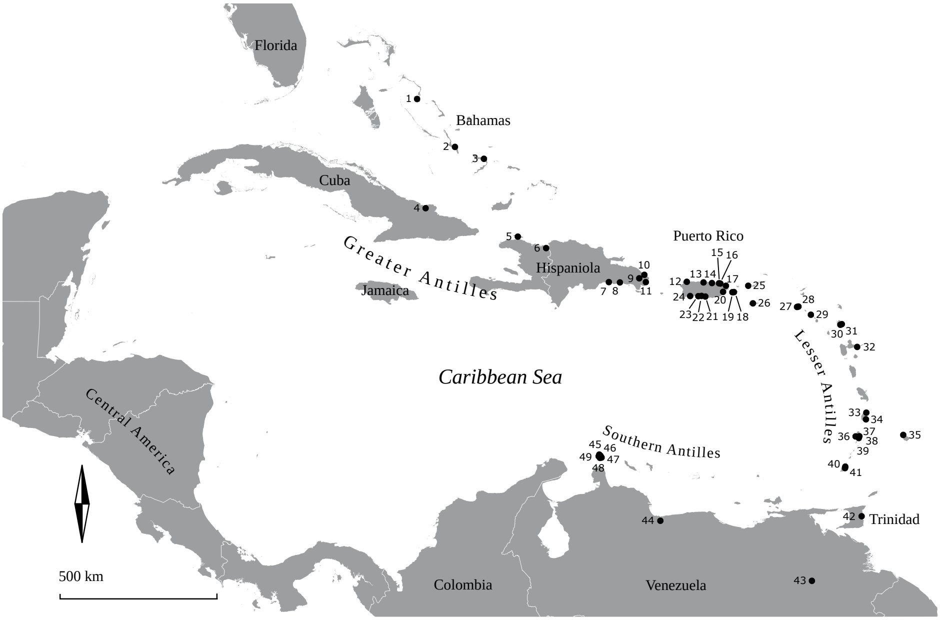

Figure .1 Map of the Caribbean showing the sites incorporated in this study (Pepijn van der Linden and Hayley L. Mickleburgh). (1) Wemyss Bight cave, Eleuthera Island, Bahamas (2) Clarence Town caves, Long Island, Bahamas (3) Gordon Hill caves, Crooked Island, Bahamas (4) Chorro de Maíta, Cuba (5) Manigat cave, Île de la Tortue, Haiti (6) Daile 1, Haiti (7) La Caleta, Dominican Republic (8) Juan Dolio, Dominican Republic (9) Higuey, Dominican Republic (10) Punta Macao, Dominican Republic (11) El Cabo, Dominican Republic (12) Coto, Puerto Rico (13) Maisabel, Puerto Rico (14) Santa Elena, Puerto Rico (15) María de la Cruz cave, Puerto Rico (16) Hacienda Grande, Puerto Rico (17) Monserrate, Puerto Rico (18) La Mina, Vieques, Puerto Rico (19) Esperanza, Vieques, Puerto Rico (20) Punta Candelero, Puerto Rico (21) Santa Isabel, Puerto Rico (22) Collores, Puerto Rico (23) Cañas, Puerto Rico (24) Yauco 1, Puerto Rico (25) Tutu, St. Thomas, USVI (26) *Unknown site*, St. Croix (27) Kelbey's Ridge 2, Saba (28) Spring Bay 1c, Saba (29) *Unknown site*, St. Kitts (30) Mamora Bay, Antigua (31) Indian Creek, Antigua (32) Anse à la Gourde, Guadeloupe (33) Lavoutte, St. Lucia (34) Point de Caille, St. Lucia (35) Heywoods, Barbados (36) Buccament West, St. Vincent (37) Argyle, St. Vincent (38) Escape, St. Vincent (39) Argyle 2, St. Vincent (40) Savanne Suazey, Grenada (41) Simon Beach, Grenada (42) Manzanilla, Trinidad (43) Saladero, Venezuela (44) Tocorón, Venezuela (45) Canashito, Aruba (46) Malmok, Aruba (47) Tanki Flip, Aruba (48) Savaneta, Aruba (49) Santa Cruz, Aruba.

number of skeletal remains from the region. A total of 458 human dentitions from 49 sites from throughout the Caribbean region were analyzed (Figure 1.1).

The study of past peoples' foodways – food consumption and its social and cultural context – can be considered one of the main lines of investigation in archaeological research both in the past and at present. More than just being the adoption of a certain diet and a means for fulfilling the daily required calorie intake, foodways encompass and influence all aspects of society and lifestyle: economic systems (how society uses and distributes its resources), division of labour (according to age and/or gender), social and political organization (access to resources and distribution of wealth and power), and ritual and ceremonial activities. Studying how past communities organized division of labour, cooperation between individuals, available technology, and access to resources, is elemental to understanding their social and cultural identity. Differences or similarities in foodways in different communities within an interaction sphere can, for instance, be an important basis for interaction and exchange between these communities. Such interaction, although possibly driven by the desire for goods and materials that cannot be produced within the own community, extends far beyond the mere exchange of objects. Strong social and cultural bonds are formed between interacting communities (Hofman et al. 2007; Hofman and Hoogland 2011). Furthermore, food procurement, production, consumption and disposal of remains are key aspects in the communication of social and cultural identity, both in intra- and intercommunity interactions. The acts of food production and consumption themselves are highly structured and follow very specific rules in all societies (Appadurai 1981; Curet and Pestle 2010; Douglas 1975, 1984; Farb and Armelagos 1980; Van der Veen 2003).

The bulk of our knowledge of foodways in pre-Columbian societies in the Caribbean is based on analyses of faunal and botanical remains, food production tools such as ceramic cooking pots and (stone and coral) grinding implements, local environment and climate, and ethnohistoric accounts. In recent years, stable isotope and trace element analyses focussing on palaeodiet in the region have greatly enhanced our understanding of foodways prior to European involvement in food production after A.D. 1492 (De Vos 2010; Farnum and Sandford 2002; Van Klinken 1991; Norr 2002; Pestle 2010a, 2010b; Pestle et al. 2008; Stokes 1995, 1998, 2005). Of course, all of these methods for studying foodways have their advantages and limitations which depend heavily on the methodology used and the scale of analysis. The analysis of diet based on faunal remains, for example, is naturally biased toward over-representation of the non-vegetable, protein rich component of the diet. Ethnohistoric accounts, while requiring caution in their interpretation due to the Eurocentric perspective of the authors, may provide more significant insights into the social and cultural context of diet and subsistence practices as opposed to specific information on the composition of the diet. Carbon and nitrogen isotope analysis, on the other hand, is an excellent tool for investigating the composition of the diet with regards to the amount of marine and terrestrial foods and the proportion of C3 and C4 plants consumed, while they are less suited to investigating the specific types of plants and animals which constitute the different components of the diet. One of the great advantages of stable isotope analyses in the reconstruction of palaeodiet is the fact that it uses individual human skeletons in an approach that is both geared toward understanding dietary practices at the micro-scale, i.e., individual persons, groups and communities, and divulging dietary practices at larger regional and temporal scales (provided enough skeletal remains are available of course). In this study, I use dental wear and dental pathology in individual humans to understand foodways at inter- and intrasite levels.

Health and disease are reflected in the human dentition in the form of dental pathology and developmental defects, which for a great part are closely associated with diet and the intake of nutrients. Particularly dental pathology such as caries, abscesses, and alveolar bone resorption are associated with the composition of the diet and preparation techniques of the foods. The dentition may reflect the general physiological condition of an individual at a certain stage in their life, for example in dental defects such as linear enamel hypoplasia, however these conditions are often heavily influenced by the adequacy of the diet (in providing the necessary nutrients), and by metabolic disorders which reduce an individual's ability to absorb and process nutrients. Interpreting health and disease from the dentition is therefore complex, and requires great attention for the role of the diet in the development of pathology and defects.

Craft activities in the pre-Columbian Caribbean have mostly been investigated by consulting the ethnohistoric sources and assigning certain categories of archaeologically recovered material culture to the realm of sociopolitical influence and the development of power relations accordingly. This study approaches the topic of craft activities from a very different angle, i.e., by defining individuals as crafts(wo) men based on dental characteristics, while the associated material culture is absent.

1.2 Reading the Dental Record: Introduction to the research

This research uses methods which are derived from dental anthropology, a field of research which is relatively new to the Caribbean, to shed new light on past foodways, health and disease, and craft activities in the pre-Columbian Caribbean region. The foremost premise of this research is the assumption that biometrical data, embedded in their cultural and social context, increase our current knowledge of foodways, health, and general lifestyle.

1.2.1 Foodways

Dental anthropology is the branch of physical anthropology and osteology that concerns itself with the biology and behaviour of hominins as reflected in their teeth. Palaeodiet reconstruction in dental anthropology generally involves analysis of patterns of dental wear and pathology in sizable skeletal assemblages. Detailed analyses of dental macro- and microwear patterns have shown that it is possible to distinguish the type of abrasive agents which cause certain patterns of wear. These abrasive agents can either be foods or other materials which are introduced into the oral cavity. Likewise, dental pathology has been shown to be indicative of diet – especially the proportion of carbohydrates in the diet, as high prevalence of dental caries (the most ubiquitous human dental disease) is often related to high carbohydrate intake. In this study statistical analyses of data on human dental wear and pathology from a range of archaeological sites throughout the Caribbean are embedded within a multi-disciplinary approach, which combines (osteo)archaeological, environmental, and ethnohistorical evidence, as well as information from clinical dentistry as the backdrop from which to interpret the dental anthropological data. In other words, the dental anthropological evidence for foodways, health and disease, and crafting is placed alongside what is currently known from palaeofaunal and palaeobotanical analyses, tool assemblages associated with food production, palaeoenvironment and palaeoclimate studies, ethnohistoric and ethnographic accounts, and clinical dental research. A major caveat in the potential for dietary reconstruction based on dental wear and pathology, however, is the fact while the pathology load (i.e., the amount and severity of pathological conditions related to the composition of the diet) is a good indicator of the proportion of protein versus carbohydrate intake, based on dental anthropological data alone the fauna and flora which were consumed cannot be reliably distinguished. In the Caribbean, as briefly mentioned above, and discussed in more detail in Chapter 3, we have a pretty good idea of the types of terrestrial and marine animals that were available, throughout the different phases of occupation of the region, and at intra-regional and site levels. With regards to the vegetal component of the diet, however, we are faced with issues of preservation in a (sub)tropical environment, although much palaeoethnobotanical research in the past few years has made considerable headway in resolving this (Berman and Pearsall 2000, 2008; Newsom and Pearsall 2003; Newsom and Wing 2004; Pagán Jiménez 2007, 2009, 2011; Pagán Jiménez et al. 2005; Pagán Jiménez and Rodríguez Ramos 2007; Pearsall 2002). In an attempt to get to grips with plant food consumption at a similar scale of analysis as the dental anthropological data used in this study (i.e., based on analyses of individual humans), I set up a parallel investigation in collaboration with Dr. Jaime Pagán-Jiménez, in which dental calculus from individuals from most of the sites I include in this study research were studied for micro botanical inclusions (in this case starch grains and phytoliths). In this way, it is possible to identify at least some of the plants which comprised the vegetal component of the diet, or in other words the carbohydrate intake (Mickleburgh and Pagán Jiménez 2012).

The results of these investigations are used to come to new insights into foodways in the region. As will be explained in more detail below, this kind of incorporation of dental anthropological research into archaeology and some of its closely related disciplines is highly advantageous to all research and researchers concerned. In addition to the research objectives outlined below, I aim to demonstrate here not only that dental anthropology is valuable to archaeologists, but also that dental anthropological research must rely upon various other fields of research in order to make itself valuable to researchers outside the confines of its own field.

1.2.2 Health and disease

[T]here is, in fact, no means of knowing the state of health during life of the individuals who come to comprise an assemblage of skeletons, especially because what determines their actual state of health depends not only upon the diseases that affected their internal organs, but their mental state, their diet and many other environmental and social factors, about which there is little to be known from the state of their bones (Waldron 2009:10).

The study of human health from the dentition, while an important part of dental anthropological research, essentially falls within the domains of palaeodemography, palaeopathology and palaeoepidemiology. For all of these research disciplines, dental health is an extremely important factor for the reconstruction of past population trends (Cohen and Crane-Kramer 2007; Steckel and Rose 2002; Waldron 2009). The issue of past oral and general health is complex however, not only for the large number of inherent assumptions that are necessarily made in order to study this subject using human skeletal (dental) remains, but also for the fact that what is actually studied is past oral and general disease, not health, as Tony Waldron elegantly remarks in the quote above. Nevertheless, dental disease has been shown to be indicative of levels of ancient health, particularly when pertaining to large groups of individuals over long periods of time. As explained above, dental palaeopathology has proved itself particularly effective in distinguishing changes in foodways and (resulting) nutritional stress. In this sense, the complete dental pathology load (Listi 2007; Lukacs 1989) for both individuals and groups is used in this study to elucidate dietary practices, but also general health trends in space and time. Other forms of (developmental) stress may also be observed in the dentition, reflecting physiological and nutritional stress during different life phases. Here, information from the dentition will be complemented by palaeopathological information from the rest of the skeleton, where available. Once again, ethnohistoric sources are consulted, as some describe diseases and conditions of physical stress in the indigenous population of the Caribbean at the time of first contact with Europeans (Crespo Torres 2005b, 2008; Schats 2010, 2011). Of course, the necessary caution in interpretation of these documents again applies to this case.

1.2.3 Craft activities and production

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. Taino artisans produced a wide variety of craft items,

> *including elaborate decorated ceramics, cotton and cotton products, ground and polished stone beads and ornaments, carved shell and bone ornaments, tools of stone, shell and bone, carved wooden objects, tobacco, various foodstuffs, and exotic birds and feathers [...] [W]omen spun and wove cotton into clothing and hammocks, made baskets and mats, and carved some ceremonial wooden items, and pottery production is assumed by most contemporary authors to have been done by women [...] [M]en carried out the fabrication of heavier wood items, such as canoes and buildings, and produced stone tools and objects* (Deagan 2004:601).

The above quote, although referring to the Late Ceramic Age and Early Contact period Taíno societies of the Greater Antilles, could equally be taken as a description of pre-Columbian Caribbean societies in general (including those of the Archaic Age), because for all periods of Caribbean history archaeologists have found – and continue to find – elaborate and decorative items which must have required considerable skill and knowledge to produce. However, the study of craft production, aside from the technological aspects involved (e.g., stone chipping and grinding techniques), or the choices of raw materials (i.e., local versus exotic), or the role of craft objects in the social and ritual realm (e.g., exchange and gift-giving), has received relatively little attention in Caribbean archaeology so far. Specifically, the individuals who became craft producers, embodying the technological, and no doubt supernatural or spiritual skills required for this role, and the manner in which their knowledge and experience was passed on, has received little attention. The two main sources of information we have on craft activities for the pre-Columbian Caribbean at this point in time are artefacts recovered from archaeological excavations (usually the end product of such activities), and of course ethnohistoric accounts of craft activities during the (Early) Contact period, which are often used as an example of such activities during pre-Columbian times. Of course, these methods for studying craft activities are affected by similar advantages and limitations as those mentioned for the study of foodways. As ever, the archaeological record is biased toward preservation of durable materials, such as pottery and stone, while perishable materials are only rarely preserved. This automatically complicates the study of craft activities, as a very important category of such activities involves perishable materials, for instance the fibrous plant materials used in basketry or organic pigments used in paints. Equally, the ethnohistoric accounts of such activities have their limitations. As mentioned above, we must be very careful in using and interpreting these accounts due to the underlying motives of the authors. Furthermore, the use of such documents may result in the tendency to gloss over the undoubtedly great social and cultural variation that was present in the region at the time of European arrival. This arrival also very rapidly had its effects on the daily lives of local populations, influencing social roles and (gender-based) labour division, and by extension changing local craft activities (Deagan 1988, 1996, 2004).

While the complexities of using certain material culture remains and ethnohistorical data in studying craft activities are not resolved through the study of the human dentition (or the entire skeleton for that matter), dental anthropological information can certainly contribute to our understanding of craft production on an individual level. In this study I use patterns of dental wear related to the use of the teeth as tools to infer craft producing individuals. This is based on the fact that in order to create such patterns of wear, a person must have engaged in a certain activity using the teeth for an extended period of time on a regular basis. This in itself of course gives little indication of the type of material being worked, or the degree of skill involved, however, the precise pattern of wear can sometimes reveal the type of action and material(s) involved. In collaboration with Saskia Kars of the VU University Amsterdam, Scanning Electron Microscopy (SEM) was used to analyse a small number of cases of teeth-as-tools wear, in order to get to grips with the type of materials being processed by the teeth, and the precise action (i.e., direction of movement, degree of force) involved.

1.3 Research Questions

As introduced above, the emphasis in this study lies on investigating foodways, health and disease, and craft activities in the pre-Columbian Caribbean archipelago, using evidence in the form of dental wear and pathology in human dentitions. These themes will be dealt with using a multi-disciplinary approach, which involves the integrated use of archaeological site context data, ethnohistoric and ethnographic sources, clinical dentistry, and of course statistical analyses of patterns of dental wear and pathology from a range of sites throughout the region. The aims of this study can be translated into the following research questions:

How does evidence from human dentitions contribute to knowledge of the lifeways and cultural practices of the pre-Columbian Amerindians of the Caribbean archipelago?

a. What do dental wear and pathology reveal about foodways in the region? Can patterns be discerned over time and/or space? If so, how do these relate to sociocultural, sociopolitical, and environmental developments in the region over time?
b. What does dental pathology reveal about oral and general health and disease patterns in the region over time, and how does this compare to other lines of evidence on past health in the region?
c. What indications are there for the use of the teeth as tools, and can these be linked to particular craft activities? Are there indications for age and/or gender-related divisions in these practices? Can 'non-alimentary activities' be elucidated using ethnographic and ethnohistoric information?

1.4 Key issues

Dental anthropological research, like many approaches in osteoarchaeology, is characterized by an interesting dichotomy between the unit of analysis (an individual person) and the type of questions the data are often used to answer (pertaining to larger groups, communities, and entire populations, often over extended periods of time). This is especially the case in dietary studies based on traces of (macro)wear and pathology in the human dentition; diet reconstruction cannot be done at the level of the individual, as a single dentition does not reveal the type of patterns and processes that allow a reconstruction of food consumption patterns. As such, the underlying assumption of this approach is that by studying large groups of individuals with some form of shared lifestyle (co-habitation, contemporaneity, social and cultural similarity, etc.), we are able to infer what life would have been like for an individual within the group. Dental anthropological studies of diet and subsistence practices are adept at distinguishing clearly different dietary practices between large samples. Subtle differences are harder to interpret, as this type of research relies on significant differences as indicated by statistical analyses. Likewise, the reconstruction of foodways based on dental wear and pathology relies heavily on the resolution of the chronological data related to the sample set. A good handle on the temporality within the dataset allows for the study of processes, trends, and developments. In this, the reconstruction of foodways in dental anthropology shows at once its greatest strength and its greatest weakness: in comparing subsets of data (e.g., the early and late phases of occupation in a particular region), this type of research may reveal incredibly detailed information on changes or continuity in diet and subsistence over time. When faced with a single, short occupation phase, however, the presence of a particular pattern of wear or pathology is often harder to interpret. For example, the type of dental wear and the pathology load may reveal a picture of a group of humans who were clearly focussed on a high carbohydrate intake. Naturally, this is hugely valuable information to an archaeologist, however, when the comparison of two phases of occupation at the site reveal subtle differences in wear and pathology between the two phases, e.g., indicating a gradual shift from predominantly marine foods to increased carbohydrate consumption, it may be possible to elucidate the relation between subsistence practices and social and economic processes at the site. This crude example merely serves to demonstrate that one of the greatest advantages of dental anthropological research in understanding past social and cultural behaviour lies in its ability to reveal processes and developments through comparisons.

The above forms one of the key issues in the present study; in applying dental anthropological data to the reconstruction of foodways in the pre-Columbian Caribbean (or any other region for that matter), fundamental choices are made in the manner in which the data are structured, and subsets of data are compared to each other. In this study, I use spatial and temporal variation in the skeletal assemblages included as the basis for comparisons, which therefore reflect differences, processes and developments over extended periods of time and across large spaces. While this approach is in part dictated by the nature of dental anthropological methods, it is also devised to simultaneously reflect potential changes or continuity in subsistence practices during grand sociocultural, sociopolitical, and environmental changes recognized over time in Caribbean archaeology, and potential differences between communities who occupied a broad interaction sphere, the circum-Caribbean, in which there is a considerable degree of environmental, biological, social, and cultural diversity (Hofman et al. 2010). Fundamental in this approach is an awareness of the variability in resolution of contextual data for the sites included here (see section 5.4). By this I mean mainly the differences in the amount of information on dating. Some assemblages have been extensively radiocarbon dated, while others are dated to broad time frames based on ceramic typologies, which are currently under close scrutiny (e.g., Rodríguez Ramos et al. 2010).

1.5 Outline of the following chapters

In Chapter 2 the history and development of the field of dental anthropology is discussed, and the different types of dental wear and pathology and their relation to three main themes of investigation of this study – foodways, health and disease, and craft activities – are described and explained based on results from extensive previous research in dental anthropology. Chapter 3 introduces the geographical, geological and climatic setting of the Caribbean region, and outlines the general development of social, cultural, and biological characteristics of pre-Columbian Caribbean peoples. The relation between previous studies of foodways and social organization in the pre-Columbian Caribbean, is discussed, as this research has profoundly influenced current understandings of past foodways in the region. Finally, this chapter also reviews current knowledge of pre-Columbian Caribbean foods and diet, health and disease, and craft activities.

In Chapter 4 the multi-disciplinary approach of the research is explained. The combined use of dental anthropology, archaeology, osteology, ethnography, and ethnohistory is argued to significantly increase the value and validity of the contributions of this work to our knowledge of foodways, health and disease, and craft activities in the pre-Columbian Caribbean. Furthermore, in this chapter the various methods employed during this study to document and analyse the results are discussed, described, and the statistical tests used are explained. Chapter 5 deals with the spatial and temporal distribution of the sites, and discusses what is known from previous research of each individual site and its burial population. Contextual information on the sites is broadly placed within the regional cultural framework discussed in Chapter 3. Chapter 6 presents the results of the analyses of dental wear and pathology, and is broadly organized into data pertaining to dental wear, dental pathology, and dental defects. Within these main categories, each individual subject is discussed at sample, site, and intra-site levels. In Chapter 7, 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. The chapter is organized along the three major themes of investigation of this study: foodways, health and disease, and craft activities. Other themes that are dealt with in this chapter are crafting, LSAMAT, and dental evidence for individual life histories and juvenile foodways. Intra-site chronological differences and the broad scale chronological differences over time throughout the region are discussed. Finally, in Chapter 8 the conclusions of this study are outlined following the research questions explained above, and future directions of research are discussed.

Chapter 2 Dental Anthropology

2.1 Dental Anthropology

The term 'Dental Anthropology' first appeared in an article published in 1900 by German physician, anthropologist and ethnographer G.H.T. Buschan (1863–1942), but it was not until much later that the term became widely used in scholarly circles (Scott and Turner 1988). 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', however creating a more specific definition of this field of research can be a tedious exercise, as numerous scholars' attempts to do so have resulted in many different definitions (Rodríguez Flórez 2003). This difficulty in defining the subject matter of dental anthropology is partly due to the fact that it has come to encompass a large number of sub-disciplines and research topics, ranging from dental metrics and morphology to the cultural treatment of teeth (Intentional Dental Modification).

In general, behaviour is recorded in the teeth in four ways: through dental wear, dental pathology, intentional dental modification, and developmental defects. Interpreting these modifications is complicated; particularly when more than one of these factors is at work. The study of biology and behaviour from hominid teeth is based on a number of physical aspects of the teeth which make them a durable and informative source of information. Firstly, teeth have a very distinct anatomy and physiology, which enables them to be readily identified even when (severely) fragmented. Physiological condition (e.g., similarities and differences) is often used to distinguish groups and individuals within a population. For example, metric and non-metric variation in dental morphology is used in diagnosing age, sex and geographic origins. Secondly, the sequence of juvenile dental development is clear and generally the same for all modern humans (although there is some variation between populations), which means juvenile human remains can be reliably identified and aged by their teeth. Thirdly, teeth are comprised of hard tissues, which are very durable and often survive in the archaeological record for far longer than other remains. Teeth are the only hard bodily tissues which come into direct contact with the environment, and once they have formed, teeth generally do not remodel. Therefore, intentional and unintentional modifications of dental tissues tend to remain visible, unless they are removed by later modification. Such modifications of the teeth can inform us about patterns of dietary and cultural behaviour. Finally, teeth can be relatively easily studied in living populations. The ability to compare past dental morphology or modifications with those in living populations is vital for understanding the biological and cultural behaviour that caused them (Hillson 1996).

Dental wear is commonly divided into masticatory wear, which comprises all forms of dental wear which occur as the result of food mastication, and non-masticatory wear, or non-alimentary wear, which comprises all non-food related dental wear. Patterns of masticatory wear can thus be used to reconstruct diet and subsistence strategies, whereas non-alimentary wear can inform us on other activities involving the teeth (e.g., the use of the teeth as tools or intentional dental modification). Dental pathology is the study of dental disease, and its development and consequences. Generally this involves anything which causes a tooth or the entire dentition to be malformed or damaged, with the exception of dental trauma, although the latter is often included in dental pathology studies. Dental diseases are directly related either to the individual genetics and physiology of an organism, or the environment. The most common diseases affecting the teeth and surrounding bone are related to the accumulation of dental plaque, which is mostly related to diet and oral hygiene (Hillson 1996). The methods, approaches and problems associated with the study of foodways, health and disease, and craft activities in dental anthropology are discussed in more detail further on in this chapter.

2.2 History of the Field

In the late 19th and early 20th century interest in the study of teeth in (physical) anthropology arose, under the influence of Darwin's theory of evolution. The variation in tooth form – previously only used for taxonomic classifications – attracted new interest as Darwin's theory directed research toward racial and evolutionary issues. This culminated in the work "The Origin and Evolution of the Human Dentition" (1922) by William King Gregory, which distinguished stages of dental evolution from fish to humans and confirmed the evolutionary relation between apes and humans (Gregory 1922; Scott 1997; Scott and Turner 2008).

Other foundational efforts were made on the subjects of dental paleopathology and dental wear, with John H. Mummery (1847–1926) being the first to recognize the link between an increase in caries rate and a growing reliance on refined foods, while Paul P. Broca (1824–1880) developed the first method for scoring human dental wear (Broca 1879; Mummery 1870; Scott 1997; Scott and Turner 2008).

Pioneering scholar Aleš Hrdlička (1869–1943) was the first to recognize morphological differences between human groups of different geographical origins during the 1920's and 1930's. His discovery of shovel-shaped incisors in Mongoloid races was the first evidence for the Asian origin of Native Americans. In the same period, Rufus W. Leigh demonstrated the relation between different subsistence economies and different patterns of dental wear and pathology (Hrdlička 1920; Leigh 1925; Scott 1997; Scott and Turner 2008).

With the introduction of the modern evolutionary synthesis in the late 1930's and early 1940's dental genetics became one of the main subjects in dental research. This period was also characterized by increasing interest in human dental variation based on ethnographic research (e.g., Moorrees 1957; Pedersen 1949).

In 1945 an influential scholar in the field of dental research, Albert A. Dahlberg (1908–1993), published "The changing dentition of man", contributing greatly to the understanding of dental evolution. In the late 1940's and early 1950's Dahlberg started taking casts of contemporary Pima Indian dentitions, leading to the first morphological characterizations of American Indian dentitions, based on over 8,000 individuals. The casts he made served as three-dimensional references for scholars world-wide (Dahlberg 1951; Rose and Burke 2006; Scott 1997; Scott and Turner 2008).

In 1963 Don R. Brothwell published "Dental Anthropology", a product of a meeting of the Society for the Study of Human Biology in 1958, which served to define the field of Dental Anthropology. It also introduced the term 'Dental Anthropology' for common use in scholarly circles (Brothwell 1963; Rose and Burke 2006; Scott 1997).

From the 1960's onward much research focussed on the morphology and shape of fossil hominid teeth, in order to understand the evolution from the Australopithecines to Homo sapiens (Scott 1997; Scott and Turner 2008). This period also brought more detailed analyses of the morphological traits associated with different ancestral groups of humans. Furthermore, researchers came to realize more fully the value of studying dental paleopathology and dental wear patterns (to understand dietary shifts through time) and intentional dental modification (to understand social and cultural reasons for the modification of the teeth in an ethnographic context).

In the 1985 the Dental Anthropological Association (DAA) was founded, and in 1988 the DAA held a symposium at the annual meeting of American Association of Physical Anthropologists, named "Horizons of Dental Anthropology", which resulted in another pivotal volume "Advances in Dental Anthropology" (Kelley and Larsen 1991). Since its publication, and especially in the last few years, the amount of ground-breaking work being done in Dental Anthropology has increased tenfold. Different perspectives and approaches to the study of teeth have been brought together, and more innovative research is being done. The range of dental anthropological research done today is increasing rapidly, not least in the field of archaeology, where researchers are becoming increasingly aware of the value of such studies (Rose and Burke 2006; Scott 1997).

2.3 DIET

2.3.1 Dental pathology and diet

As described above, John H. Mummery was the first to discover the relation between dental pathology and diet. He observed an increase in caries rate over time in prehistoric dental material from ancient Britains, Egyptians, and contemporary aboriginal groups, and concluded that this was due to the increased consumption of soft, refined foods (Mummery 1870; Rose and Burke 2006; Scott 1997). The association between dental pathology and diet and subsistence strategies, later termed the "Economics of Dental Pathology" (Scott and Turner 1988), remains an important research focus in dental anthropology.

Rufus W. Leigh described in detail the relation between dental caries, periapical and alveolar abscesses, periodontal disease, dental attrition and certain diets and food processing types. He demonstrated a correlation between a high caries percentage and a diet based mainly on maize and other carbohydrate rich plants, and he interpreted the frequent occurrence of abscesses in agricultural groups as resulting from the higher rate of attrition (due to the use of stone mortars) and caries in these groups. He also linked high prevalence of periodontal disease to an agricultural diet and a sedentary lifestyle (Leigh 1925). Until Leigh's work the adoption of agriculture was considered to be the most advanced stage of development in human history, however he demonstrated that this technological change had major impacts on the (dental) health of the population.

Caries

The increase in caries rates over time, observed worldwide, has been attributed to a shift toward a more carbohydrate rich diet (Cohen and Armelagos 1984; Klatsky and Klatell 1943; Larsen 1995; Larsen et al. 1991; Littleton and Fröhlich 1993; Meiklejohn et al. 1984; Milner 1984; Turner 1979). 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 and food processing techniques can result in differences in caries rates (Larsen 1997).

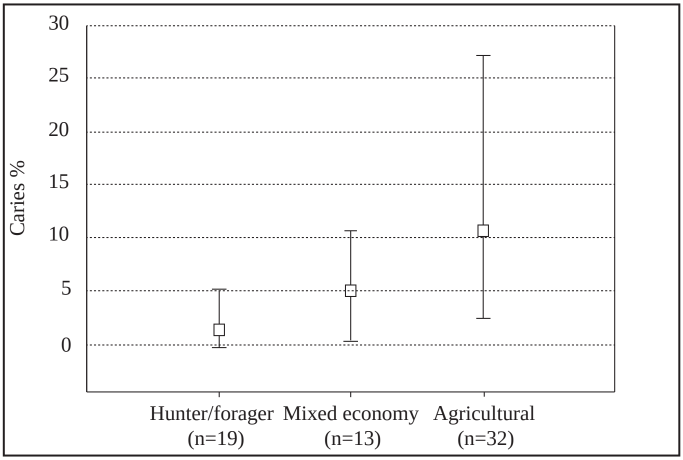

Figure 2.1 Caries rate per subsistence type (Turner 1979), after Lukacs (2008) (Hayley Mickleburgh).

It has generally been accepted in the field of dental anthropology that the 'hunter-gatherer/forager' diet is associated with a very low caries percentage, while 'mixed economies' and 'agricultural economies' have much higher caries rates in comparison. Worldwide reviews of caries frequencies in hunter-gatherers/foragers, mixed economies, and agricultural economies have found that hunter-gatherers have less than a 2% caries rate, mixed economies about 5%, and agricultural economies 10% or more (Koca et al. 2006; Larsen et al. 1991; Powell 1985; Scott and Turner 1988; Turner 1979; see Figure 2.1).

Contrary to these data, high caries rates have been documented for some prehistoric and contemporary hunter-gatherer/forager groups (e.g., Lubbell et al. 1994; Sealy et al. 1992). The consumption of carbohydrate rich plants from non-agricultural sources could be the cause, since some non-agricultural diets are comprised of large amounts of (non-domesticated) plant foods (Hardy 2007). Exchange of food with agricultural groups, or low levels of fluoride in the local water sources, are others explanation for the inflated caries rates in some hunter-gatherer/forager groups (Larsen 1997; Lukacs 1990; Sealy et al. 1992; Walker and Hewlett 1990).

Even so, the categories of caries frequencies distinguished by Turner (1979) still generally hold true, although other work has indicated that the aetiology of caries is much more complicated than originally thought. For example, some research has shown a correlation between the degree of occlusal wear of the teeth and the percentage of caries. A study by Maat and Van der Velde (1987) determined that the rapid wear of the teeth decreases the chances of cavity formation, refuting the idea that heavily worn teeth are more exposed to carious lesions. Other research, however, has indicated that heavy dental wear and the presence of dental caries are independent variables (Larsen 1995; Meiklejohn et al. 1988; 1992).

Furthermore, food processing techniques have been indicated to be highly 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; usually between adjacent teeth or in the fissures of occlusal cusp patterns (Larsen 1995; Powell 1985).

Moreover, 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 (Kelley et al. 1991; Larsen 1997). These differences have frequently been explained as the result of gender-based differences in food processing and consumption (Larsen 1983; Larsen et al. 1991; Lukacs 1992; Lukacs and Pal 1993; Sealy and van der Merwe 1988; Walker and Hewlett 1990). Often gender-based differences in labour division are thought to be the cause of such differences. However, more recent research suggests that biological differences between males and females may be the cause of higher caries rates in females (Lukacs 1996; Lukacs 2008; Lukacs and Largaespada 2006). Women's reproductive biology and associated hormonal fluctuations cause changes in the immune response system (Cheyney 2007), dietary preferences (Vallianatos 2007) and saliva composition during pregnancy (Laine 1988), which in turn make women more susceptible to dental caries.

Still, some research has shown no significant differences between male and female caries rates, while others have shown that in some cases males have significantly higher caries rates than females, indicating that the relation between caries prevalence and sex is far from straightforward (Burns 1979; Clarkson and Worthington 1993; Larsen 1997; Powell 1988; Walker et al. 1998).

Differential caries prevalence has often been observed between the members of different social groups, indicating dietary differences between them. Studies of social status in various cultural settings have found that high-status individuals often have very different caries rates than lower class individuals. In some cases high-status caries rates are elevated, due to the consumption of more refined, carbohydrate rich foods than other groups (Valentin et al. 2006), whereas in other cases the higher classes show lower caries rates, due to the consumption of larger proportions of meat and fish (Cucina and Tiesler 2003; Hodges 1985; Walker and Hewlett 1990).

Caries location is partly related to the type and consistency of foods. Highly abrasive diets that are rich in carbohydrates are expected to produce mainly interproximal caries, since these locations can harbour plaque while in other parts of the dentition it is removed during mastication (Caglar et al. 2007; Lubell et al. 1994; Vodanovic et al. 2005). Diets comprised of soft, sticky starches are expected to produce mostly CEJ and occlusal surface caries, since soft, sticky foods encourage the accumulation of plaque and – the bacteria that thrive in plaque – around the gingiva, while sticky food remains become trapped in the occlusal fissures of molars and premolars (Lubell et al. 1994). Smooth surface caries are generally attributed to the consumption of large amounts of sugars. Some research has suggested that CEJ caries and root caries may be more strongly associated with the consumption of starches, the consumption of sugars is related to both CEJ and occlusal caries, although the precise relation is complex and poorly understood (Lingström et al. 2000; Waldron 2009).

Dental caries are usually associated with a high rate of ante-mortem tooth loss (AMTL), as the destructive effects of carious lesions frequently lead to the exfoliation of the teeth. This means that the 'true' percentage of dental caries in a population is unknown (see also section 2.2.1).

Other dental pathologies 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 (Listi 2007; Lubell et al. 1994; Lukacs 1989).

Calculus

Dental calculus is a hard, yellowish to brownish-black deposit on teeth formed largely through the mineralization of dead bacteria in dental plaque by the calcium salts in salivary and sub-gingival secretions. In prehistoric dental material, calculus is often fragile, and easily detaches from the teeth, but in life calculus is very hard and strongly attached. The formation of calculus is generally classed as a dental disease, which is heavily influenced by oral hygiene and dietary makeup. It is this link with the constitution of the diet which enables dental anthropologists to use the presence and severity of dental calculus as an indicator for diet. However, as poor oral hygiene was fairly ubiquitous in prehistoric societies, such interpretations based on the presence of calculus should be treated with care. Furthermore, it is extremely important to keep in mind that the formation of dental calculus is a very complicated process, which involves many other causative factors, such as age, sex, fertility, hormonal imbalances, hereditary predisposition, salivary constitution, mineral composition of drinking water, and fluid intake (Hillson 1996; Lieverse 1999).

Although the mineralization process of dental calculus is still not fully understood, it is generally agreed that microorganisms that thrive in dental plaque play an important role in initiating mineralization. At the base of a plaque deposit, which is an anaerobic environment, mineralization of dead bacteria occurs under the influence of minerals present in the saliva. Subsequently, calcium phosphate crystals are deposited among and on the bacteria in the dental plaque. An important factor in the formation of calculus is the alkalinity of the oral environment, with is known to facilitate precipitation of minerals from the saliva (Hillson 1996; Lieverse 1999). The fact that diets which are high in protein increase the alkalinity in the oral environment is thought to be a good indication that diet and calculus formation are related (Hillson 1979). The reason for this link between protein and alkalinity is thought to be the fact that microorganisms in the mouth produce ammonia – which is very alkaline – when metabolizing urea levels in oral fluid. Protein consumption results in increased urea levels in the saliva, and therefore indirectly leads to increased alkalinity in the oral environment.

Following the reasoning above, a high protein diet would lead to (higher) calculus formation, and therefore the presence and amount of dental calculus is indicative of the protein content of the diet. Still, research to try and understand this relationship more fully has led to contradictory results, as high carbohydrate diets have been shown to facilitate the formation of calculus too. In the latter case it is important to consider the abrasivity of the carbohydrates involved, as soft, sticky carbohydrates tend to lead to increased plaque formation.

In a study on the relationship between diet and dental calculus, Angela R. Lieverse concluded that the role of high protein consumption must be re-evaluated. Furthermore, she suggested that "[d]ietary reconstruction based on the presence and frequency of dental calculus should be combined with as much other associated data as possible" (Lieverse 1999:230). Nonetheless, numerous studies in anthropology have used the presence and severity of dental calculus to understand dietary patterns, many of which have proven to be fruitful. Specifically, changes in calculus rates over time are considered to be a valuable indication of shifts in diet or food preparation techniques.

Other factors also need to be taken into account when studying the effect of diet on dental calculus. The relationship between dental calculus and other oral diseases, namely, is crucial in understanding its aetiology. The relationship between dental calculus and periodontal disease is an important subject of study in clinical research, and dental calculus has long been thought to be the primary cause for periodontal diseases (White 1997).

Dentists distinguish two different types of calculus: supragingival and subgingival. Supragingival calculus is located above or along the gingival margin, or gums, whereas subgingival calculus is located in the gingival pocket on the surfaces of the roots of the teeth. Supragingival calculus is most frequently located on the lingual surfaces of the mandibular incisors and the buccal surfaces of the maxillary first molars, due to their proximity to the salivary ducts. Furthermore, the different types also differ somewhat in chemical composition and structure. Subgingival calculus is usually more heavily mineralized, which in theory would lead to better preservation in the archaeological record (Hillson 1996; Lieverse 1999; White 1997).

Whereas supragingival calculus is not always associated with periodontal disease, subgingival calculus is. Numerous studies have indicated a clear association between subgingival calculus and gingivitis (inflammation of the gums), which is most likely the result of the formation of a periodontal pocket at the gingival margin, due to the detachment of the periodontal ligament by subgingival calculus build up, and subsequent inflammation and lesions of the gingivae. In later stages, when chronic gingivitis leads to periodontitis, gum recession eventually results in alveolar bone loss. Bone resorption can eventually lead to tooth loss, as the teeth become increasingly detached from supporting tissues (Hillson 1996; Lieverse 1999; White 1997).

As periodontal disease is associated with alveolar bone resorption (and as a consequence also with CEJ and root caries) and ante mortem tooth loss, it is clear that calculus build up is of significant influence on the overall state of the dentition. The complex aetiology associated with calculus formation is of paramount importance in dietary studies of calculus.

Another important relationship between calculus and other oral diseases to be taken into account is the 'caries-calculus inverse relationship'. The caries-calculus inverse relationship theory is based on the assumption that because calculus formation is a mineralization process, and carious lesions are the result of a demineralization process, the absence of calculus would be a useful predictor of caries, and perhaps even vice versa. Although earlier research found no indication for a relationship between calculus and caries, some researchers have suggested that the relationship may have been obscured by other factors which contribute to the caries and calculus rate observed in clinical trials (Duckworth and Huntington 2005; Schroeder 1969). For example, the fact that the prevalence of both calculus and caries increases with age and the fact that both conditions tend to be strongly related to poor oral hygiene, could have concealed the true relationship between the two. Duckworth and Huntington (2005) conducted a large scale clinical study that indicated the presence of an inverse relationship, suggesting the presence of calculus is a good indicator of lower caries rate, however the exact causes of this relationship remain unclear.

Research on dental calculus in living populations has focussed mainly on the consequences of different oral hygiene habits and on the development of chemical mineral inhibitors which can be added to toothpastes and mouthwashes in order to counteract calculus formation (White 1997).

The distribution of the calculus deposits throughout the dentition and on the surfaces of individual teeth, although known to be related to dietary practices, follows a particular 'natural' pattern in all humans (Bergström 1999; Corbett and Dawes 1998; Jin and Yip 2002; Parfitt 1959; Schroeder 1969; White 1997). This 'natural pattern' of supragingival calculus build-up in the dentition is largely determined by the location of the salivary ducts in the mouth. As 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 more frequently affected, as they are bathed in saliva more often and thus suffer from greater calculus accumulation than the other teeth. Generally, the lingual surfaces of the lower front teeth and the buccal surfaces of the upper back teeth are most prone to natural calculus build-up. Of course, individual hormonal differences, which can affect the chemical composition of the saliva, and oral hygiene practices, influence the pattern of calculus build-up. In people who practice regular and thorough cleaning of the teeth, calculus accumulation is mostly restricted to the subgingival pockets and the supragingival surfaces of teeth closest to the salivary ducts. Those who practice poor or no dental cleaning are more prone to larger supragingival accumulations throughout the dentition, although the teeth closest to the salivary ducts are still more heavily affected (White 1997). Exceptionally poor oral hygiene may result in large calculus deposits throughout the entire dentition, masking the natural pattern of calculus accumulation. In addition, deviation from the natural pattern of calculus deposition may be the result of non-dietary behavioural patterns that affect the processes of mineralization which underlie the formation of calculus.

AMTL

Ante mortem tooth loss (AMTL) is of course not a disease of the dentition, but rather it can be the result of numerous ailments and diseases, or traumatic injury, which may be intentional (i.e., removal of teeth for aesthetic reasons) or unintentional. AMTL is very common in prehistoric dentitions, and is therefore often dealt with in palaeopathology as a pathological condition or disease. The 'aetiology' of this condition is far from straightforward. Dental caries and periodontal disease are usually the cause of AMTL, especially in populations with carbohydrate rich diets. In diets traditionally associated with hunter-gatherer/foragers, which generally have less carbohydrates and less refined foods, AMTL is traditionally associated with rapid dental wear and resulting pulpal exposure (which may lead to infection and eventually loss of the tooth). While all human groups, regardless of their subsistence type, suffer from AMTL, there is a marked tendency for higher AMTL rates in populations that consume refined, carbohydrate rich diets (Larsen 1995; Larsen 1997; Scott and Turner 1988). A high degree of AMTL in a skeletal population may considerably affect the analysis and interpretation of dental pathology, as the cause(s) of AMTL are difficult or even impossible to discern. A high rate of AMTL may significantly distort true caries frequencies, for example, as a large number of teeth may (or may not) have been lost due to caries, but cannot be included in the calculation of caries frequencies. In order to deal with the effects of AMTL on interpretation of caries percentage in a population, a number of researchers have come up with various (mathematical) methods to calculate the true caries percentages (Duyar and Erdal 2003; Erdal and Duyar 1999; Lukacs 1995).

2.3.2 Dental wear and diet

Why do the teeth grow to the end of our life, and not the other bones? Because otherwise they would be consumed with chewing and grinding (Aristotle 4th century B.C.).

Macrowear

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 (i.e., grinding, baking, boiling), the physical properties of the food (i.e., tough, unrefined, fibrous, versus soft, sticky, refined), and the inclusion of sand and grit in the food, for example in marine diets or in sandy (desert) environments. The first to notice the relation between the degree of dental wear and particular subsistence patterns was Rufus W. Leigh. He observed that groups who relied mainly on stone ground maize had very high degrees of wear, while groups with a high proportion of meat in the diet had much lower degrees of wear. Groups with a mainly vegetarian diet (including maize), who did not stone grind their food, were found to have a much lower rate of wear than those who used mortars, but a higher rate of wear than those who consumed a large amount of meat. In this way he demonstrated that the degree of dental wear is related to both the type of food and the processing techniques (Broca 1879; Leigh 1925). Next to the use of stone grinders, which introduces tiny particles of stone to the food, high rates of wear have since been related to the consumption of tough, fibrous plant foods or sandy, gritty marine foods, the consumption of dried or frozen meat and fish, and the inclusion of sand, grit, and ash in baked foods (bread). Lower rates of wear are associated with the consumption of soft, refined foods without stone particles, and boiled foods (Cucina and Tiesler 2003; Eshed et al. 2006; Jurmain 1990; Kaifu 1999; Larsen 1997; Macchiarelli 1989; Molleson and Jones 1991; Molnar 1972; Powell 1985; Rose and Ungar 1998; Sealy and van der Merwe 1988; Smith 1984; Walker and Erlandson 1986).

The decline in mean degrees of molar wear over time has been attributed to the transition from hunter-gatherer subsistence to agricultural subsistence practices

(Hinton 1981; Lubell et al. 1994; Molnar 1971a; Powell 1985; Rose et al. 1991; Smith 1984). 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 (Larsen 1995). Some research has found high mean degrees of molar wear associated with marine food consumption. In the latter case it is thought to be the grit adhering to these foods, and sometimes the consumption of dried fish or fish with bones that cause this high rate of 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). One study has even found parallels between human and canine dietary shift toward greater marine food consumption. In both cases the degree of wear increased as the proportion of marine food in the diet grew (Clark 1997). Despite this, some studies have shown that both hunter-gatherers/foragers and agriculturalists can have extremely high rates of wear, although the aetiology of the wear differs drastically (Deter 2006; Scott and Turner 1988). Overall, however, research has shown that mean degrees of wear tend to decline as shifts toward an agricultural subsistence economy take place (Benfer and Edwards 1991; Molnar 1971a; Pastor 1992; Powell 1985; Walker 1978). Recent research by Deter (2009) on occlusal dental wear in hunter-gatherers and agriculturalists from three North American late Archaic (3385 ± 365 cal. B.C.) and late Anasazi – early Zuni agricultural sites (~ A.D. 1300) has confirmed earlier reports that hunter-gatherers have a higher degree of occlusal surface wear, especially in the anterior teeth (Kaifu 1999; Molnar 1971a). However, Deter also found that differences in degree of wear along the dental arch can be attributed to the eruption sequence of the teeth. Thus, the teeth that erupt early on (such as the first incisors and the first molars) are inevitably more worn than teeth that erupt in later stages, since they spend a longer amount of time in functional occlusion (Deter 2009).

Research on dental wear in northwest Mexico has shown that degrees of dental wear can change drastically over time solely due to changes in food processing techniques, while the diet remained stable (Watson 2008). This means that certain dental wear patterns can only be linked indirectly (through processing techniques) to certain food types.

Comparison of the degree of dental wear in skeletal populations to reconstruct diet remains complex, due to the relation between dental wear and age. Age estimation in skeletal populations is based on changes in the skeletal frame during life, and is often restricted to broad age categories. The completeness and preservation of the skeletal material may severely affect the preciseness of aging, but perhaps more importantly, when comparing populations with differing age profiles it is hard to determine whether differences are the result of diet and food preparation techniques, or due to the differing age profiles. This problem can sometimes be avoided by comparing intra-individual rates of wear. The rate of wear is measured using the difference in degree of wear between the permanent molars: M1, M2, and M3. This is possible due to the fact that these teeth erupt at approximately 6-year intervals in all humans, which means inter-individual and inter-group comparisons can be made (Chattah and Smith 2006; Scott and Turner 1988; Smith 1972; Watson 2008; Watson et al. 2011).

Direction and shape of occlusal wear

The direction of molar wear, i.e., the angle of the occlusal surface, has been shown to become increasingly oblique as the proportion of processed (e.g., ground, boiled) foods in the diet increases (Eshed et al. 2006; Lubell et al. 1994; Smith 1984). Smith (1984) studied molar wear patterns in five hunter-gatherer and five agricultural groups from around the globe, and found that agriculturalists tend to have more obliquely worn molars than hunter-gatherers. The greater the reliance on agricultural foods over time, the greater the wear angle was found to be (Smith 1984). Soft, agricultural foods allow for more contact between occluding teeth without lateral excursion, which causes attrition increasing the natural angle and positions of the molars in the alveolar bone. Lower molars tend to be slanted buccally, while upper molars (with the exception of the third molar) tend to slant lingually. The upper lingual cusps and the lower buccal cusps are worn on both sides and thus more rapidly in a normal dentition where there is a slight overbite, causing sloped surfaces when the wear progresses. Tough, fibrous foods, and foods with large amounts of grit and sand contaminants require what is called 'puncture-crushing', where the teeth do not meet, and more intense chewing and lateral movement of the teeth which abrades the tooth crown more evenly and results in a more flat and rounded wear of the occlusal surface (Lubell et al. 1994; Smith 1984). Another study found that hunter-gatherers tend to have labially rounded wear of the anterior teeth, most likely associated with the use of these teeth as tools, whereas agriculturalists tend to have more cupped wear in the anterior teeth. In general, anterior teeth are also more worn in hunter-gatherers than agriculturalists. Furthermore, hunter-gatherers tend to have larger interproximal wear facets, due to slight movements of adjacent teeth as the result of the heavy mastication of non-processed foods (Hinton 1981, 1982).

Smith (1984) also found that agriculturalists have a higher proportion of cupped molar surfaces than hunter-gatherers, which she attributes to the presence of small particles from grinding implements in the refined agricultural diet. Similarly, Lubell et al. (1994) found that the shift from the highly abrasive Portuguese Mesolithic marine dominated diet with sand and grit to the more refined Neolithic diet with processed agricultural foods led to a change from flat molar wear to cupped molar wear. Contrastingly, Deter (2009) found no evidence of difference between hunter-gatherer and agriculturalist cupping. Her sample of three North American late Archaic (cal. 3385 ±365 B.C.) hunter-gatherer sites (n= 306) and late Anasazi–early Zuni agricultural sites (~ A.D. 1300) (n= 87) displayed cupping in many of the hunter-gatherers and agriculturalists. The reason for this apparent contradiction may lie in variation in the constitution of the hunter-gatherer and agriculturalist diets analysed in both studies. Other studies have revealed that hunter-gatherer diets tend to be far less protein oriented than once thought, and may include considerable amounts of processed plants, either through exchange with agricultural groups (Larsen 1997; Lukacs 1990; Walker and Hewlett 1990), collection of wild plants, or simple agricultural/horticultural practices (Milton 2000). The hunter-gatherer diet is known to be widely variable per region and period in time (Lee 1968), and often includes a (large) proportion of starchy plant foods (e.g., Kubiak-Martens 2002).

The mechanisms causing cupped or non-cupped molar wear are likely to be the same in all humans. Patches of dentine become hollowed out once exposed, since dentine is softer than enamel and wears away more rapidly. The wearing of such patches occurs due to the abrasive properties of pliable foodstuffs or stone particles in them, which when brought into contact with the exposed dentine patches wear them away faster than the surrounding dentine (Chattah and Smith 2006; Kaidonis 2008). These foodstuffs must generally be soft in nature, since tough, abrasive foods would also severely abrade the surrounding enamel, and produce a flatter and rounder occlusal surface shape. Occlusal cupping therefore seems associated with soft, refined foods (generally assumed to be more typical of an agricultural diet) with small abrasive particles, rather than tough fibrous foods (usually thought to characterize a hunter-gather diet).

Evidence from clinical dentistry would suggest a different aetiology for dental cupping altogether. In modern dental practice, the loss of (occlusal surface) enamel, paired with cupping, and often also a polished appearance, is attributed to dental erosion caused by intrinsic or extrinsic acids in the oral environment (Lussi et al. 2004). Erosion that is dietary in origin, i.e., due to the consumption of acidic beverages (carbonated soft drinks, fruit juices, certain alcoholic beverages) or fruits could theoretically be a major factor in prehistoric dental wear patterns, since acidic foods would have been readily available to many human populations in the past. Intrinsic acids, i.e., gastroesophageal reflux, affect all modern human populations, and presumably would have done so in the past too (Scheutzel 1996). This begs the question whether cupped molar surfaces truly reflect the abrasivity of the diet and dominant subsistence and food preparation techniques, or rather a (significant) component of acidic fruits, and perhaps fermented beverages or even gastroesophageal reflux. With regards to the latter, this disorder is generally characterized by a highly typical pattern of erosion throughout the dentition, which affects most smooth surfaces of the teeth too (Scheutzel 1996).

Traditional dental wear evaluation systems (i.e., Brothwell 1981; Murphy 1959) are not equipped to document such characteristics of dental wear (i.e., angle and direction of wear or occlusal surface shape). These dental wear evaluation systems are based on a grading system where numerals represent differing degrees of dentine exposure and loss of crown height. They often either pertain only to the molars or make little or no distinction between the different types of teeth (incisors and canines, premolars, molars). In reaction to these problems, Stephen Molnar developed a more detailed dental wear evaluation system (Molnar 1971a). Molnar's dental wear evaluation method relies on a three-way scoring system where scores are given to the severity of dentine exposure, the direction of the wear, and the shape of the occlusal surface. He increased the accuracy of this scoring system by providing different criteria for degree of wear for each element type. Incisors and canines, for example, are subject to different patterns of wear than premolars or molars. Using this scoring system he was able to prove a positive correlation between tooth wear and cultural factors, since the types and degrees of wear in the different cultural groups he studied showed significant differences. He also found differences between the sexes within each population (Molnar 1971a).

As is the case for dental pathology, previous research has revealed significant differences between male and female patterns of dental wear (e.g., Benfer and Edwards 1991; Molnar 1971a; Powell 1988). These are usually interpreted as the result of differences in non-alimentary activities involving the teeth (see section 2.3.1) or differences in dietary patterns as the result of gender-based differences in labour division. These differences in labour division are thought to lead to differences in food consumption, because women tend to be most heavily involved in foraging and/or plant cultivation and would therefore consume more plant foods (Molnar 1971b). Some have suggested that differences in mean degree of dental wear between the sexes could be attributed to the fact that males are generally larger and more robustly built than females (Chattah and Smith 2006; Chuajedong et al. 2002; Scott and Turner 1988). It is thought that the fact that males require more food intake, and the fact that they are capable of exerting greater force during mastication, may cause higher degrees of dental wear in males (Molnar, McKee, Molnar, and Pryzbeck 1983). However, this does not explain why in some cases females exhibit higher degrees of wear than males (Molnar 1971b; Molnar, McKee, and Molnar 1983; Richards 1984), or why some studies have found no differences between male and female degrees of wear (Kieser et al. 1985; Lovejoy 1985).

Clearly, the interpretation of dental wear patterns is far from straightforward. In order to build a more accurate picture of the relation between patterns of dental wear and diet, each population must be assessed in its own sociocultural and biological context to interpret dental wear and diet.

Hypercementosis

Hypercementosis is the accumulation of excessive cementum on the roots of the teeth, usually affecting the apex of the roots most severely. The result is a swollen, bulbous appearance of the tooth root. The precise cause of hypercementosis remains unclear. Suggested causes include the friction and stress on the periapical ligament associated with heavy dental wear, although the condition also occurs in unerupted teeth (Hillson 1996, 2008b). Alternatively, the condition may be related to Paget's disease, periodontal inflammation, or trauma (particularly in localized hypercementosis). Hypercementosis in prehistoric populations is most frequently observed in older individuals and populations displaying heavy dental wear (Hillson 2008b).

2.3.3 Dental erosion and diet

Erosion is the result of the chemical dissolution of hard tissues due to the presence of acidic chemicals in the mouth. These acids can be categorized as either extrinsic or intrinsic acids, or alternatively as dietary or non-dietary acids. Dietary acids are present in acidic plant foods such as citrus fruits, while non-dietary acids tend to be introduced into the mouth through gastric regurgitation. Extrinsic acids comprise dietary acids but also include for example (industrial) airborne chemicals (Bartlett 2005; Cengiz et al. 2009; Ganss 2006; Lussi 2004). Dietary acids would appear most interesting in this study, but since the origin of the acid cannot be derived from the clinical presentation of erosion, evidence of erosion cannot be used to identify particular acidic components in the diet or environment. Nevertheless, it is extremely important to be aware of possible dental erosion in dental material as it not only erases other forms of dental wear, but it also very closely resembles some patterns of abrasion (Bell et al. 1998).

Certain patterns of dental wear (abrasion) are easily confused with dental erosion, as both can result in characteristic cupping of the dentine on the occlusal surface. Some research has indicated that the depth and orientation of the cupping is a diagnostic criterion for distinguishing abrasion and erosion (Bell et al. 1998). Other studies have shown that occlusal dental cupping appears not to be a reliable characteristic for diagnosis, as it is mostly caused by abrasion or the combination of erosion and abrasion. Instead, the occurrence of concavities on smooth surfaces is suggested to be a diagnostic criterion for identifying dental erosion (e.g., Ganss et al. 2002; Ganss 2008; Kaidonis 2008; Scheutzel 1996).

The effect of dietary acids on archaeological dentitions was assessed in a study by Ganss and colleagues (2002). They compared a group of medieval (A.D. 400–800) dentitions from regions of Griesheim (Hesse) and Sindelsdorf (Bavaria), Germany (group 1), to a modern clinical group consuming an acidic, erosive diet (group 2), and a randomly selected group consuming an average Western diet (group 3). Occlusal cupped patches, where dentine had worn more rapidly than the surrounding enamel, were found in all three groups, but were typical of the group 1. The characteristic dental lesion associated with erosion, which was found very frequently in group 2, is buccal loss of enamel and slightly cupping. This type of lesion was completely absent in group 1 and infrequently observed in group 3. The researchers conclude that although erosion (both intrinsic and extrinsic) must have been a factor in all groups, the typical pattern of cupped occlusal wear is associated not with acidic erosion, but with severe dental wear (attrition and abrasion). The similarity of lesions in the acid erosion clinical group was simply the result of erosion induced severe wear: i.e., heavy wear brought on by compromised enamel strength due to repeated acid attack.

Kaidonis (2008) argues that dental erosion is a modern-day condition, associated with the elevated levels of extrinsic acids available to humans in modern diets (i.e., carbonated soft drinks, certain alcoholic beverages, large quantities of fruit, fruit juices), stating that if erosion was excessive, non-occlusal lesions would be expected. The latter have to date not been documented in archaeological material. Kaidonis (2008) attributes dentine cupping in archaeological dentitions to abrasion, which in these cases is always characterized by relatively shallow cups, with a depth-breadth ratio that remains the same throughout increasing stages of wear (see also Bell et al. 1998).

2.4 Health and Disease

2.4.1 Developmental defects

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.

Enamel hypoplasia

Hypoplasia are disparities in enamel thickness across the crown, which change the appearance of the crown surface. The most common type of hypoplasia are Linear Enamel Hypoplasia (LEH), also known as furrow-type, so named because of their horizontal linear appearance on the tooth crown. LEH tend to be arranged in a band which extends around the crown surface, representing a disruption event in the layered formation of the matrix of the crown. Essentially, LEH are disruptions in the formation of the perikymata (growth lines that appear on the surface of enamel as a series tiny of grooves), which causes them to become 'exaggerated'. As the development sequence of the perikymata on the tooth crowns is well known, and can be linked to age, the location of the LEH on the tooth crown can indicate the period in life when the disruption took place. As early as the 1940's methods were being developed to estimate the timing of enamel defects, although certain limitations to these techniques still exist (Massler et al. 1941; Hillson 1996).

Other types of hypoplasia are pit-type defects, and plane-type defects. Pit-type defects can affect a part of or the entire crown. The pits may be encountered in clusters and sometimes in bands, which can follow the furrows of LEH. Plane-type defects are larger exposed areas than pit-type defects (Hillson 1996).

Hypoplasia are generally classed as non-specific defects, which means a very large number of factors contribute to their formation. However, it is clear that some factors tend to be more strongly related to the formation of hypoplasia than others. Specifically, physiological stress including particularly metabolic disorders and nutritional deficiency (but also infectious disease, and physical and emotional trauma) during the development of the teeth appears to be an important cause of (linear) enamel hypoplasia. Diets which are extremely specialized or monotonous may be linked to hypoplasia, as a non-varied diet can lead to malnutrition. Furthermore, despite the non-specificity of hypoplasia, research has shown that they are well suited to large scale studies of long term changes in nutritional status, e.g., the transition from hunter-gatherer subsistence to agriculture (Goodman and

Rose 1991; Hillson 1996; King et al. 2005; Smith et al. 1984).

Specific disease related defects

There are developmental defects of the dentition which are specific to a particular disease, and which can be recognized by the characteristic pattern they leave on the teeth. A well-known example is a series of dental defects associated with congenital syphilis. This disease, which affects the dentition only in a very small percentage of cases, leaves characteristic deformations of the crown enamel predominantly in the permanent incisors (Hutchinson's incisors) and the first molars (bud molars and mulberry molars), but also in the canines (Fournier canines) (Anderson 1939; Hillson et al. 1998).

Another example is celiac disease, which can also lead to characteristic deformities in the dentition which occur during development of the teeth. Celiac disease (also gluten-sensitive enteropathy) is an autoimmune disease of the digestive system that damages the small intestine when gluten is ingested. The immune system is activated by the ingested gluten, resulting in inflammation of and damage to small intestine. Symptoms of the disease are diarrhea, weight loss, and the inability to absorb nutrients from foods. The disease can cause (symmetrical) patterns of damage to the enamel of the tooth crowns, with discolouration and hypoplasia as a result of poor mineralization, and crown shape may be affected, with teeth being more pointed or conical than normal (Aine et al. 1990; Greene and Cellier 2007).

Opacities

Opacities, sometimes referred to as hypocalcifications, are defects in the mineralization of enamel during the final or maturation stage. They appear as opaque white to brownish-black patches in the enamel, and can be divided into demarcated opacities and diffuse opacities. The first variety has a clear boundary, although they may vary in size and location, whereas the second variety has no clear boundary (Hillson 1996). Opacities can be the result of a high fluoride consumption during the formation of the teeth; a condition known as dental fluorosis. One of the main components of enamel is hydroxyapatite, which is formed during the early developing stages of the teeth. In the presence of fluoride, fluorapatite is formed and built into the enamel, causing opacities. Consumption of fluoride is known to inhibit the formation of dental caries, as fluoride enhancement of remineralization, combats demineralization and inhibits bacterial enzymes which produce carious lesions. Fluoride may be naturally present in the environment, and may be consumed through drinking water, or certain foodstuffs. Specifically, certain plants (e.g., tea leaves) and marine foods are known to be high in fluoride content (Elvery et al. 1998; Featherstone 1999; Hadjimarkos 1972; Malde et al. 1997; Spencer et al. 1970). Some researchers suggest that marine food consumption has considerable cariostatic effects, meaning that populations who regularly consume large amounts of marine food should be protected from dental decay (Walker and Erlandson 1986).

Discolouration

Discolouration of the enamel may result from pigment deposits due to metabolic disorders (e.g., celiac disease, see above), deficiencies during mineralization (Hillson 1996), or extrinsic staining factors such as smoking. Tobacco and tobacco smoke are well known causes of enamel discolouration, as they contain chemicals, such as nicotine, tar, and other substances, that cause staining of the enamel surface. Tobacco smoke can cause thermal irritation due to the temperature of the smoke which can lead to damage of the enamel surface, leaving it further exposed to staining materials. Chewing tobacco can also cause discolouration, which is particularly severe when parts of the dentine are exposed (Davies 1963).

2.5 Cultural Practices

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 be the by-product of an activity which involves the use of the teeth as tools, or the result of intentional alteration of the appearance of the teeth. In the latter case, the teeth are modified by filing, chipping, in-laying with stone or metal, or even extraction, for aesthetic reasons. It is currently thought that the use of the teeth as tools was common in many prehistoric populations.

2.5.1 Teeth as tools

In a review of the field Albert A. Dahlberg suggested “grasping, holding, crushing, cutting, tearing, gnawing, tool-making, leather-treating, and thong, reed and thread fashioning” as just some of the “special uses” the human teeth are put to (Dahlberg 1963:237). Later, Molnar’s complete and comprehensive overview of the non-alimentary uses of teeth defined a set of criteria by which to distinguish non-alimentary wear patterns from masticatory wear, and emphasized the value of ethnographic comparisons in linking the clinical presentation of non-alimentary wear to particular (craft) activities (Molnar 1972).

However, research on the non-alimentary uses of the teeth has often been somewhat anecdotal in nature; modifications are relatively rarely encountered in skeletal populations, and are very specific to particular individuals, groups or regions, which initially led to a tendency for an unstructured approach toward their study (Milner and Larsen 1991). Alt and Pichler (1998) have formulated very useful and clear definitions of the non-alimentary uses of the teeth, dividing them into occupational modifications, individual habitual modifications and intentional dental modifications. Occupational modifications can clearly be defined as modifications resulting from the use of the teeth as tools, whereas individual habitual modifications can be the result of other non-masticatory activities, where the teeth are not used as a tool. An example of the latter may be habitual tooth-picking, which can result in clear interproximal grooves, but does not involve the active engagement of the teeth in a specific task (Alt and Pichler 1998; Lukacs and Pastor 1988; Molnar 2008).

Non-alimentary modifications can often be identified by their 'odd' appearance. Some types of modifications occur relatively frequently in prehistoric dental assemblages, and are therefore more readily identifiable than others. The modifications most often associated with the use of teeth as tools are occlusal surface grooves or notches, and dental chipping.

In some cases, however, the identification of non-alimentary modifications can pose a problem, as malocclusion of the teeth can lead to strange dental wear patterns which may appear to be the result of the use of the teeth as tools. When the jaws are largely intact, such cases are usually easy to spot, however when dealing with loose teeth this can be more challenging. Distinguishing non-alimentary wear patterns from other wear patterns, and occupational from individual habitual modifications, poses the greatest problem in this line of research. In some cases there is no simple way of making distinctions. Research has tended to focus on specific contextual information, and ethnographic parallels. Classificatory systems have been developed for certain types of non-alimentary wear, such as dental notching/grooving (e.g., Bonfiglioli et al. 2004). These classifications are based on the size and shape of the affected area on the tooth crown, and the amount of the tooth crown involved. The development of systems like these is encouraging, as they facilitate comparison between different assemblages, but they have no clear explanatory purpose in determining the exact relation between the activity (if known) and the physical appearance of the wear pattern(s). For example, the length and depth of a dental notch/groove is both indicative of the length of time spent using the teeth as a tool in a particular activity, and the physical characteristics of the material which caused the notch/groove. Again ethnographic parallels may provide valuable comparisons, but with many traditional craft activities dwindling, and the fact that ethnography has rarely focussed on the use of the teeth as a tool, means useful comparisons are scarce (but see Berbesque and Marlowe 2009; Berbesque et al. 2012; Walker et al. 1998).

It seems, therefore, that for the interpretation of non-alimentary dental wear, dental anthropologists need to rely more heavily on what is known of the context in which the skeletal material was found. Any indications in the site context or material culture of activities such as basket manufacture, for example, could be crucial in explaining non-alimentary wear patterns on the teeth. Also, the application of techniques such as Scanning Electron Microscopy (SEM), currently predominantly used for diet reconstruction, may enable more precise identification of the physical characteristics of the materials involved in non-alimentary uses of the teeth (Krueger and Ungar 2010).

Grooves/notches

Occlusal surface and interproximal grooves or notches are formed when an object of generally corresponding size and shape to the groove or notch is repeatedly passed across the occlusal surface, or clamped between occluding teeth. A well-known example of an activity associated with this type of wear is basketry. Some basket makers use their teeth to clamp or strip the flexible materials they use when their hands are occupied. The stripping of sinew is (in order to make it supple) another well-known example of an activity which produces grooves and notches (Alt and Pichler 1998; Brown and Molnar 1990; Larsen 1985; Milner and Larsen 1991; Pedersen 1949; Schulz 1977; Ubelaker et al. 1969; Wallace 1974).

Dental chipping

Dental chipping was first described at length by Turner and Cadien (1969). They analysed 324 prehistoric and protohistoric dentitions belonging to Aleuts, Eskimos and northern Indians, and observed what they called "a little known type of tooth wear […] characterized by severe crushing and/or flaking of the crown surface of one or more teeth", which they named 'pressure-chipping' due to the resemblance to flake scars on chipped stone artefacts (Turner and Cadien 1969:303). They strongly associated this type of dental wear with a diet consisting mainly of meat and with the action of crushing bones with the teeth. The consumption of frozen meat, which was usually the state in which meat was available to Aleuts and other northern Indians, would have caused considerable damage to the teeth. The crushing of bones would have been done mainly as a pastime in order to extract the maximum amount of nutrients – from the bone marrow – from the meaty component of the diet.

More recent research into dental chipping has indicated that it may be the result of increased masticatory function of certain teeth in the dental arch, due to the absence of other teeth (i.e., ante mortem tooth loss or congenital absence of elements). In an epipalaeolithic assemblage from Taforalt, Marocco, the higher frequency of chipping on the posterior teeth was related to the practice of purposeful avulsion of the maxillary central incisors. As a consequence, masticatory and non-alimentary activities shifted to the posterior teeth (Bonfiglioli et al. 2004).

Some researchers have suggested that there is a relation between heavy dental wear and chipping (Bonfiglioli et al. 2004; Budinoff 1991; Molnar 2008). This relation could be the result of the weakening of the tooth by severe wear, which would make the tooth more susceptible to chipping[1], or conversely it is possible that severely chipped teeth wear faster than unchipped teeth. Furthermore, the frequency and severity of dental chipping has been positively correlated with age. The increase in number and severity of dental chips with age is logical, as older individuals have been exposed to the causes of dental chipping for a longer period of time (Molnar 2008).

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[1] As the occlusal surface of the tooth becomes worn, the dentine is exposed. The remaining rim of enamel around the occlusal surface becomes less well supported, leaving the tooth prone to chipping.

A number of researchers have suggested masticatory causes for dental chipping, such as the extreme toughness and abrasiveness of some food types which sometimes include parts of snail shells, fruit stones and bones (Bonfiglioli et al. 2004), the adherence of sand and grit to certain foods (Budinoff 1991; Molleson and Jones 1991), and the consumption of dried fish (Budinoff 1991).

Numerous non-alimentary causes for dental chipping have also been suggested, including cracking nuts (Mickleburgh 2007), cracking crab shells (Budinoff 1991), chewing seal hides and preparing sinew (Merbs 1968; Pedersen 1947), cracking bones (de Poncins 1941), retouching chert artefacts (Gould 1968), and holding objects between the teeth (Bonfiglioli et al. 2004; Merbs 1968; de Poncins 1941; Schour and Sarnat 1942).

It seems more likely that dental chipping is the result of any or all of the above mentioned causes. A combination of masticatory and non-alimentary causes most likely gave rise to the numerous dental chips or fractures found in prehistoric dental assemblages, which makes interpreting patterns of dental chipping very complex. There are, however, some indicators which can be used to differentiate between masticatory and non-alimentary causes for dental chipping. Molnar (2008) suggests that next to general morphological appearance, significant differences between the sexes, the increase and decrease of expressions with age, and the link to oral pathology are important indications for distinguishing between masticatory and non-alimentary causes. Significant differences between the sexes may indicate gender-based divisions of labour or craft activities which involve the use of the teeth as a tool, and therefore can be an important indication of a non-alimentary cause. In her study of the relation between dental wear and oral pathology in a Swedish Neolithic assemblage, Molnar found that certain patterns of dental wear were correlated with particular dental and oral lesions. In her analysis of the relation between dental wear and lesions, she classifies dental chipping as a dental lesion. She found that in particular, occlusal excessive load wear[2] was correlated with dental chipping. Furthermore, she found that in general "[t]he patterns of dental wear that were found to correlate with dental and oral lesions are[...] likely to be results of the same actions that also produced chipping, periapical lesions, and tilting" (Molnar 2008:430)

Another important indicator of non-alimentary causes for dental chipping is the location along the dental arch. Broadly speaking, chipping in the anterior teeth could be interpreted as the result of non-alimentary wear, whereas chipping in the posterior teeth (in particular the molars) could be interpreted as the result of the mastication of hard particles and grit in food. Furthermore, any differences between the mandible and the maxilla could be indicative of the cause(s) of the chipping (Belcastro et al. 2007; Bonfiglioli et al. 2004; Scott and Winn 2010).

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[2] Occlusal excessive load wear is defined as "Homogenous, excessive wear, i.e., little or no enamel is present on the occlusal surface of molars and on occasion premolars. The excessive wear is in many cases oblique and more severe in the lower jaw than the upper." (Molnar 2008:424).

LSAMAT

Lingual surface attrition of the maxillary anterior teeth (LSAMAT), a pattern of wear found in over 85% of 46 adult individuals excavated at the Itaipu phase (preceramic hunter-gatherer) site of Corondó, Brazil, was first described by Turner and Machado (1983). They define this LSAMAT as "the occurrence of progressive wearing with age of upper anterior lingual tooth surfaces without corresponding lingual or labial surface wear on any lower teeth. It is not the result of any manner of occlusal overbite, overjet, malocclusion, or other normal or abnormal anatomical consideration" (Turner and Machado 1983:126). LSAMAT was found to be correlated with a high rate of caries – in this case 11% – and manifests from the relatively young age of about 10 years onward. The presence of LSAMAT at Corondó was not found to be related to gender. Turner and Machado argue that the most probable cause of LSAMAT is the use of the upper front teeth and the tongue to shred or peel abrasive plant material for either a masticatory (to extract nutrition) or a non-alimentary (teeth as tools) activity. They strongly favour a masticatory cause as they feel that the high degree of lingual attrition paired with the absence for evidence of gender-based differences must be indicative of a dietary practice. They suggest that the use of the maxillary anterior teeth and the tongue to strip the roots of manioc of their outer peel (or perhaps to manipulate tule) was the most likely cause of LSAMAT. The peeling of raw manioc also explains the association of LSAMAT with a high caries rate, which they argue is unexpected for a preceramic hunter-gatherer population. Manioc roots and are extremely nutritious and especially rich in carbohydrates. Regarding the problem of the extreme toxicity of raw manioc tubers, they posit that iodine and protein rich foods, which would have made up a large part of the rest of these hunter-gatherers' diet, would have limited the cyanide uptake in the body (Turner and Machado 1983).

In later studies, Irish and Turner (1987, 1997) found LSAMAT in late prehistoric remains from Venado Beach, Panama and historic skeletal remains from Senegal, and were able to identify the consumption of sweet manioc or sugarcane as the most likely cause. Sucking on manioc roots or sugarcane stems to extract the sugary juices would have caused the patterns of wear on the lingual surfaces of the maxillary teeth, and also explain the associated high caries rate. Furthermore, they suggested that not only the peeling of manioc, but also the sucking of raw (sweet) manioc peel could be the cause of LSAMAT in Amerindian skeletal material (Irish and Turner 1987, 1997).

In reaction to Turner and Machado's work Robb et al. (1991) suggest that erosion due to (gastric) acids is a far more likely cause for the LSAMAT dental wear pattern, sparked a lively discussion. Turner and colleagues strongly refuted the suggestion that LSAMAT could be associated with habitual regurgitation of stomach acids, mainly because they did not believe that very high percentages of populations could take part in such activities – voluntary or involuntary. They also argue that the LSAMAT that they observed did not display the characteristic cupping that erosion does. They reiterate that the pattern of wear they documented was "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). Later research focussed on the possibility of a non-alimentary 'teeth as tools' aetiology for LSAMAT, for example for cordage manufacture or basketry (Comuzzie and Steele 1988; Hartnady and Rose 1991; Larsen et al. 2002).

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 archaeological settings throughout the world (e.g., Liu et al. 2010; Pechenkina et al. 2002).

Microwear

Dental microwear analysis is the study of microscopic patterns of dental wear, in the form of scratches and pits on a tooth's surface. These scratches and pits result from the use of the tooth, and its coming into contact with other materials, principally foodstuffs. Foods (as well as other materials) leave particular patterns of microwear on the teeth, depending on their material properties. Dental microwear research is focussed mainly on the study of the characteristic patterns of microwear in human and animal teeth, in order to understand the relationships between microwear and subsistence patterns. To this end, usually the molar teeth are studied, as these are most heavily involved in the mastication of foods. The majority of research has focussed on humans and non-human primates, often with the aim to reconstruct the diets of our human ancestors (Teaford 1991; Ungar et al. 2008). Dental microwear analysis has also been used to study patterns of wear resulting from the use of the teeth in other activities than food mastication, often referred to as 'teeth as tools' use. As such non-alimentary activities usually involve the anterior dentition, this type of research focuses on microwear patterns in the incisors and canines, and how to distinguish non-alimentary wear patterns from masticatory wear patterns (Krueger and Ungar 2010).

Dental microwear analysis generally uses Scanning Electron Microscopy (SEM), a technique which employs an electron microscope that projects a high-energy beam of electrons in a raster scan pattern onto the surface of the sample. The signal produced by the electrons as they hit the surface of the sample contains information on for example the surface topography and composition of the sample. Using this signal, high-resolution images can be prepared of the sample surface, revealing incredible detail at nanometre scale. This technique has been the basis for dental microwear analysis since the late 1970's and early 1980's, however, over the years researchers have come to realize that this method has a number of drawbacks with regards to interpretation of the patterns of scratches and pits. Foremost among these is the time consuming and subjective practice of identifying individual features of microwear on tooth surfaces, and the effects of observer error on the results. In more recent years, researchers have focussed on solving these issues, introducing among others 'microwear texture analysis', a method for quantifying patterns of dental microwear based on three-dimensional surface data and scale-sensitive fractal analysis. This method does not require the subjective identification of individual features, countering observer error, while at the same time reducing the amount of man hours involved (Scott et al. 2005; Ungar et al. 2008). Nonetheless, qualitative analyses of dental microwear may still give valuable insights into dietary patterns and the use of the teeth as tools, especially in the light of the vast amount of work done in recent years with which such analyses may now be compared.

2.5.2 Intentional Dental Modification

Alt and Pichler (1998) distinguish two forms of Intentional Dental Modification (IDM): dental mutilations (sometimes known as dental transfigurement) and therapeutic measures on the teeth (dentistry). IDM can be classed as a type of bodily modification for social, cultural, and/or aesthetic reasons. Bodily modifications, or 'bodmods' as they are nowadays popularly known among western practitioners, include a range of artificial modifications of the body, such as tattooing, piercing, scarification, and cranial modification. In contemporary – and in particular in westernized – societies IDM is rare, except for example in the form of gold coating of one or more teeth for social and aesthetic reasons. By contrast, therapeutic treatment of teeth is practiced on a large scale in contemporary societies.

The practice of IDM has been documented in a range of geographical areas, for both living and archaeological populations. It has been extensively reported – although most often in isolated cases or pertaining only to one particular site – for large parts of Africa, North America, Mesoamerica, South America, India, Malaysia, the Philippines, New Guinea, Japan, and Oceania (Milner and Larsen 1991). Less extensively researched is IDM in the Caribbean region, although a small number of cases are known. Our current understanding of these cases is that they represent an African tradition of IDM, introduced into the Caribbean together with 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).

IDM in pre-Columbian Mesoamerica is very well documented, as important work done by Javier Romero (1970) sparked a lasting interest in the subject. Romero distinguished 7 types of modification, based on his study of a collection of 1212 teeth housed at the Instituto Nacional de Antropología e Historia, Mexico City. Each type has 5 or more subtypes, giving a total of 59 types of modification (Milner and Larsen 1991; Romero 1970). Although Romero's work largely pertains to Mesoamerican dental material, his classification system has been widely used by scholars working in other regions.

Based on a broad range of practices from many regions worldwide, some basic types of dental modification can be distinguished. The first, and possibly most common form of IDM, is the filing of the tooth crowns into a different shape. As with all dental modifications, the anterior teeth are more often treated in this way (as they are the most visible to others). The same effect of reshaping the tooth crown can be achieved by chipping parts of the crown off. This practice is often used together with, or in preparation for, filing. Staining or bleaching of the teeth is another form of dental modification which is practiced in many different regions of the globe. Perhaps the most striking dental modification, however, is the inlaying with ornaments. In this case, the labial surfaces of (usually) the anterior teeth are drilled until there is a hole deep enough to insert a small piece of stone or metal. In Mesoamerica, this form of dental modification has often been documented together with tooth crown filing. Sometimes the complete removal of certain teeth (again usually the anterior teeth), is thought to be aesthetically pleasing. The teeth may be extracted by pulling or knocking them out (Alt and Pichler 1998; Milner and Larsen 1991).

In recent years, researchers have tended to focus on the social role of dental modification rather than on constructing classification systems for the different types which can be identified (e.g., Labajo González et al. 2007; Tiesler 1999; Williams and White 2006). It is now recognized that IDM, like other intentional body modifications, represents an important class of archaeologically available data which can be used to understand social and cultural practices. This demands a more systematic approach to the study of IDM in skeletal populations, in order to understand the complex social dynamics which underlie them.

Therapeutic treatment

Although therapeutic treatment of the teeth, or dentistry, seems to be a relatively modern practice, cases have been documented for the past nine millennia. The oldest known evidence for dentistry comes from the Neolithic site of Mehrgarh in Pakistan. Here, flint-tipped bow drills were used to create holes of 1.3 to 3.2 mm in diameter with a depth of 0.5 to 3.5 mm. The drilling was performed ante mortem, as is evidenced by the smoothing of the edges of the affected area, which must have occurred through food mastication after the holes were drilled. The nine individuals affected were dated to between 9000–7500 B.P. (Coppa et al. 2006).

In prehistoric dentitions worldwide, documented types of dental therapy are tooth extraction, drilling, filling, trepanation (of the jaw bone), splinting, and fabrication of artificial dentures. Obviously, intentional extraction of teeth is (almost always) indistinguishable from exfoliation due to trauma or pathology. The other forms of dental therapy, however, are very clearly the result of human intervention, and therefore represent unambiguous evidence of cultural practices of healing, affording insights into past human attitudes toward health and sickness.

2.5.3 Other non-alimentary modifications

Other non-alimentary practices leading to modification of the teeth are generally the result of wearing facial jewellery or individual habits such as pipe smoking. Classed as 'individual habitual modifications' (Alt and Pichler 1998), these modifications are not the result of a particular task activity involving the teeth as tools. Neither are they associated with occupation, although in some cases there is an

indirect link between the modification and the occupation.
As these types of modification tend to be very individual in nature, there are no clearly distinguishable types of modification, although some modifications have been reported relatively frequently. The first of these is the modification of the teeth caused by pipe smoking. As pipe smokers tend to clamp the stem of the pipe between the occluding teeth, the stem wears away an oval shaped 'hole' over time, often referred to as a 'pipe notch'. Similarly, extensive tooth picking has been shown to leave interproximal grooves (Lukacs and Pastor 1988; Ubelaker 1969; Wallace 1974). Habitual pen biting, causing similar wear patterns to pipe smoking, was found to be common among office workers by Hickel (1989). In this case, although the habit was clearly individual, it was indirectly related to the occupation. Oral and facial jewellery, such as lip studs, lip plugs, lip rings, labrets, and cheek plugs have been shown to crack and chip teeth, or leave smoothly polished wear facets on the (labial) surfaces. Very large ornaments in the lower lip sometimes cause malpositioning of the anterior mandibular teeth, as a result of the pressure exerted on them during long term use of the ornament. Regardless of the type of material the ornament is made of, where it comes into contact with the gingiva, it will invariably damage them and cause them to recede. Gingival recession may in turn eventually lead to exfoliation of the teeth as the alveolar bone resorbs and leaves the teeth unsupported. In modern dentistry the wearing of tongue studs has provided ample examples of the trauma and infection associated with wearing oral jewellery. Next to (localized) recession of the gingiva, alveolar bone resorption, and infection and abscessing, the use of tongue studs has been shown to cause among other things increased salivary flow, nerve damage and paraesthesia, swelling, risk of haemorrhage, risk of inhalation of the studs, allergic reactions to the metal, and interference with speech, chewing, and swallowing (Kieser et al. 2005; Maheu-Robert et al. 2007; O'Dwyer and Holmes 2002; Pires et al. 2010).

Bruxism

Bruxism or bruxing is "the habit of grinding the teeth together (tooth to tooth contact when not eating" (Abrahamsen 2005:269). It is a major cause of abrasion to the human dentition. Estimates from clinical studies of percentages of bruxers, range from 6% to 88% of the population (Ahlberg 2002). Precise reasons for bruxing remain unclear, although researchers have put forward a number of explanations, including stress, temporomandibular joint disorder (TMJD), and reflex chewing during sleep (Abrahamsen 2005; Ahlberg et al. 2002; Watts et al. 1999). Due to the extremely high forces of pressure when the teeth are clenched together or ground, bruxing can cause chipping and fracturing of the enamel and underlying dentine, and (severe) wear of the entire crowns of the teeth (Arnold 1981; Pavone 1985). The latter is usually associated only with severe or prolonged sleep bruxing, or bruxing which goes undiagnosed or untreated by a dentist.

2.6 DENTAL ANTHROPOLOGY AND ARCHAEOLOGY

In the increasingly interdisciplinary and interdependent academic world, it has become clear that no discipline is an island – that, in fact, formerly rigid boundaries are displaying a considerable amount of elasticity that encourages interaction (Rose and Burke 2006:323).

As shown above, dental anthropology is a multifaceted discipline which deals with a range of topics, many of which overlap with the disciplines of archaeology, osteoarchaeology, biology, forensics, evolutionary biology, and genetics. In fact, 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, as is discussed below.

One of the underlying notions of the research presented here is that the incorporation of numerous lines of evidence from different fields of research will ultimately benefit all disciplines involved. Archaeology has a lot to gain from the routine incorporation of dental anthropological research in the study of past human lifeways. Dental anthropology can be of particular importance in subsistence studies and the study of specific cultural practices, and complements interpretations of dietary patterns derived from stable isotope and faunal and palaeobotanical data. Conversely, of course, closer collaboration with archaeologists allows dental anthropologists (and osteoarchaeologists in general) to interpret their findings within their specific socio-cultural context. 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. The lack of such an inclusive approach has been an important point of appraisal in recent discussions on the disciplinary divide between archaeology and osteoarchaeology (Larsen 2006). Osteoarchaeologists are said to have contributed to this situation by presenting their research as a highly specialized set of research techniques as opposed to a research paradigm in its own right. Conversely, archaeologists are charged with considering osteoarchaeology simply as a 'service provider', supplying archaeologists with raw data which they then interpret within the correct socio-cultural context (Sofaer 2006). To all intents and purposes, osteoarchaeology needs to shed its reputation for being a largely atheoretical discipline to fulfil its role as a sub-discipline of archaeology. Achieving this is the responsibility of researchers in both fields, as all will ultimately benefit from overcoming this 'disciplinary divide', thus opening up a range of possibilities for archaeologists and osteoarchaeologists or dental anthropologists alike to strengthen and incorporate different lines of evidence into their research.

2.6.1 Dental anthropology and Caribbean archaeology

Dental anthropological studies have rarely been done in the Caribbean region, and the research that has been done on the subject falls within the scope of more general physical anthropological and osteological pursuits. Some researchers have however highlighted the potential of pre-Columbian Caribbean human dentitions to reveal past patterns of biology and behaviour in this region. These studies are summarized here.

Forensic specialist and physical anthropologist Edwin Crespo Torres, being a student of one of the most influential researchers in the field of dental anthropology, Christy Turner, has shown a profound interest in human dental wear, morphology and pathology, incorporating routine and thorough dental analysis into his research (Crespo Torres 1991, 2000, 2005a, 2005b, 2010, 2011). Crespo Torres was the first to identify LSAMAT in pre-Columbian Caribbean dentitions (Crespo Torres 1994; see also Turner and Machado 1983).

In his osteological report on the human skeletal material recovered from the site of Hacienda Grande, Jeffrey Walker included a very extensive analysis of dental wear, linking the patterns and degree of wear to particular subsistence strategies and including an investigation into the use of teeth as tools (Walker 1985).

On Barbados intensive research led by Peter Drewett in the 1980's yielded a larger number of human skeletons, which were subsequently subjected to thorough osteological analyses. The latter included a study of the dentitions by Don Brothwell, revealing excessive tooth wear and tooth loss, and patterns of wear associated with the use of the teeth as tools in cultural activities. Research into the prehistory of Barbados continued throughout the 1990's to the present, always including systematic osteological analysis of human remains by experts in the field (Drewett 1991, 2000).

Also during the late 1980's, Aad Versteeg conducted research on Aruba, where among other things he excavated the Archaic cemetery site of Malmok and together with physical anthropologist Jouke Tacoma studied the osteology and mortuary practices of the approximately 60 individuals buried there. Later, in the mid 1990's, efforts were made to place this Archaic cemetery of Malmok in a Caribbean-wide cultural context for the period, as both Versteeg and Tacoma visited Cuba to compare their results to Archaic burial assemblages there (Versteeg 1991; Versteeg et al. 1990). Tacoma studied a number of skeletal assemblages from Aruba, Curacao, and Suriname. He professed an acute interest in the study of the human dentition, making certain that the teeth were carefully collected during excavation and that the pathological conditions of the dentition were documented. He also documented some of the most conspicuous morphological traits in the dentitions that he studied, paying specific attention to the presence and degree of incisor shovelling (Tacoma 1959, 1990, 1991; Versteeg et al. 1990).

The 42 human skeletal remains excavated at the site of Tutu, St. Thomas, USVI, were the subject of a multi-disciplinary investigation into past biology and behaviour, including osteology and pathology, mortuary practices, and dietary practices at the site, including trace element and stable isotope analyses and a dental anthropological study (Farnum and Sandford 2002; Larsen et al. 2002; Norr 2002; Righter et al. 1995; Sandford et al. 2002). The latter study recorded pathological conditions of the Tutu teeth, including dental caries, enamel defects, and calculus, as well as macro- and microwear patterns. The researchers conclude that the high degree of dental wear exhibited in the Tutu population was the result of abrasives in the diet, such as sand and grit. They distinguished a small number of cases of non-alimentary wear related to the use of the teeth as tools, including the presence of LSAMAT. Furthermore, they found slight differences in caries prevalence between males and females, which they interpreted to be the result of different food consumption patterns (Larsen et al. 2002).

Characteristics of non-metric dental traits have been used to study the degree of biological affinity between some groups (e.g., Archaic Age vs. Ceramic Age) within the region (Coppa et al. 1995; Crespo Torres 1994). Alfredo Coppa and colleagues document changes in stress incidence over time, evidenced by a decrease in the frequency and timing of enamel hypoplasia (disruptions in the enamel formation) between Archaic Age groups and Ceramic Age groups in the Dominican Republic. They furthermore found evidence for a greater genetic homogeneity in Late Ceramic Age groups from the Dominican Republic when compared to Archaic Age groups, which they relate to different waves of migration to the island (Coppa et al. 1995; Coppa et al. 2008).

Where dental anthropology has grown into a discipline in its own right in other parts of the world, sadly in the Caribbean dental studies are still few and far between. Nonetheless, the precedent for dental anthropological research in the Caribbean has already been set by a number of researchers such as Edwin Crespo Torres, Alfredo Coppa, Jouke Tacoma, and Jeffrey Walker, who demonstrated the value of dental anthropological studies in the region. What has been lacking is a comprehensive overview of what is known of the human dentition in the prehistoric Caribbean, and larger-scale research involving the comparison of numerous skeletal assemblages from different periods in time from throughout the region. The routine incorporation of dental analyses into osteoarchaeological endeavours – already the norm in other regions in the world – will undoubtedly benefit the discipline of osteoarchaeology in the Caribbean, and as argued above will ultimately benefit the discipline of archaeology to an equally great extent (Crespo Torres et al. 2013).

CHAPTER 3 THE PRE-COLUMBIAN CARIBBEAN: FOODWAYS, HEALTH AND DISEASE, AND CRAFTING

3.1 INTRODUCTION

The human dentitions used in this study were recovered from a range of archaeological sites in the Caribbean, distributed throughout space and time (see Chapter 5). Understanding how similarities and differences between these sites inform us on past Caribbean peoples, requires an understanding of the sociocultural setting from which they derive. In this chapter the general development of social, cultural, and biological characteristics of the pre-Columbian Caribbean is outlined. The geographical and geological setting of the region is briefly introduced in section 3.2. The sites incorporated in this study, although selected mainly on the basis of available skeletal assemblages, represent communities that witnessed and took part in some of the main cultural and social developments in the region from the Early Ceramic Age occupation of the islands to the earliest contact with Europeans, as outlined in section 3.3. In this section, I also deal with the topic of social organization in the pre-Columbian Caribbean, as this research has profoundly influenced our understanding of past subsistence practices. The latter are elaborated on in section 3.4, explaining the relation between studies of social organization and foodways in the region. This section furthermore deals with our current knowledge of food and subsistence in the different periods of occupation of the pre-Columbian Caribbean. Section 3.4 also briefly reviews current knowledge on pre-Columbian

Figure 3.1 Map of the Caribbean (Pepijn van der Linden and Hayley L. Mickleburgh).

Caribbean foods and foodways. In the remaining part of this chapter our current knowledge on pre-Columbian craft activities (3.5) and health and disease (3.6) is reviewed, and the implications hereof for this study are discussed.

3.2 Geography, Geology, and Climate

Geographically, the Caribbean archipelago, or the West Indies, is divided into four main areas: the Greater Antilles, the Lesser Antilles, the Bahamas, and the Southern Caribbean Islands (or Southern Antilles) (Figure 3.1). These groups differ in their biogeography and geology. A large part of the insular Caribbean is situated on the Caribbean tectonic plate, with the exception of the north-western part of Cuba and the Bahamas, which are situated on the North American plate, and are therefore not part of the geological Caribbean. The Caribbean plate is moving eastward, where it borders with the South American plate, which is positioned to the east and to the south of the Caribbean plate. Along the eastern boundary of the Caribbean plate, the South American plate is being subducted under it. In this subduction zone the islands of the Lesser Antilles were formed during the Eocene to Miocene. The Lesser Antilles comprise a mix of (mostly) volcanic islands and low-lying limestone islands. From Guadeloupe northward the Lesser Antillean arc splits, with volcanic islands in the inner arc and composite volcanic and limestone plateau islands in the outer arc. The inner arc and the islands south of Guadeloupe were formed when radial cracks in the subduction zone allowed the plastic interior to escape and rise to the surface. The outer arc was formed in a similar way, however here the islands were submerged and covered with limestone sediments before being lifted again by tectonic movement. Barbados formed as the result of sediments from the subducting South American plate collecting at the subduction zone and eventually being forced upward and covered in reef limestone as the amount of sediment increased (Dillon et al. 1987; Hedges 2001; Knippenberg 2006). Geographically speaking the Lesser Antilles include Trinidad and Tobago. Geologically and biogeographically these islands form a part of the South American mainland, from which they were separated relatively recently (Tobago in the Late Glacial and Trinidad in the post-Pleistocene) due to a rise in sea-level (Boomert 2009).

The Greater Antilles are geologically older than the Lesser Antilles, and consist of continental rock which formed from the Upper Jurassic onward in a complex succession of volcanism, marine sedimentation, and metamorphism (Knippenberg 2006). The Greater Antilles support a more diverse flora and fauna than the Lesser Antilles, due to their greater size and age, meaning there is a larger variety of habitats available.

The Lesser Antilles are smaller, with less habitat diversity, and have never been attached to the mainland, meaning that the range of endemic species is relatively restricted. No mammals larger than small rodents such as rice rats occurred there naturally in pre-Columbian times, although the Amerindians did introduce hutía to various islands from Hispaniola, and dogs and agoutis from the South American mainland. The islands of the Lesser Antilles vary in their ecological conditions, with islands like Dominica and Trinidad being covered with dense forest, while other islands like Antigua are more arid (Newsom and Wing 2004; Rouse 1992; Wilson 2007).

The Bahamas are located on the North American tectonic plate, and comprise the youngest geological formation of the West Indies. The Bahamas comprise a series of low limestone islands that formed during the Jurassic period due to marine sedimentation. Limestone areas of the Bahamas became exposed when the sea-level dropped in the Pleistocene (Gerrace et al. 1998).

The Southern Antilles, which include the islands of Aruba, Bonaire, Curacao, Margarita, and Los Roques, consist of limestone and volcanic rock, and formed as the result of volcanic activity and subsequent submergence, limestone sedimentation and rise, as the Caribbean plate moved eastward past the South American plate to the south (Meyer 1998; Pors and Nagelkerken 1998).

The current climate in the Caribbean is generally categorized as subtropical, even though a large part of the region lies in the tropics (i.e., south of the Tropic of Cancer). Mean sea-level biotemperature below 24 °C indicates a subtropical climate in some parts of the region. Climate, particularly precipitation, has fluctuated over time, affecting the distribution of flora and fauna across the region. The Holocene witnessed a general rise in precipitation levels between 8500–3000 B.P. Drought episodes have been recorded in more recent times, with a particularly long and severe drought documented between A.D. 800–1000 (Brenner et al. 2001; Curtis and Hodell 1993; Curtis et al. 2001; Higuera-Gundy et al. 2009; Hodell et al. 1991). Precipitation levels vary locally throughout the region, although all areas are affected by seasonal variation in precipitation. As a whole the region experiences a wet season between June and November, although the timing of the wet season may vary per island. Elevated areas, such as the mountainous parts of Jamaica, Hispaniola, and Puerto Rico, are cooler and moister, while lower areas are hotter and drier (Newsom and Wing 2004).

3.3 Caribbean prehistory

The islands in the Caribbean Sea, also referred to as the insular Caribbean, were first colonized around 6000 years ago, when people from the surrounding mainland areas of Mesoamerica and South America travelled across relatively large open waters to the islands, and subsequently spread throughout the region. The first migrants are referred to as Lithic and Archaic peoples respectively, and their socioeconomic organization is thought to have been characterized by a semi-mobile lifestyle, exploiting terrestrial and marine fauna, along with small-scale plant cultivation, and producing an array of lithic and shell tools and some simple pottery (Keegan 1994, 2006; Newsom and Wing 2004; Pagán Jiménez et al. 2005; Rodríguez Ramos et al. 2008; Wilson 2007; Chanlatte Baik 1995). Traditionally, it was thought that these peoples were non-ceramic producing hunter-gatherers who were displaced by later migrants into the islands starting around 500 B.C., with some of them marginalized and pushed into the periphery of the insular Caribbean, such as western Cuba, where they lived up to first contact with Europeans (Rouse 1964, 1986, 1992). The new migrants came from the South American mainland, from the Lower Orinoco, and brought with them a characteristic material culture, notably including highly decorative and refined ceramics (Petersen et al. 2004), referred to as the Saladoid series (Rouse 1986, 1992). This marked the start of the Early Ceramic Age in the region (400 B.C. – A.D. 600/800). The precise manner and route of the dispersion of Saladoid material culture (and by extension the associated cultural groups) is still a matter of debate. Two principal hypotheses have been supported by scholars in the region: the northward 'stepping-stone' hypothesis and the southward route hypothesis.

The first assumes that Saladoid groups originating in the Lower Orinoco entered the chain of islands from the south, and moved northward from island to island in a stepping-stone fashion, eventually reaching Puerto Rico and perhaps even the eastern Dominican Republic (Lathrap 1970; Rouse 1986, 1992). The second sees a direct long distance migration from the South American mainland to Puerto Rico, where Saladoid culture settled and developed for some time, and eventually colonized the chain of Lesser Antilles from north to south, i.e., the 'southward route hypothesis' (Callaghan 1995; Fitzpatrick 2013; Fitzpatrick et al. 2010; Keegan 1995, 2004, 2006). Recently, some researchers have posited that the appearance of Saladoid material culture and society was an insular development from Archaic populations, which later spread to the South American mainland (Fitzpatrick and Callaghan 2009). More recently, some have posited a less rigid approach to the colonization of the islands, with communities upholding long-distance ties with their homeland area for extended periods of time, and with continuous interaction and repeated migration between the two areas ('to-ing and fro-ing'). This model not only provides a more nuanced view on the social processes which underlie human migration and mobility, but it also goes some way in explaining the degree of variation in Early Ceramic Age (Saladoid) material culture which has arguably been concealed by the so-called 'Saladoid veneer' (Hofman, Boomert, Bright, Hoogland, Knippenberg, and Samson 2011; Keegan 2004). Whatever the true manner of its migration or development, most Caribbean scholars now accept that the appearance and development of Saladoid material culture and society in the Caribbean from about 500 B.C. onwards does not reflect a simple displacement of the already present Archaic population in the region. Some degree of social, cultural and biological interaction and acculturation took place between the Archaic groups and the Ceramic migrants, perhaps over a substantial period of time. However, the nature and extent of these interactions is debated. Changes in our perception of the Archaic Age populations and culture in the Caribbean are related to a number of relatively recent discoveries, such as probable Archaic Age pottery and plant cultivation (Keegan 2006; Rodríguez Ramos et al. 2008; Veloz Maggiolo et al. 1976), that have suggested that Archaic Age technology and food economy may have been very different to what we once thought. Some scholars have posited that Archaic Age groups persisted for hundreds of years in the Greater Antilles (particularly Hispaniola and Cuba) after the arrival of Saladoid groups in the Puerto Rico, and were either responsible for the later development of ceramic styles and technologies of the Ostionoid and Meillacoid (and eventually 'Taíno' societies) in the Greater Antilles (Keegan 2006), thus signalling the beginning of the Late Ceramic Age in this region (A.D. 600/800–1500), or played a significant role through multifocal development of Archaic ('pre-Arawak') peoples and interaction with Saladoid peoples (Rodríguez Ramos et al. 2008). These Ostionoid and Meillacoid material culture traditions were previously assumed to have either developed from the Saladoid over time, expanding from Puerto Rico westward and northward (Rouse 1964, 1986, 1992), or to have arrived in the islands with yet another migration from the South American mainland (Veloz Maggiolo et al. 1981). Current theories on the origins of the Meillacoid include the development through interaction between early Ostionoid immigrants and Archaic populations on Hispaniola (Jorge Ulloa Hung, personal communication), or the development through increasing marine orientation of certain Hispaniolan groups with Archaic roots and connections with the South American mainland (Sinelli and Keegan 2011). These material culture traditions are followed in some areas of the Greater Antilles by so-called Chicoid styles, which represent an increasing local diversification in material culture expressions (Siegel 2004). In the Lesser Antilles the widespread Saladoid ceramics and other material culture of the Early Ceramic Age was similarly replaced by significant diversification at local and interregional levels during the Late Ceramic Age, producing a variety of subsequent pottery styles characterized as belonging to the Suazoid, Troumassoid, or Cayoid series (Bright 2011; Hofman and Hoogland 2004; Petersen et al. 2004).

3.3.1 Social organization in the pre-Columbian Caribbean

Significant developments in social organization in the Caribbean islands are thought to mark the transitions from the Lithic/Archaic Age to the Early Ceramic Age, and subsequently to the Late Ceramic Age (Wilson 2007; Rouse 1992). The Lithic/Archaic Age is thought to have been characterized by a hunter-gatherer-forager food economy and social organization without formalized social or political roles, although it has recently been suggested that people had developed "complex social and political organization" by this time (Keegan 2010b:18). The Early Ceramic Age is believed to have brought village-based sociopolitical organization to the region, with permanent settlements, a food economy based on horticulture and hunting-fishing, and somewhat more formalized social and political roles, although leadership is thought to have been achieved rather than ascribed (Boomert 1999; Siegel 1992). There was generally little social differentiation, and sociopolitical organization did not extend beyond the village. The Late Ceramic Age is believed to have witnessed changes in social organization which in the Greater Antilles and parts of the northern Lesser Antilles included ingrained hierarchical status differentiation, institutionalized inequality (i.e., there is a non-producing elite population), and regional scale political organization in (complex) 'chiefdoms' (Curet 1992; Hoogland and Hofman 1999; Keegan 2000; Wilson 1997, 2007). In the Lesser Antilles, particularly the windward islands, Late Ceramic Age societies are currently understood to have continued in smaller scales of social organization with no evidence for institutionalized hierarchies, although considerable local and inter-regional diversity in material expressions arose, in contrast to the relative 'uniformity' of the Early Ceramic Age in this region (Bright 2011; Hofman and Hoogland 2004; Hofman et al. 2007; Hofman, Boomert, Bright, Hoogland, Knippenberg, and Samson 2011).

However, excepting (large ceremonial) ball courts documented in Puerto Rico, Hispaniola, and the Virgin Islands, the region has not produced the kind of 'clear cut' archaeological evidence for increasing social complexity over time that is seen in other parts of the Americas, such as the strong status differentiation between elite and commoners in for example burial practices or monumental architecture. The notion that somehow, somewhere during the Late Ceramic Age, prehistoric Caribbean societies in the Greater Antilles developed into (paramount) chiefdoms is largely built on descriptions in ethnohistoric sources of the first five decades or so of contact with and colonization by the Europeans (Curet 1992; De las Casas 1875, 1992; Fernández de Oviedo y Valdés 1851). These accounts do not necessarily accurately reflect social organization prior to European invasion of the area, and overreliance on these sources has been said to obscure the degree of variability in social organization over space and time in the region (Curet 2002, 2003). Currently, archaeological evidence for growing social complexity brought forward by scholars in the region consists of settlement patterning (size, distribution), increasing population density, and site hierarchies (Bright 2011; Crock 2000; Curet 1992, 2005; Keegan 2000), site structure (burial location, and presence of ceremonial architecture such as ball courts and central plaza areas) (Curet and Oliver 1998; Siegel 1992, 1996, 1999, 2010), and exchange of prestige objects (Bright 2011; Crock 2000; Hofman et al. 2008; Mol 2007, in prep.; Oliver 2009).

3.4 Food and Subsistence in the pre-Columbian Caribbean

Research on food and subsistence in the Caribbean has revealed the incredible degree of diversity, flexibility, and aptitude with which Amerindian populations used and managed their environments. Analysis of faunal and botanical remains has shown how indigenous peoples influenced their environment through their subsistence activities, for example in wood collection for fuel and construction, the clearing of vegetation in and around habitation sites, and in exploiting terrestrial and marine food resources (Carlson and Keegan 2004; Grouard 2001, 2002; Newsom and Wing 2004; Wing 2001a, 2001b; Wing and Wing 2001). These studies, while revealing a highly detailed picture of resource exploitation, including preferred species, exploitation techniques and environmental impact, have infrequently dealt with the sociality of food (Pestle 2010b). As noted by Pestle (2010b:47–51) they generally follow broad temporal and cultural categories and base interpretations of these on a relatively small number of sites per category. This has meant that based on these data changes in subsistence practices over time are principally apparent when contrasting the Archaic Age with the Ceramic Age. The latter period has been characterized as a dynamic phase in which various species were introduced into the islands, for which the precise timing is hard to define, and when intensification of food procurement activities (especially agriculture/horticulture) took place. The influences of increasing sociopolitical control toward the Late Ceramic Age are inferred, but the precise relation between the process of change in subsistence practices and social organization over time remains unclear. For instance, Newsom and Wing (2004) propose that the overexploitation of certain food resources over time, which led to changed or intensified subsistence techniques in the Late Ceramic Age, may be related to increasing social complexity. However, they indicate that climate change between A.D. 800–1000 may have equally affected food procurement (Beets 2003; Beets et al. 2006; Brenner et al. 2001; Curtis and Hodell 1993; Curtis et al. 2001; Higuera-Gundy et al. 2009; Hodell et al. 1991; Newsom and Wing 2004). Other studies have found that marine resource exploitation remained the same or similar over hundreds of years throughout the Early and Late Ceramic Ages, without leading to overexploitation of certain species (Carder and Crock 2012; Carder et al. 2007; Grouard 2001, 2002). Serrand (2007) emphasizes the fact that invertebrate marine food procurement activities diversified over time in the Lesser Antilles, and that the effects of climate change were not felt equally throughout the archipelago. She concludes that changing foodways must have therefore been related to processes of social change, rather than environmental or climatic circumstances. Petersen (1997) notes a general increase in the consumption of marine foods throughout the region in the Late Ceramic Age, which he interprets as the result of populations adapting from a food economy that mirrored the tropical forest model of the South American mainland, to the broad range of marine protein available in an island setting (see also Haviser 1991; Watters and Rouse 1989).

Outside of zoological and paleobotanical studies, our understanding of the subsistence practices in the pre-Columbian Caribbean is for an important part derived from models and understandings of social organization. Froelich G. Rainey's early research, in which he identified different cultures (and migrations) by their different food remains (the 'crab-shell dichotomy'), effectively attached different levels of social organization to the Crab and Shell 'cultures' (Rainey 1935, 1940). In later research by Rouse, subsistence practices were assumed to parallel certain forms of social organization, meaning for example that the shift from a village-based to regional polity type organization was understood to entail some form of agricultural intensification – to support larger numbers of people, a group of craft specialists, a non-producing elite, and the complex system of exchange and/

or tribute upheld by the (paramount) chief – directed by a central authority. Rouse saw evidence for this agricultural intensification and complex farming techniques, and thus for higher social complexity, in the form of prehistoric terracing in Hispaniola and Puerto Rico (Rouse 1992). Parallels to this idea can be found in the work of Latin American, in particular Cuban, Dominican, and Venezuelan, archaeologists (e.g., Guarch Delmonte 1978; Veloz Maggiolo 1984; Veloz Maggiolo et al. 1981; Vargas-Arenas 1998). Building on Marxist historical materialism their work is characterized by the concept of 'modos de vida', an approach which centralizes the strong link between subsistence practices and social organization (i.e., recolectores-cazadores, agro-alfareros). Where proponents of the modos de vida approach saw subsistence practices as the basic structuring factor in social organization, others simply assumed that certain forms of sociopolitical organization entailed certain types of subsistence practice (i.e., tribe = home gardening, chiefdom = agriculture). Support herefore was drawn from ethnohistoric accounts by De las Casas and Fernandez de Oviedo y Valdés, which describe the practice of irrigation in southern Haiti, the use of the slash and burn technique, and the construction of earthen mounds or conucos throughout Hispaniola to aid drainage for plants that prefer well drained soils (such as manioc). Similarly, the existence of clear categories of social status, such as Taíno elite and commoners (nitaínos and naborías), expressed among other things through differential foodways, provided evidence for the significance of food in social complexity (De las Casas 1992; Fernandez de Oviedo y Valdés 1851; Lovén 2010).

More recent research sought to clarify the relation between social organization and subsistence. In the Maunabo Valley in Puerto Rico, Curet (1992) found that carrying capacity had not been reached at the start of growing complexity, indicating agricultural intensification was not born out of necessity (i.e., to feed a growing population). He concludes that increasing social complexity in this part of Puerto Rico is not due to ecological factors, but rather ideological shift over time, and notes that "it is important to recognize that correlation does not necessarily imply causality" (Curet 1992:339–340). Based on research into social complexity in the northern Lesser Antilles Crock (2000) has argued that subsistence production comprised only one of many ways in which sociopolitical control could be exerted. These studies have reacted to ideas from cultural ecology, which seeks to explain the differences between and development of human societies through environmental factors (Meggers 1971; Steward and Faron 1959). This critique has shown that the ability to produce a staple food surplus (as determined by for example the fertility of the environment), does not necessarily mean that increase in social complexity and centralized control will follow (see also Heckenberger 2005). Nonetheless, these approaches continued to emphasize a clear-cut association between subsistence practices and sociopolitical organization.

The implicit notion that subsistence practices in the Caribbean defined, or were defined by, social organization is similarly apparent from the recent urges to reconsider what we know of Lithic/Archaic social organization based on new findings on subsistence and technology (Curet 2003; Pagán Jiménez et al. 2005; Pagán Jiménez and Rodríguez Ramos 2007). Other recent research has focussed on the role of particular food items as markers of social identity and status, and how this may be distinguished in the archaeological record. Curet and Pestle (2010) have recently broached the subject of elite foods, what characterizes these foods as desirable and by extension socially exclusive, and how such foods may be recognized in the archaeological record. They define a large number of characteristics by which foods suitable for elite consumption may be selected, including scarcity and abundance, labour intensity, exoticness, diversity, and 'tastiness'. Consequently, defining the evidence for these criteria in the archaeological record, and using ethnohistoric accounts, allows these researchers to distinguish elite foods at the ceremonial centre of Tibes (A.D. 700–1200), Puerto Rico. In a similar vein, Morsink (2012) identifies certain physical aspects of salt that allow this food item to accrue sociopolitical and ideological significance, playing an important role in exchange and negotiation of power relations. In contrast, Crock and Carder (2011) present evidence of social differentiation during the Late Ceramic Age on Anguilla, based on differences in quantities of marine food remains at different contemporary sites on the island and association with elite paraphernalia. While the faunal assemblages were very similar in composition, with the exception that at the site of Sandy Hill there appeared to be slightly more 'dangerous' fishes present (i.e., riskier to catch), the differences in quantities and associated material culture indicated elite control of food sources in feasting activities.

Worldwide studies into social complexity have long recognized the significant role of foodways in social change and increasing complexity (e.g., Dietler and Hayden 2001). In the Caribbean, this subject is currently particularly thought-provoking in the light of recent research. The boundaries once perceived in the occupation history of the Caribbean, such as the dichotomy between the simple, nomadic hunter-gatherer-foragers of the Lithic/Archaic period and the increasingly organized and complex horticulturalists/ agriculturalists of the Ceramic Age, are fading (Keegan 2006; Rodríguez Ramos et al. 2008) not in the least concerning subsistence practices. As we will see below in more detail, Lithic/Archaic period inhabitants of the islands engaged in (early forms of) horticulture, which alone raises questions of the true dietary and subsistence differences between the different periods of occupation and forms of social organization in the region. New studies of the role of food continue to characterize foodways by their role in social organization, e.g., as a means of social differentiation and power. This development stands to benefit from a better grip on temporal and spatial differences in the data. As we start to reconsider some of our assumptions on diet and subsistence practices in the Caribbean, we must search for new ways of examining changes over time. As described in more detail in Chapters 1 and 4, this study approaches this problem through a unique perspective, which is focussed on the evidence for foodways in individual human dentitions, and the traces of dietary change in groups spanning large periods of time.

3.4.1 Fauna

Lithic/Archaic Age

During the Lithic Age, in Cuba and parts of the Dominican Republic, the main focus of faunal food procurement was large animals such as giant sloths (now extinct), hutia, seals, manatee and sea turtles. There is some evidence for the collection of shellfish, but as yet none of fishing during this earliest period of occupation of the region (Díaz-Franco 2011; Keegan 1994; Wilson 2007). In the Archaic Age the chief focus of faunal food procurement in the Caribbean archipelago was marine resources. Throughout the region, despite the ecological differences between the Greater Antilles, the Lesser Antilles, and the Southern Antilles, human populations settled close to the shore and relied heavily on reef fishes and molluscs, which were most likely caught in traps made of plant fibres or using hook and line techniques. On some islands, birds were also an important food resource, and there are indications that rock iguanas were also exploited. As yet, there is little evidence for the exploitation of terrestrial animals in the Greater Antilles, although remains of rice rats are abundant in Archaic Age sites from the Lesser Antilles. No animals appear to have been introduced into the archipelago by humans during this period (Newsom and Wing 2004; Wing 2001b; Serrand 2007).

Ceramic Age

Evidence has been found for (extensive) overexploitation of various animal species in certain sites throughout the archipelago in both the Early and Late Ceramic Age, in the form of clearly visible changes in the composition of faunal assemblages at sites over time (Allen et al. 2009; Carlson and Keegan 2004; LeFebvre 2007; Newsom and Wing 2004; Wing 2001a, 2001b; Wing and Wing 2001). One of the most striking changes in fauna exploitation known for the region was first documented by Froelich G. Rainey (1935). Rainey noticed that the number of land crab remains at sites in Puerto Rico declined sharply at the end of what later became known as the Saladoid period. He subsequently devised a chronology distinguishing an early 'Crab culture' and a later 'Shell culture' (Rainey 1935, 1940). Later, it became apparent that the dramatic decline in land crab remains was a mostly local phenomenon, resulting from overexploitation. A steady decline in the relative abundance and size of reef fishes in the Late Ceramic Age at sites throughout the islands, similarly indicates overexploitation. The decrease in number and size of reef fishes appears to be the result of 'growth overfishing' (Murawski 2000; Newsom and Wing 2004), where certain types of fish, such as the less shy reef carnivores, are preferred, leading to depletion of the population. The fish are caught before they have time to grow, which is reflected in the decreasing sizes of these types in the faunal assemblage. In the Caribbean growth overfishing of reef fishes resulted in an increase in exploitation of offshore fish types in the Late Ceramic Age, for which watercrafts are needed (Newsom and Wing 2004).

Some small animals were intentionally introduced to the archipelago by humans in the Ceramic Age, such as the agouti, which was brought to the Lesser Antilles (particularly the windward islands), the hutía, which was introduced to Puerto Rico, and the opossum which has been found in sites in the Lesser Antilles. While these animals sometimes comprised an important part of the diet at certain sites, they were never fully domesticated (Newsom and Wing 2004). Next to these species, other animals were important contributors to the meat portion of the diet, including a variety of birds, manatee, sea turtles, and sea turtle eggs (Newsom and Wing 2004).

While some animal foods were clearly overexploited throughout the Early and Late Ceramic Age, other animals were increasingly exploited without leading to a clear decline in their abundance and size. At various sites throughout the Virgin Islands and northern Lesser Antilles garden hunting (the exploitation of small fauna such as rice rats that are attracted to agricultural/horticultural plots), specifically for rice rats, increases in Late Ceramic times, perhaps due to intensification of horticulture during this period and the resulting improvement of environmental conditions for rodents (Newsom and Wing 2004; Wing 1999, 2008). There is also evidence for the continued sustainable exploitation of marine resources at certain sites throughout the Ceramic Age, indicating that some communities did not overexploit these resources (Carder and Crock 2012; Carder et al. 2007; DeFrance et al. 1996; Grouard 2001, 2002). In the Lesser Antilles, similarities in food exploitation strategies (of invertebrate fauna) have been found in Early Ceramic Age sites, where in the Late Ceramic Age food procurement strategies diversified (Serrand 2007).

The overexploitation of land crabs and fishes and the increase in exploitation of other faunal resources in certain areas of the archipelago seem to accompany an intensification of horticulture/agriculture during the Late Ceramic Age, which is particularly visible in the Greater Antilles. For the Lesser Antilles, there is some tentative evidence for horticultural intensification in the form of a change in the fuel wood assemblages on Nevis and St. Martin in the Late Ceramic Age. The increased use of pelagic fishes and horticultural/agricultural produce appears to have been linked to human population growth and a more 'intensive occupation of the islands' (Newsom and Wing 2004; Wing 2001b; Wing and Wing 2001).

Contact period

Ethnohistoric accounts of animal food procurement in the earliest period of contact pertain mainly to Hispaniola and Cuba. Marine foods are described as a very important component in the diets of both Greater and Lesser Antillean communities. Columbus, De las Casas, and Fernandez de Oviedo y Valdés describe various fishing and collecting methods employed by the inhabitants of the Greater Antilles, including collecting molluscs and shellfish by hand, catching of sea turtles on the beach by turning them over with a stick, gathering sea turtle eggs from the beach, fish poisoning in riverine environments, shooting fish with arrows or spears or harpoons, using a line and bait, using a hook and line, with baskets or stationary fish weir, and using fish nets (De las Casas 1875, 1992; Fernandez de Oviedo y Valdés 1851; Sauer 1966). These same chroniclers describe hunting practices such as catching hutias after the burning of the agricultural fields, the capture of geese by approaching them from under water, and the gagging and tying up of iguanas (De las Casas 1875, 1992; Fernandez de Oviedo y Valdés 1851; Lovén 2010).

For the Lesser Antilles, ethnohistoric accounts of animal food procurement pertain predominantly to the 17th century, since the colonization process started later in these islands, and the Island Carib of this region resisted complete European colonization until the late 18th century. The Island Carib diet appears to have been heavily marine food oriented, with a substantial land crab component. Fishing techniques included collecting molluscs and shellfish by hand, diving for lobsters from boats, catching sea turtles with harpoons, fish poisoning in riverine environments, using a line and bait, and using a hook and line. The Island Carib are also said to have been excellent hunters with bows and arrows, which with they caught lizards and perhaps agouti (Breton 1999; Lovén 2010; Rochefort 1665; Vérin 1968).

Animal food processing techniques that have been described in the ethnohistoric sources include the cooking of a stew of vegetables, meat or fish, spices, and cassareep (a non-toxic, boiled manioc juice condiment) known as pepperpot (De las Casas 1992; Lovén 2010). Meat and fish were also dried or roasted over a fire on wooden racks, referred as boucan or barbacoa, a term that gave rise to our current use of the word barbecue (Jesse 1968; Sauer 1966; Vérin 1968).

3.4.2 Flora

The study of plant food exploitation in the prehistoric Caribbean region was for a long time convoluted by the region's (sub)tropical climate, which hampers the preservation of both macro- and microbotanical remains. Early research in the Caribbean therefore relied heavily on descriptions of plant use in ethnohistoric sources from the contact period and ethnographic accounts of subsistence practices in the South American tropical lowland (Sauer 1966). Research over the past few decades has demonstrated the successful application of palaeobotanical research in the Caribbean: a large array of macro- and microbotanical remains can be retrieved despite the Caribbean climate (Newsom 2008; Newsom and Pearsall 2003; Pagán Jiménez 2011).

Lithic/Archaic Age

The Archaic Age inhabitants of the Greater Antilles introduced a variety of wild fruit bearing trees and smaller seed bearing herbs into the archipelago. Some of the most prominently present species, such as wild avocado and yellow zapote (eggfruit), originate in areas of the mainland (Mexico and Central America), and are associated there with home garden cultivation. Various woods, notably palm wood, were also exploited during this period, for construction, fuel, and wooden tools and other objects (Davis 1988; Newsom 2008; Newsom and Pearsall 2003; Newsom and Wing 2004). Starch grains on the surface of stone grinding implements from Archaic sites in Puerto Rico, Vieques and Cuba show that maize (Zea mays), beans (Fabaceae, Phaseolus sp.), sweet potato (Ipomoea batatas), manioc (Manihot esculenta), and other (wild) tubers were systematically exploited as early as 3000 B.C., and perhaps even earlier (Pagán Jiménez 2005, 2009, 2011; Pagán Jiménez et al. 2005; Pagán Jiménez and Rodríguez Ramos 2007). In contrast to the traditional notion that horticulture was brought to the insular Caribbean by the Early Ceramic Age migration(s), it now appears that horticulture (or at least its precursors) was established very early on in the occupation history of the region. The currently available evidence points toward a semi-sedentary lifestyle and the use of home gardens and open plots for the cultivation of plants previously domesticated on the mainland and brought into the islands. Wild local plants were also exploited (Pagán Jiménez 2011).

Plant food preparation techniques certainly included stone grinding of root crops and maize, as evidenced by stone grinding tools from Archaic Age contexts with adhering starch grains, indicating that refined foods (i.e., highly processed, relatively non-abrasive foods) such as bread were consumed early in the occupation history of the region (Pagán Jiménez 2011).

During the Archaic Age in the Lesser Antilles fruit bearing trees and various seed bearing plants were exploited, alongside the use of wood – chiefly for construction and fuel. Some researchers have suggested that Archaic Age plant use in this region was largely opportunistic, lacking the early 'horticultural focus' of the Greater Antilles (Newsom and Pearsall 2003; Newsom and Wing 2004), however, recent microbotanical studies have found evidence for the exploitation of cabbage palm (Prestoea montana), maize (Zea mays), marunguey (Zamia sp.), and arrowroot (Maranta arundinacea) at the archaic settlement of Plum Piece on Saba, (Hofman et al. 2006; Nieuwenhuis 2008; Pagán Jiménez 2009, 2011; Jaime Pagán Jiménez, personal communication 2012).

Paleobotanical evidence from the Archaic Age in the Southern Antilles is generally sparse, in the sense that no edible plant macroremains have as yet been identified in either Archaic or Ceramic Age sites in the area. Well preserved carbonized wood remains have been recovered from a number of sites. The Southern Caribbean islands were most likely more densely forested during the prehistoric period, offering plenty of material for construction and fuel. Based on the types of wood that have been recovered, it seems various fruit bearing trees would have been available (Newsom and Pearsall 2003; Newsom and Wing 2004). Microbotanical investigations have offered some preliminary insights into plant use in this region. The study of starch grains found adhering to stone tools from the site of Saint John, Trinidad (5300 B.C.) have revealed that maize and some other domesticated starch crops (Jaime Pagán Jiménez, personal communication 2011) were exploited. Also, maize starch grains, showing evidence of grinding and baking, were retrieved from the dental calculus of a single individual from Canashito, Aruba. Although this individual has not yet been radiocarbon dated, a closely associated burial was dated to between cal. 350 B.C. and A.D. 150 (Mickleburgh and Pagán Jiménez 2012).

Ceramic Age

The Ceramic Age presents an altogether different picture in the Greater Antilles than the preceding Archaic Age. Palaeobotanical evidence from Ceramic Age sites in this region indicates a huge growth in both the cultivation of fruit trees and crops and the number of species being actively managed. Various fruits were exploited, prominent among which are the guava, soursop, papaya, star apple (caimito), and genip. Some of these species which became increasingly important during the Ceramic Age, were introduced into the Caribbean islands from the mainland, such as papaya and genip. The latter, for example, originates on the South American mainland. Papaya most likely came from Central America, although there are a number of varieties which are native to various regions (Newsom and Wing 2004). Originally, maize was also believed to be imported from the Central and Mesoamerican mainland into the Caribbean archipelago during the Late Ceramic Age. It was thought not to have been consumed as a staple food in the Caribbean, but rather as a ritually significant plant, or perhaps a high-status food type (Berman and Pearsall 2000, 2008; DeFrance et al. 1996; Lane et al. 2008; Newsom 2006, 2008; Newsom and Deagan 1994; Newsom and Pearsall 2003; Newsom and Wing 2004). This view is now changing. It appears people were exploiting maize far earlier than originally thought, and that the plant may have been consumed more frequently than first suggested, perhaps during communal activities such as feasts (Berman and Pearsall 2000, 2008; Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez 2005, 2009, 2011; Pagán Jiménez et al. 2005; Pagán Jiménez and Rodríguez Ramos 2007).

The Ceramic Age in the Greater Antilles is largely characterized by the great variety of plants that were cultivated in home gardens. Plant use was flexible, and differed according to the locally available resources and environment. Staple food crops mostly comprised tubers including manioc, marunguey, cocoyam, and sweet potato. Manioc consumption has traditionally been inferred in Caribbean archaeology from the presence of large numbers of griddle fragments in Ceramic Age contexts throughout the region. The griddle was assumed to have been used to grill manioc bread (Rouse 1992; Keegan 2000). However, recent research has demonstrated that griddles were used for the preparation of a variety of plant foods including tubers and even meat and fish, but not manioc (Rodríguez Suárez and Pagán Jiménez 2008).

Next to the staple food crops, hallucinogenic plants such as evening primrose and cojóban and spices such as wild pepper were in common use. Also, the range of trees used in construction and for fuel, but also for wooden tools and other objects increased greatly. Plants were also important for the manufacture of baskets and nets, which in turn allowed the capture of for example molluscs and fish (Newsom 1995; Newsom and Pearsall 2003; Newsom and Wing 2004; Ostapkowicz 1998). In the Late Ceramic Age agricultural practices in the Greater Antilles intensified, as evidenced by both palaeobotanical evidence and for example evidence for agricultural terracing in Puerto Rico (Newsom and Wing 2004; Ortiz Aguilú et al. 1991).

In the Bahamas, which remained uninhabited until the Late Ceramic Age, local vegetation (specifically wood types) was used for the manufacture of (hard)wood items, such as a small canoe recovered on Andros Island and a wooden bowl recovered from Major's Cave. The presence of basketry impressions on pottery indicates plant fibres, most likely from palm or grass leaves, were used for the manufacture of baskets and/or mats. Certain types of pottery (griddles) also indicate the use of starchy staple crops, such as manioc or marunguey. Some remains of carbonized and desiccated seeds have shown that fruit bearing trees were also exploited (Newsom and Pearsall 2003; Newsom and Wing 2004). Starch grain analysis on chert microliths has shown that by at least A.D. 800 and perhaps earlier, the inhabitants of this region used maize (Zea mays), chilli (Capsicum), and perhaps manioc (Manihot esculenta) and other tubers (Berman and Pearsall 2000, 2008).

Plant use in the Lesser Antilles during the Ceramic Age is also characterized by home gardening and the cultivation of a variety of fruits and staple crops. As in the Greater Antilles, manioc, marunguey, cocoyam, and sweet potato are thought to have comprised the main staple crops. With regard to the collection of wood for construction and fuel, the inhabitants appear to have focussed their efforts on locally available dry forest trees. Subtle changes in the constitution of the floral assemblage during the Late Ceramic Age in this area indicate increased human pressure on the local environment. There are some indirect indications that horticultural practices intensified during the Late Ceramic Age, although the evidence is far less clear than for the Greater Antilles (Newsom and Pearsall 2003; Newsom and Wing 2004). New evidence from starch grain analysis of human dental calculus from Late Ceramic Age sites in the Lesser Antilles[3] confirm the consumption of sweet potato, and show that beans and maize were also a part of the diet. No evidence for manioc consumption was found (Mickleburgh and Pagán Jiménez 2012).

Our knowledge of plant resource exploitation in the Southern Antilles is rather sparse, for both the Archaic and the Ceramic Ages. While we know from plant macroremains that fruit bearing trees were exploited, there is little other macrobotanical evidence for the Ceramic Age. Generally, it has been inferred that the Southern Antilles were particularly attractive due to their extremely rich marine resources, leading investigators to assume marine foods formed a far more important part of the diet than vegetable foods (Newsom and Pearsall 2003; Newsom and Wing 2004). Nonetheless, recent research based on starch grains recovered from dental calculus has revealed that maize and marunguey, part of the spectrum of staple plant foods elsewhere in the archipelago, were consumed at the Late Ceramic Age site of Tanki Flip (Mickleburgh and Pagán Jiménez 2012).

Plant food preparation techniques in the Ceramic Age continued to include stone grinding of root crops and maize and the production of refined foods such as bread, which would have been baked on burénes or griddles. Furthermore, the presence of stone grater flakes in numerous habitation settings indicates that stone

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[3] Anse à la Gourde (Guadeloupe), Kelbey's Ridge 2 (Saba), and Point de Caille (St. Lucia).

grater boards (with inlayed stone grater 'teeth') were used to grate and shred plant foods (e.g., Berman 1995; Righter 2002; Rostain 1995; Walker 1983). From archaeological and ethnographic contexts in the South American mainland it is known that such grater boards are generally used for the preparation of manioc and other (root) crops (Mowat 1989; Perry 2004).

Contact period

The ethnohistoric accounts of agricultural practices and cultivated plants in the earliest period of contact pertain mainly to Hispaniola and Cuba. De las Casas describes how women in Hispaniola and Cuba created small heaps or mounds of earth using wooden digging sticks, in which they planted various (root) crops. Large areas of land with such agricultural mounds, or montones, were observed by De las Casas in the Vega Real region of Hispaniola and east of the city of Santo Domingo (De las Casas 1875; Lovén 2010). Fernandez de Oviedo y Valdés similarly describes the practice of constructing montones in Hispaniola, however for wooded or mountainous areas of this island he describes a slash and burn practice, with crops being planted directly in the loosened soil (Fernandez de Oviedo y Valdés 1851). For the Lesser Antilles, ethnohistoric accounts of crop cultivation pertain predominantly to the 17th century. The Island Carib also used montones, in which they planted a range of root crops, particularly manioc (Breton 1999; Lovén 2010; Rochefort 1665).

Important (staple) crops mentioned in the sources are manioc (Benzoni 1857; De las Casas 1992; Fernandez de Oviedo y Valdés 1851; Rochefort 1665), sweet potato (Benzoni 1857; Fernandez de Oviedo y Valdés 1851), arrowroot and/or leren (Fernandez de Oviedo y Valdés 1851; De las Casas 1992), maize (Benzoni 1857; Fernandez de Oviedo y Valdés 1851), and beans (Breton 1999; De las Casas 1875; Fernandez de Oviedo y Valdés 1851). Root crops, particularly manioc, were used to bake a type of dry and hard bread, which was grilled on a ceramic griddle. This bread usually formed the staple of the diet and was consumed together with pepperpot, a dish of various stewed vegetables, meat or fish, spices (particularly pepper), and cassareep (a non-toxic, boiled manioc juice condiment) (De las Casas 1992; Lovén 2010).

Next to (staple) crops, the sources mention a number of fruits which were exploited by early contact period Amerindians. Some belonged to wild trees, while others were kept in and around the settlement or house gardens. Fruits mentioned prominently in the sources are pineapple, guava, papaya and star apple (caimito) (De las Casas 1992; Fernandez de Oviedo y Valdés 1851).

The ethnohistoric sources also suggest that social differentiation may have been expressed through foodways. De las Casas mentions differentiation in food consumption between common people and caciques (chiefs). More refined manioc cakes, so-called xauxau, which were reserved for consumption by the cacique, contained more finely ground manioc and were whiter due to their higher starch content (De las Casas 1992; Fernandez de Oviedo y Valdés 1851). Interestingly, the distinction between elite and common food made here does not involve restricted access to a particular plant or animal food, but rather to a certain food preparation technique. De las Casas further mentions having seen caciques eating from the same dishes as common people, apparently indicating that caciques also ate 'regular' foods, and that status differentiation did not necessarily affect the communal use of utensils (De las Casas 1992; Lovén 2010).

3.5 Health and Disease in the pre-Columbian Caribbean

The bulk of the information that can be acquired on health and disease in the past is derived from skeletal material or documentary evidence. When written sources are lacking, human skeletal material may be used to, for example, study the effects of specific social and cultural developments, such as the introduction of agriculture. However, the study of past (trends in) health using human skeletal remains is subject to fundamental disadvantages. The foremost among these is the fact that most diseases do not affect the skeletal system (or at least leave visible traces on it). Nonetheless, palaeopathological work has for decades produced coherent interpretations of patterns of ancient health, and particularly in the case of large scale social and cultural processes has proven to be highly valuable.

With regards to the Caribbean, research into ancient health has generally been sparse and has rarely focussed on disease patterns for (larger parts of) the region. Most palaeopathological research that has been done, has focussed on skeletal assemblages from individual sites. Extrapolating these data to the entire region is problematic, due to the small number of individual skeletons which must be taken to represent large time frames and broad units of sociopolitical organization. Furthermore, there is a clear disparity in numbers of skeletons representing the different regions and occupation phases in the Caribbean islands. The numbers of human remains recovered from the Lesser Antilles are small when compared to the large numbers excavated in the Greater Antilles. Archaic (and even Early Ceramic Age) skeletal material is similarly very scarce. Nevertheless, some general trends can be observed in the light of the palaeopathological research that has been done in this region to date. Certain infectious diseases, most notably treponemal disease or yaws, are known from throughout the area, although in many cases the diagnosis is tentative. The distribution of known cases of treponemal disease across the islands appears to show a concentration of cases in the Greater Antilles in the Late Ceramic Age, however as yet this seems most likely to be the result of the smaller numbers of skeletal remains that are available for study in the Lesser and Southern Antilles (Schats 2010, 2011). Treponemal disease has been reported in various pre-Columbian Caribbean skeletal collections, including Anse à la Gourde (Guadeloupe) (Weston 2011b), Atajadizo, La Cucama, and Narrangjo Arriba (the Dominican Republic) (Luna-Calderon 1993; Rothschild et al. 2000), Bull Savannah (Jamaica) (Santos et al. 2013), Cueva Calero (Cuba) (Vento and Gonzalez 1996), Lavoutte (St. Lucia) (Weston 2011a), Paso del Indio (Puerto Rico)

(Crespo Torres 2005b, 2008, 2009), and Tutu (St. Thomas) (Sandford et al. 2002; Sandford et al. 2005). At the latter site the mean number of lesions per individual increased from the Early to the Late Ceramic Age (Sandford et al. 2002; Sandford et al. 2005). However, this does not necessarily mean people were more severely affected by the disease in the later phase of occupation at the site, as longer survival throughout the course of development of the disease may indicate the population had developed increased resistance to the disease over time. Skeletal remains from numerous sites in the Dominican Republic dating to the Late Ceramic Age show evidence of treponemal disease, while the remains from two Archaic sites studied show no trace of treponematosis, perhaps indicating the disease did not arise until the (Late) Ceramic Age (Rothschild et al. 2000).

Numerous cases of tuberculosis have been identified in skeletons from Eleuthera Island in the Bahamas, although some of these cases may in actual fact be treponemal disease, as the cause of the skeletal lesions proved difficult to interpret. Due to the proximity of the Bahamas to Florida and North America, it has been suggested that the tuberculosis observed in skeletal material there may have derived from this region, where a form of endemic tuberculosis is known to have been present during pre-Columbian times (Drew 2009). Other cases of tuberculosis have been mentioned for the site of Cueva Maria Sosa, in the Dominican Republic (Luna Calderón 1982).

Evidence of so-called deficiency diseases in the form of for example dental hypoplasia and cribra orbitalia has been found throughout the Caribbean region (Luna Calderón 1977; Coppa et al. 1995; Crespo Torres 2010), although Drew (2009) suggests that Early Ceramic Age groups and groups occupying the smaller islands were affected more frequently than Late Ceramic Age groups living on the larger islands. Evidence from the Puerto Rican site of Paso del Indio points to a link between the greater agricultural focus (intensification) of the Late Ceramic Age due to increasing social complexity and growing physical stress as indicated by dental hypoplasia, cribra orbitalia, porotic hyperostosis and osteomyelitis (Crespo Torres 2008). By contrast evidence from pre-Ceramic and Ceramic Age assemblages from the Dominican Republic has shown that, based on a decrease in frequencies of enamel hypoplasia, life conditions improved over time. Nutrition deficiencies reflected in the presence of enamel hypoplasia at these sites was found to likely be related to weaning stress (Coppa et al. 1995). Luna Calderón (1982) links the presence of Harris lines, numerous enthesopathies, and the extremely small stature in skeletons from the Archaic Cueva Maria Sosa site to the harsh local environment, presumable occupation stress and the lack of adequate foods. Evidence for occupational stress is found among most skeletal assemblages from the region, indicating that certain hard physical labour activities were habitually engaged in, resulting in stress markers on the bones where muscles and ligaments were attached (Drew 2009; Hofman et al. 2012; Weston 2010, 2011a, 2011b, 2012, in prep.).

Although it is not strictly speaking a form of pathology, evidence of trauma has also been found throughout the region, although the small number of individuals involved and the types of trauma documented point to accidental trauma or interpersonal violence as opposed to larger scale warfare (Budinoff 1991; Crespo Torres 2008, 2010; Hofman and Hoogland 2011; Luna Calderón 1976; Schaffer et al. 2012; Weston 2010, 2011a, 2011b, 2012; Weston and Schats 2010).

Finally, the most ubiquitous pathology found throughout the pre-Columbian Caribbean is dental pathology in its various forms. This is rather unsurprising as dental pathology is the most frequently documented type of pathology found in human skeletal remains worldwide (Waldron 2009). Extreme dental wear and caries are the most commonly occurring cases of dental pathology observed in Caribbean skeletal assemblages, followed by ante mortem tooth loss and periodontal disease (Coppa et al. 2012; Crespo Torres 2008; García-Godoy 1980; Hofman et al. 2012; Luna Calderón 1980; Mickleburgh 2007, 2011, 2012; Morbán Laucer et al. 1977). Changes in dental pathology over time, as observed in dental material included in this study, are discussed in the following chapters.

Although there is relatively little evidence to go on for the moment, it seems there are some trends for changes in health and disease patterns in the Caribbean over time. Differences have been noted between the pre-Ceramic Age and the Ceramic Age, and between the Early Ceramic Age and the Late Ceramic Age. From what we currently know, environmental, biological, and nutritional circumstances were affecting population health over time. Some of the evidence is contradictory, for example whether skeletal evidence for disease was greater in the Early or Late Ceramic Age, however these results may reflect local variation and local environmental conditions. Furthermore, the paucity of Archaic Age skeletal remains means that this period in the history of the Caribbean is sorely underrepresented with regard to skeletal pathology. It is clear that a comprehensive and comparative study is needed to elucidate whether apparent contradictions in the data represent local differentiation, or result from the small sample sizes used to represent large populations over extended periods of time.

3.6 Craft Activities in the pre-Columbian Caribbean

Early theoretical approaches to socioeconomic development, such as V. Gordon Childe's theory of the origins and development of civilization, paid special attention to craft production, particularly craft specialization, as a key aspect in the sociopolitical development of state societies and resultant status differentiations. While more recent research has shifted its focus toward the social and cultural identity of artisans and the meanings attached to the goods they produced, studies into craft production have largely been characterized by a clearly social evolutionary perspective (Patterson 2005). This viewpoint works from the premise that craft specialist activities are linked to – or made possible by – the production of agricultural surpluses (and therefore also to the technological advances which made these possible), and as a consequence inherently assumes that craft specialists did not engage in food production (Stein 1996). Concomitantly, a great deal of attention has been given to the relation between craft specialization and the emergence or maintenance of a powerful elite class, who effectively controlled craft production in order to validate and support their political power. Such research has focussed heavily on craft production of such items as personal ornamentation and exotic exchange goods, as these would have been actively sought after and adopted by elites as a highly visible emblem of their power and authority (Peregrine 1991).

The main aim of much research into craft production in archaeology has been to elucidate the organizational structure of the production process; with the power relations between the various actors in the production sequence, and the role of craft products in the sociopolitical arena frequently taking precedence over material and functional aspects of the product, and social role and identity of the producer (except regarding status). This significance attributed to the organization of craft production is also reflected in more recent work in this field, such as Cathy Lynne Costin's (1991) influential model which categorizes the organization of production. She distinguishes four parameters: context, concentration, constitution, and intensity.[4] Using these parameters, Costin distinguishes eight types of craft specialization which differ in the social, political, economic and environmental circumstances that gave rise to them, in an attempt to shed light on the social role of the artisan in the organization of production (Costin 1991; Costin and Hagstrum 1995).

As we will see further on in this work, almost all sites under study here include individuals, who based on their dental wear (i.e., dental evidence for the use of the teeth as tools), could arguably have been craft specialists in the sense that they provided a service for which a large degree of knowledge, training and expertise was needed; but there is no evidence to suggest that their social identity fits that of a craft specialist as set out in the social evolutionary perspective (Patterson 2005). Uniquely, this study's dataset presents a situation in which the craft product is unknown (or cannot be precisely determined), but the craftsman or woman is known. This requires a completely different approach to craft production and producers: one that is not focussed on the role of the producer in the greater picture of social organization, but on the producer's identity as an individual crafts(wo)man.

Very little is known about the circumstances under which craft specialists worked in the pre-Columbian Caribbean. For the early contact period – and thus, it has been argued, for the latest phase of the Late Ceramic Age – we know that regional leaders, or caciques, controlled the circulation of certain religious paraphernalia: for example, Peter Martyr D'Anghera (1912: decade I, book V) describes how the

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[4] Context in this sense refers to the difference between attached and independent specialization; in other words whether the craftsmen produce goods which serve to reinforce political and social power of an elite class, or whether they produce utilitarian goods which circulate outside of the realm of political control. Concentration refers specifically to the spatial distribution of craftsmen, i.e., dispersed throughout the community versus clustered together in one location. Constitution describes the nature of the production unit, such as the group size and social relations between individuals in the group. Intensity refers to the amount of time craftsmen spend on their craft activities, as these are not necessarily full-time jobs (Costin 1991).

cacica Anacaona held a house full of wooden 'idols', including duhos and bowls made of a black wood, thought to be ebony (see also Ostapkowicz 1998; Sauer 1966). Implicitly, it is assumed that the production of such items also lay under chiefly or elite control. Some archaeological evidence has been found, which may serve to endorse this notion. Berman and Hutcheson (2000) have for example suggested that basketry may have functioned as trade, tribute, or gift exchange items expressing shamanic authority and power relations in Lucayan-Taíno society in the Bahamas. Based on impressions in pottery, they found evidence for complex designs and inter-site variation in technology and style of weaving patterns. Similar research on basketry impressed pottery from Antigua and Montserrat, mostly dating to the Early Ceramic Age, has indicated that the technology and weaving patterns used may be an expression of ethnicity (Petersen et al. 1999). The manufacture of shell beads at the Late Ceramic Age site of Governor's Beach on Grand Turk was interpreted by Carlson (1995) as a specialized craft activity, with part-time Taíno specialists of high social ranking producing highly uniform shell beads (Carlson 1995; Littman and Keegan 1993). Stone bead manufacturing sites specializing in the production of certain types of beads have been identified at the Early Ceramic Age sites of Trants on Montserrat and Pearls on Grenada, presumably indicating some form of central organization of craft production in this earlier period too (Cody 1991; Watters and Scaglion 1994). However, aside from this, the current evidence does not justify working explicitly from the assumption that craft activities were controlled by a politically elite class, especially in the earlier period. It is not discounted here that crafts(wo)men may have achieved a higher status through crafting and the associated ritual knowledge (Spielman 2002); such non-formalized social differentiation may be present in all forms of social organization. Still, the data used in this study do not allow for such an approach. It is not intended here to explore the intricacies of the organization of production and hierarchical control. The objective of investigating craft activities in this research is not centred on attempting to expound whether individuals could be considered 'specialists', in the sense that their contribution to the economy was strictly non-food related, and regulated by a central authority. Nor will I attempt to define whether production was performed on a full-time or part-time basis. Whether production was attached or independent is equally outside of the scope of this research. The aim here will be simply to investigate which individuals in the dataset show signs of craft production, and what materials they were most likely fabricating. The age, biological sex, dating, mortuary practices, and any other information, including for example pathology, provide an informed picture of the identity of crafts(wo)men.

Chapter 4 Approach and Methods

4.1 Approach

As outlined in Chapter 1, the approach used in this research is multi-disciplinary, in which multiple lines of evidence from different research disciplines are combined in order to answer the research questions. The reason for this approach is threefold. Firstly, as explained in Chapter 1, I am of the opinion that the closer integration of dental anthropological research in archaeology, and vice versa, is of importance to both disciplines. By closer integration, I mean that dental anthropologists (and osteologists in general) must cultivate a thorough understanding of the social and cultural context of the materials they study, or in other words analyze the material as if they were an archaeologist. Only when one understands the archaeological context of the materials, can sensible interpretations be made. Secondly, when dealing with broad research topics such as diet and subsistence practices, human health and disease, and craft activities no single source of evidence can be exhaustive, and using multiple lines of evidence enriches interpretations of the data. This is not to say, as is too often assumed, that a multi-disciplinary approach is by definition somehow better than a mono-disciplinary approach. But specifically in the Caribbean where little previous dental anthropological work has been done, comparison of results with results from other lines of investigation and the results of research from other regions is incredibly fruitful. Thirdly, as explained in Chapter 1, with regards to diet and subsistence practices, dental (macro)wear and pathology are highly appropriate for researching broad trends and/or changes over time. Very subtle differences between groups are detected only when samples sizes are large, which facilitates certain statistical analyses. In this case, other lines of evidence may provide contextual information to interpret subtle variations within the dataset. An example here is ethnographic information, which may provide examples of labour divisions or dietary differences between males and females that could lead to very slight differences in wear and pathology between the sexes. Another example is evidence from modern dentistry on dental erosion, which may provide the basis for an alternative interpretation of LSAMAT. The disciplines incorporated in this multi-disciplinary approach are dental anthropology, archaeology, osteology, ethnography, and ethnohistory; although to define them as separate entities in itself defies the holistic sentiment of multi-disciplinarity. The dataset is composed of dental anthropological and osteological quantifiable measurements (i.e., dental wear patterns, dental pathology, age, and sex) and structured according to the norms for these disciplines, but with the individual person as primary unit of analysis. Both archaeological (i.e., site, region, period, etc.) and osteological (i.e., sex, age, etc.) data form the basis for comparison of subsets within the main dataset; i.e., different sites from different periods are compared to each other, as are males and females within and between these sites. More importantly, archaeology provides appropriate research questions, by defining the cultural and geographical area of interest, and by defining fields of inquiry (for example craft activities) to which the study can contribute. Dentistry provides examples of clinical studies in living populations, meaning the precise aetiology of patterns of wear and pathology can be explored. Ethnography likewise offers the opportunity to observe living populations in similar sociocultural settings. Ethnohistory allows for insights into Caribbean Amerindian communities before their almost complete demise, albeit at a tumultuous period in their history.

4.2 Methods of Classifying

4.2.1 Age-at-death and biological sex estimation

Skeletal age-at-death and biological sex estimation of the individuals from the majority of the larger assemblages included in this study are based on analyses by physical anthropologist Dr. Darlene Weston. These sites are Anse à la Gourde, Chorro de Maíta, Kelbey's Ridge, Lavoutte, Maisabel, and Manzanilla (Valcárcel Rojas et al. 2011; Weston 2010, 2011a. 2011b, 2012; Weston and Schats 2010; Darlene Weston, personal communication 2010, 2011).

	Weston	**Crespo Torres**	**Tacoma**
Juvenile	<0	0–4	
	<1	5–9	
	1–4	10–14	
	5–9		
	10–14		
	15–17		
Adult	18+ (adult)	15–19	17–25
	18–25 (young)	20–24	25–35
	26–35 (young middle)	25–29	33–45
	36–45 (old middle)	30–34	45+
	46+ (mature)	35–39	
		40–44	
		45–49	
		50–54	
		55–59	
		60+	

Table 4.1 Age-at-death groups assigned by Weston, Crespo Torres, and Tacoma.

Weston based age-at-death estimation on anthroposcopic changes in the pubic symphyses (Katz and Suchey 1986; Todd 1921a, 1921b), the auricular surfaces of the os coxae (Lovejoy et al. 1985), and the sternal ends of the ribs (Işcan and Loth 1986a, 1986b). Other methods used include the degree of cranial suture closure (Meindl and Lovejoy 1985) and dental attrition (Brothwell 1981). Juvenile age estimations are based predominantly on the eruption sequence of the dentition

(Smith 1991), the lengths of the long bones (Sundick 1978; Ubelaker 1989), and the degree of epiphyseal fusion (Scheuer and Black 2000). Weston assigned both adult and juvenile skeletons to standard age groups. These age groups can be found in Table 4.1.

Weston's determination of biological sex of adult individuals was based on numerous anthroposcopic and metric methods; anthroposcopic features of the skull (Ascádi and Nemeskéri 1970; Buikstra and Ubelaker 1994) and pelvis (Buikstra and Ubelaker 1994; Phenice 1969), the measurements of numerous bones, including the clavicle (Jit and Singh 1966), femur (Pearson and Bell 1917/1919; Stewart 1979), humerus (Stewart 1979), and scapula (Iordanidis 1961).

Age and sex estimations of individuals from the remaining assemblages used in this study are based on previous published and unpublished physical anthropological studies.

For the site of Punta Macao, the results of an unpublished study by Tavarez María (2004) were consulted. Tavarez María based adult age-at-death estimations on the degree of cranial suture closure, epiphyseal fusion in the long bones, and degree of dental wear (Bass 1995). She did not assign standard age groups. Juvenile age estimations were based on mean diaphyseal length (Johnston 1962). Biological sex estimation in adults was based on anthroposcopic features of the skull and pelvis, general skeletal robustness and traces of muscle attachments and measurements of the femoral heads (Bass 1995).

For the sites of Esperanza, Hacienda Grande, La Mina, Punta Candalero, and Santa Elena (Toa Baja 2), a series of published and unpublished results from analyses by Edwin Crespo Torres were consulted (Crespo Torres 1991, 2000; Edwin Crespo Torres, personal communication 2011). Crespo Torres based determinations of adult skeletal age on dental wear, epiphyseal fusion of the long bones, and cranial suture closure (Meindl and Lovejoy 1985), and the auricular surfaces of the os coxae (Bedford et al. 1993; Lovejoy et al. 1985; Lovejoy et al. 1997). Crespo Torres assigned both adult and juvenile skeletons to standard age groups, using 5 year intervals (Table 4.1). Estimations of biological sex were based on methods outlined by Ubelaker (1989).

Age and sex estimations for the small number of individuals from Point de Caille are taken from the results of physical anthropological observations in Fabrizii-Reuer and Reuer (2005) Age-at-death was determined using methods outlined in Nemeskéri et al. (1960) and Ubelaker (1978). Estimation of adult biological sex followed Ubelaker (1978).

For Tutu results of osteological assessments by Sandford et al. (2002) were used. Sandford et al. based adult age estimations on anthroposcopic changes in the pubic symphyses (Brooks and Suchey 1990) and the auricular surfaces of the os coxae (Lovejoy et al. 1985). Cranial suture closure (Meindl and Lovejoy 1985) was used in only a small number of cases, as many of the crania were damaged during construction works at the site prior to excavation (Sandford et al. 2002). Standard age categories were not used, although most adults were placed in 10 year age ranges.

Age estimation in juveniles and sub-adults was based on the dental eruption sequence, following Bass (1987) and Ubelaker (1989), and the degree of epiphyseal fusion (Webb and Suchey 1985; Krogman and Işcan 1986; Ubelaker 1989).

Estimations of biological sex were based on anthroposcopic features of the skull and pelvis outlined in numerous studies (Bass 1987; Buikstra and Ubelaker 1994; Krogman and Işcan 1986; Phenice 1969; Ubelaker 1989; White 1991). Other morphometric indicators used by Sandford et al. (2002) for determination of biological sex include the diameter of the femur head, femoral shaft circumference, diameter of the humerus head, and height of the glenoid fossa.

For the sites of Canashito and Malmok the results of a study by physical anthropologist Jouke Tacoma were used (Versteeg et al. 1990). Tacoma based determinations of biological sex in adults on the guidelines set out by the Workshop of European anthropologists in (1980), with some adaptations regarding the hierarchical sequence of importance given to the individual characteristics used in sex determination (Versteeg et al. 1990:53–54). Determination of age-at-death in adults was based on the degree of dental wear (Brothwell 1981), as poor preservation of the material meant that anthroposcopic changes in the pubic symphyses and degree of cranial suture closure could not be used. Determination of age-at-death in children was based on the sequence of dental eruption. Tacoma assigned adult skeletons to standard age groups (Table 4.1).

For the most of the skeletal material housed at the Yale Peabody Museum, New Haven, Connecticut (including Camaguey, Cañas, Clarence town cave, Collores, Diale 1, Gordon Hill caves, Imperial lighthouse caves, Managas Saladero, María de la Cruz, Monserrate, Santa Elena [Toa Baja 2], Santa Isabel [Cayito], Yauco 1, and Wemyss Bight cave) age and sex estimations were derived from analyses done by Rose Drew (2009). Drew used White (2000) and Bass (1995) for assessment of age-at-death and biological sex, along with Buikstra and Ubelaker (1994). Age-at-death was determined according to the degree and completeness of long bone epiphyseal fusion, degree of cranial suture closure, presence and severity of age-related pathology including osteoarthritis, and dental wear.

For the other Aruban sites of Ceru Noka, Savaneta, Santa Cruz, and Tanki Flip, basic age and sex estimations were done by the author. Biological sex estimation was done following guidelines set out by Buikstra and Ubelaker (1994). Age-at-death was estimated using the degree of molar wear sequence set out by Brothwell (1981).

Similarly, for the sites of Argyle 2, Bellavista, Buccament West, Cacoq 2, La Caleta, Caliey, Dario Yune, Escape, Heywoods, Higuey (unknown site), Indian Creek, Juan Dolio, Manigat cave, St. Croix (unknown site), and St. Kitts (unknown site) biological sex and age-at-death estimation was performed by the author (Brothwell 1981; Buikstra and Ubelaker 1994). In the case of Heywoods, an extensive report of osteological analysis exists (Drewett 2000), however the material at the author's disposal could not be reliably linked to these data.

Table 4.2 gives a brief overview of sources used for age-at-death and biological sex estimations in this study.

4.2.2 Dental wear

Dental wear is the wearing away and loss of the occlusal (and interproximal) surfaces of the tooth crowns. Dental wear is a normal process in mammals, which results from a combination of factors and affects individuals progressively throughout their lifetime. Dental wear in humans can be caused by alimentary or non-alimentary actions. Alimentary wear is caused by the abrasive properties of the food and inclusions in food, such as sand and grit, or small stone particles from grinding implements (Hinton 1981; Molnar 1972; Smith 1984). Non-alimentary wear can be caused by using the teeth as tools, bruxism (habitually grinding or clenching the teeth together), or by wearing oral ornamentation such as labrets (Alt and Pichler 1998; Santoni et al. 2006; Torres-Rouff 2003). Once dental tissues are lost due to wear, they are not replaced or repaired. As such, the observed degree and pattern of dental wear at any stage in an individual's life is the result of all wear on the teeth since their eruption and functional occlusion, and wear on the teeth may become erased by later wear.

In dental anthropology, which deals with all aspects of primate, fossil hominid, and modern human teeth, dental wear is categorized according to the agent causing the wear. Attrition is the result of tooth-on-tooth contact, which causes wear facets at the points where teeth come into contact. Abrasion is caused by contact with foreign materials, such as food, abrasives in food, and non-food objects put in the mouth.

Erosion is the chemical dissolution of the enamel, dentine, and cementum by acids in the mouth. In clinical dentistry, distinguishing between the different factors causing dental wear is sometimes necessary for therapeutic reasons. In archaeological material, however, this is generally not possible (Alt and Pichler 1998; Bell et al. 1998; Hillson 1996; Kaidonis 2008).

Dental wear in hominins is known to be strongly related to age: the older an individual becomes, the greater the amount of wear that will have accumulated on the teeth (Brothwell 1963; Hillson 1996; Miles 1963). For this reason the degree of wear on the dentition (particularly the molars) is commonly used in age estimation. However, the rate of dental wear in any human individual is also strongly related to the physical properties of the food (i.e., tough, unrefined, fibrous, versus soft, sticky, refined), contaminants in the food (i.e., sand, grit, stone particles), and food preparation techniques (i.e., grinding, baking, boiling) (Cucina and Tiesler 2003; Eshed et al. 2006; Jurmain 1990; Kaifu 1999; Larsen 1997; Macchiarelli 1989; Molleson and Jones 1991; Molnar 1972; Powell 1985; Rose and Ungar 1998; Sealy and van der Merwe 1988; Smith 1972, 1984; Walker and Erlandson 1986). As such, young individuals in a given population may exhibit extreme dental wear, or alternatively older individuals may exhibit very slight dental wear. Any comparison of the effects of food consistency and/or food preparation techniques on dental wear between populations must therefore take the relation between age-at-death and

Site	Sources	Methods
Anse à la Gourde Chorro de Maíta Kelbey's Ridge Lavoutte Maisabel Manzanilla	Valcárcel Rojas et al. 2011 Weston 2010, 2011a. 2011b Weston and Schats 2010 Weston pers. comm. 2010, 2011	Ascádi and Nemeskéri 1970; Brothwell 1981; Buikstra and Ubelaker 1994; Iordanidis 1961; Işcan and Loth 1986a, 1986b; Jit and Singh 1966; Katz and Suchey 1986; Lovejoy et al. 1985; Meindl and Lovejoy 1985; Pearson and Bell 1917/1919; Phenice 1969; Scheuer and Black 2000; Smith 1991; Stewart 1979; Sundick 1978; Todd 1921a, 1921b; Ubelaker 1989
Punta Macao	Tavarez María 2004	Bass 1995; Johnston 1962
Esperanza Hacienda Grande La Mina Punta Candalero Toa Baja 2	Crespo Torres 1991, 2000 Crespo Torres pers. comm. 2011	Bedford et al. 1993; Lovejoy et al. 1985; Lovejoy et al. 1997; Meindl and Lovejoy 1985; Ubelaker 1989
Point de Caille	Fabrizii-Reuer and Reuer 2005	Nemeskéri et al. 1960; Ubelaker 1978
Tutu	Sandford et al. 2002	Bass 1987; Brooks and Suchey 1990; Buikstra and Ubelaker 1994; Krogman and Işcan 1986; Lovejoy et al. 1985; Meindl and Lovejoy 1985; Phenice 1969; Ubelaker 1989; Webb and Suchey 1985; White 1991
Canashito Malmok	Versteeg et al. 1990	Brothwell 1981; Workshop of European anthropologists in (1980)
Camaguey Cañas Clarence town cave Collores Diale 1 Gordon Hill caves Imperial lighthouse caves Managas Saladero María de la Cruz Monserrate Santa Isabel Toa Baja Yauco 1 Wemyss Bight cave	Drew 2009	Bass (1995); Buikstra and Ubelaker (1994); White (2000)

Site	Sources	Methods
Argyle 2 Bellavista Buccament West Cacoq 2 La Caleta Caliey Ceru Noka Dario Yune Escape Heywoods Higuey Indian Creek Juan Dolio Manigat cave Savaneta Santa Cruz St. Croix St. Kitts Tanki Flip	Assessment by Mickleburgh	Buikstra and Ubelaker 1994; Brothwell 1981

Table 4.2 Sources and methods used for age-at-death and biological sex estimations.

degree of wear on the dentition into account (Chattah and Smith 2006; Hillson 2001; Scott 1979a, 1979b; Smith 1972; Watson et al. 2011). Differences in group age profiles are a significantly complicating factor, as well as the fact that absolute age-at-death (i.e., the precise age in years at which an individual died) is rarely known for archaeological specimens. Generally, estimations of age-at-death in adult skeletons are made based on a number of changes in the skeleton, such as on anthroposcopic changes in the pubic symphyses (Katz and Suchey 1986; Todd 1921a, 1921b), the auricular surfaces of the os coxae (Lovejoy et al. 1985), and the sternal ends of the ribs (Işcan and Loth 1986a, 1986b). Other methods used include the degree of cranial suture closure (Meindl and Lovejoy 1985) and degree of dental wear (Brothwell 1981). Estimation of age based on degree of dental wear is based on the assumption that rates of wear are constant throughout life, and generally the same within populations living in the same environment and with the same or similar foodways. Estimated ages are presented as a range (i.e., 18–25 years, 26–35 years, etc.), which means that the individuals in a certain age category may represent any combination of absolute ages within that category, and as such the use of such age estimation ranges can potentially bias comparisons between groups quite significantly. Therefore, comparisons of the rate of dental wear between individuals and groups must be based on factors that can be assessed independently of such estimated ranges of age-at-death, and independently of group age profiles (which may differ significantly). Similarly, the condition of preservation and completeness of the skeletal assemblage greatly affects intergroup comparisons of rate of wear, particularly in cases where the condition of the material is too poor to estimate age-at-death or where the dentitions are incomplete; often the case in archaeological assemblages (Hillson 2001, 2008b; Smith 1972)

To avoid age-at-death as a factor, it is possible to use intra-individual rates of wear, as opposed to group averages of degrees of wear (Smith 1972). In wear gradient analysis, the rate of wear is measured as the gradient between the degree of wear of the adjacent permanent molars within individuals: M1, M2, and M3. This is possible due to the fact that the eruption sequence is generally the same in all humans (Hillson 1996). The molars erupt at certain intervals in all humans – although the third molars show a greater variation in eruption age – which means that the difference between adjacent molars reflects the amount of wear accumulated in those 6 years (Hillson 1996; Smith 1972). Based on the assumption that the rate of wear remains constant during life, this difference will remain present regardless of age. The use of wear gradients based on differences of wear between adjacent molars represents an age independent method of comparing wear rates between individuals and groups (Benfer and Edwards 1991; Bernal et al. 2007; Chattah and Smith 2006; Scott 1979a; Scott and Turner 1988; Smith 1972; Watson et al. 2011). Since the method is age independent, differences are assumed to result from other factors which influence the rate of wear, such as food consistency, food preparation techniques, and (unintended) inclusions such as grit and sand.

Scoring dental wear

Various dental wear scoring techniques have been designed and used in the past. Research by Murphy (1959a, 1959b) on the pattern of dentine exposure in human dental wear led to an array of studies of the process of dental wear in humans and its variation across populations (e.g., Brothwell 1963; Miles 1963; Molnar 1971; Scott 1979a, 1979b; Smith 1984). A number of methods for scoring dental wear in past human populations were developed as a result. The most commonly used of these methods in archaeology today are Brothwell's (1981), Scott's (1979b), and Smith's (1984) (Hillson 1996).

Brothwell's (1981) scoring method was originally devised for early medieval British material, but has been widely used throughout the world (Hillson 1996). The method, which was devised as a simple and rapid aging technique, distinguishes four stages of molar wear that are each assigned an age category (17–25, 25–35, 35–45, and about 45). Differences between the age categories are based on the amount of dentine exposure, and variations are given for the pattern of molar dentine exposure in each group (Brothwell 1981).

Scott's (1979b) method involves the use of a quadrant system which visually divides the occlusal molar surfaces into four sections. Each quadrant is given a score based on the amount of enamel present in the quadrant, on a scale from 1–10. The sum of the scores for the four quadrants represents the score for the entire tooth, which ranges from 4–40. Scott uses the amount of enamel present in his quadrants, as opposed to the amount of exposed dentine (which is used in most other ordinal scoring methods), since he argues that the presence of enamel best reflects the “functional life of the tooth” (Scott 1979a:213). An advantage of Scott’s method is the fact that it distinguishes four different categories of wear without dentine exposure. Methods that are based on the pattern of dentine exposure tend to assign only one or two classes to wear without exposed dentine patches (e.g., Molnar 1971; Smith 1984), meaning that subtle differences in the earliest stages of wear are partially obscured. Scott’s method also allows for comparison of degree of wear between the different quadrants, for example in obliquely worn teeth (see also Watson 2008; Watson et al. 2011).

Smith’s (1984) method represents one of the most frequently used dental wear scoring methods in investigations of archaeological material. Smith adapted the method from that the eight score method developed by Murphy (1959a, 1959b). Murphy’s system was based on assemblages of Australian aboriginal dental material, and was adapted by Smith for use in Amerindian materials, as well as other human groups. Smith’s scoring method distinguishes eight stages of wear that are each assigned a number: stage 1 represents no wear at all; stage 8 represents a tooth which has lost all enamel, except for perhaps a very slim rim around the edge of the tooth. Smith’s method is an ordinal scoring system that allows rapid collection of data. The method is also comparable to other scoring methods (e.g., Molnar 1971).

The scoring methods devised by Brothwell (1981), Scott (1979b), and Smith (1984) are ordinal scoring systems, based on ordinal categories of wear. A number of researchers have suggested that ordinal scoring systems for the study of dental wear should not be used in comparisons between populations, and quantitative indices of wear should be used instead (Deter 2006, 2009; Lunt 1978; Walker 1978). The main points of critique stated by these researchers consist of issues of standardization and reproducibility. Since the differences between the scales of the ordinal ranking system are not measurable, it is felt that assigning scores is overly subjective, and as a result poorly standardized. As such, these methods may be influenced by inter-observer differences, leaving data collected by different researchers incomparable (Deter 2006; Molnar et al. 1983; Walker 1978; Walker et al. 1991).

The use of continuous measurements of dental wear is advocated to resolve these issues. The amount of dentine exposure is measured in relation to the total area of the occlusal surface and expressed as a percentage thereof. Today, this technique involves taking high resolution images of the occlusal surfaces, which are subsequently analyzed using a software package that counts the number of pixels in the area of exposed dentine and the total occlusal surface area in order to calculate the desired percentage (Deter 2006, 2009; Hillson 1996; Richards and Brown 1981; Walker 1978; Walker et al. 1991).

Despite the advantages of using quantitative indices for rates of dental wear, this method involves the collection of continuous measurements of the surface area of exposed dentine, which requires elaborate photography equipment and software to process images, and is far more time consuming overall than using ordinal scoring techniques to document dental wear. Furthermore, the borders between exposed dentine and enamel can be hard to define (Walker et al. 1991). Chipped teeth, particularly those with chipping along the occlusal rim, must be excluded from the analyses, since the loss of enamel distorts the ratio between the area of exposed dentine and the entire occlusal surface area. Furthermore, teeth that are very heavily worn, i.e., where most or all of the enamel has been lost, must be excluded, since the exposed dentine comprises (most of) the entire surface. As a result the difference values between adjacent teeth decrease as a tooth's wear increases in comparison to its highly worn neighbour. Teeth without exposed dentine must similarly be excluded, because only when there is some dentine exposure on both adjacent teeth can difference values be assessed (Deter 2006; Walker 1978).

For the current study, the rapid and effective collection of data in variable working conditions and variably preserved dental material was required. Based on previous experience with pre-Columbian Caribbean dental material (Mickleburgh 2007), the proportion of (very) heavily worn and chipped teeth was predicted to be very high. For these reasons, the use of an ordinal scoring method was deemed most appropriate. The risk of inter-observer differences due to the subjective nature of such methods is avoided, since all observations and recording of dental wear was performed by the author. In each assemblage, a random sample of 10% of the total number of individuals (or in assemblages comprising four or fewer individuals, the total assemblage) was re-analyzed at least a week after the initial analysis. The repeatability of observations was over 90% in all cases.

Molnar's scoring method

In this study, documentation of both the degree of wear and the angle and shape of occlusal surface wear follows a scoring method developed by Stephan Molnar (1971). Molnar devised a scoring method that not only records tooth crown loss and dentine exposure but also records other aspects such as the direction of wear of the occlusal surface, and occlusal surface shape. The direction of molar wear – the angle of the occlusal surface – is known to be related to the proportion of processed (e.g., ground, boiled) foods in the diet (Eshed et al. 2006; Smith 1984). Studies have shown that in agricultural populations, who consumed large amounts of refined plant foods, the molars tend to be worn more obliquely than in populations subsisting on tougher, more fibrous diets (such as some hunter-gatherers) (Chattah and Smith 2006; Deter 2006; Smith 1984; Watson 2008; Watson et al. 2011).The greater the reliance on refined (agricultural) foods, the greater the angle of molar wear was found to be (Smith 1984), however the angle of wear has also been found to be correlated with age (Deter 2006). A large proportion of soft, refined agricultural foods in the diet has also been suggested to be related to the formation of cupped molar surfaces, thought to result from small particles from grinding implements in the otherwise soft and pliable foods (Smith 1984).

Molnar developed different scoring scales for the different tooth classes (incisors and canines, premolars, and molars) as these teeth are subject to different patterns and processes of wear. The degree of crown loss and dentine exposure is therefore evaluated using a different scale for each of the three different types of teeth. The numerical code given for degree of crown loss and dentine exposure is the first digit in a three-digit code which is assigned to each individual tooth. The scale runs from 1–8, with 1 representing ‘unworn’ teeth and 8 representing ‘roots functioning in the occlusal surface’. The second digit is used to describe the direction of the wear, i.e., natural form, horizontal, oblique, etc. The third digit is used to describe the occlusal surface shape. Molnar recognizes six different categories of occlusal surface shape, however I have added two categories (one half of surface rounded and other) because not all of the teeth in the present sample could be categorized using the six categories given by Molnar (Mickleburgh 2007).

The first digit in Molnar’s scoring method, indicating the degree of wear, corresponds broadly to other evaluation methods which have commonly been used, such those devised by Brothwell (1981), Murphy (1959), and Smith (1984). The three-digit code which is assigned to each tooth is simple to use and well suited to use in databases. Table 4.3 presents the categories used in Molnar’s dental wear scoring method (Molnar 1971).

Dental wear was assessed by the author both macroscopically and microscopically

Degree of dentine exposure			**Direction of wear**	**Occlusal surface form**
Incisors & Canines	**Premolars**	**Molars**		
1. Unworn	1. Unworn.	1. Unworn	1. Natural form	1. Natural form
2. Minimal wear facets	2. Wear facets, no dentine exposure	2. Wear facets, no dentine exposure	2. Oblique, buccal-lingual	2. Flat surface
3. Cusp pattern obliterated, possible small dentine patches.	3. Cusp pattern obliterated, small dentine patches	3. Cusp pattern obliterated, small dentine patches	3. Oblique, lingual-buccal	3. One-half of surface cupped
4. Dentine patch minimal	4. Two or more dentine patches, one of large size	4. Three or more small dentine patches	4. Oblique, mesial-distal	4. Entire surface cupped
5. Dentine patch extensive	5. Two or more dentine patches, possible slight secondary dentine	5. Three or more large dentine patches, secondary dentine no to slight	5. Oblique, distal-mesial	5. Notched
6. Secondary dentine moderate to extensive	6. Secondary dentine moderate to extensive	6. Secondary dentine moderate to extensive	6. Horizontal	6. Rounded
7. Crown enamel worn away on at least one side	7. Crown enamel worn away on at least one side	7. Crown enamel worn away on at least one side	7. Rounded, buccal-lingual	7. One-half of surface rounded*
8. Roots functioning in occlusal surface	8. Roots functioning in occlusal surface	8. Roots functioning in occlusal surface	8. Rounded, mesial-distal	8. Other*

Table 4.3 Dental wear evaluation method (Molnar 1971), with two added categories (*) (Mickleburgh 2007).

using a BMS 143 Trino Zoom stereo microscope with attached digital camera and a digital Dino Lite 413TZ polarizing microscope. A small number of teeth were studied for patterns of microwear using a Scanning Electron Microscope (SEM).

Principle axis analysis

As discussed above, food consistency and food preparation techniques strongly influence the abrasivity of foods and as such significantly affect occlusal dental wear. The degree of dental wear is also known to be strongly associated with age. Comparisons between the rates of dental wear in different groups must be based on factors that can be assessed independently of age (i.e., estimated ranges of age-at-death, and group age profiles which may differ significantly).

Using principle axis analysis, this study compares intra-individual rates of wear, measured using the difference in degree of wear between the adjacent permanent molars. This is possible due to the fact that these teeth erupt at approximately 6-year intervals in all humans, which means inter-individual and inter-group comparisons can be made (Bernal et al. 2007; Chattah and Smith 2006; Hillson 1996; Scott and Turner 1988; Smith 1972; Watson et al. 2011). Although some studies have used both adjacent M1–M2 and adjacent M2–M3 comparisons, this study uses only adjacent M1–M2 comparisons. The reason for this is that although the eruption timing for the first and second molars shows relatively little variation across human populations, the eruption of the third molars shows a much broader range, meaning that the interval between eruption of the M2 and M3 varies significantly more than the M1–M2 interval. Calculations of the rate of wear based on this interval will be affected by this broader range, and are therefore excluded from the comparisons made here (Bernal et al. 2007; Hillson 1996; Scott 1979b).

In dental wear studies, the principle (or major) axis analysis test is used to measure the rate of occlusal surface wear on the molars and identify whether there are differences in how fast molars wear between groups. Scott (1979a) demonstrated that the slope of the principle axis equation, which is an indicator of the relationship between the variables (i.e., the degree of wear on the adjacent molars), could be used as an indicator of the rate of wear. A steep principle axis slope (b) indicates a rapid rate of wear, whereas a gentle principle axis slope indicates a slow rate of wear.

The principle axis analysis test is a type of model II regression analysis, which measures the intensity of association between a pair of variables (Sokal and Rohlf 1981, 2012). Similar to model I regression analysis, the degree of association between the variables can be visually expressed as a trend line (the slope of the principle or major axis). Different than model I regression analysis, this test does not assume a causal relationship between the variables and does not assume that the x-axis is uniformly measured without error (Bernal et al. 2007; Chattah and Smith 2006; Scott 1979a; Scott 1979a; Sokal and Rohlf 1981, 2012). This makes the principle axis method more appropriate than model I regression analyses, as these are based on bivariate correlation measures, which measure to what degree two variables co-vary. This means that high correlation could be produced by both rapid and slow wear, since the correlation coefficient merely represents the whether the two variables vary together, and not whether the differences are great or small. Furthermore, the aim of defining rates of wear based on adjacent molar wear scores is not to predict one variable from the other. In model I regression analysis, where this is the case, assumptions are that that one variable is measured without error and is fixed, while the other varies (Scott 1979a; Sokal and Rohlf 1981, 2012). Both assumptions are not applicable in the case of wear scores of adjacent molars. The principle axis method is a parametric test, meaning that in a normal situation the variables should be continuous, or at least interval in nature for statistical treatment. However, research has shown that this method can be applied to the ordinal variables used in many dental wear scoring methods, since test have shown that the results are similar to those of analyses using continuous or interval data (Benfer and Edwards 1991; Scott 1979a, 1979b). Scott explains that "[f]or the principal axis analysis to perform most satisfactorily, however, the data should be either interval level or the best approximation which an ordinal scale can give" (1979a:213). He compared the use of the principle axis method using his own ordinal dental wear scoring technique (Scott 1979b), and that designed by Molnar (1971). He found that the use of the more elaborate method of dividing the molar occlusal surface into quadrants, which each are assigned a score for the degree of wear (Scott 1979b), produced more satisfactory results than the use of the eight category Molnar method (1971), due to its smaller confidence regions. He argued that the use of the latter method may lead to (greater) overlap in the confidence limits for the different groups in the comparison. Nonetheless, his comparison demonstrated that both methods produce similar and interesting results, and since Molnar's method is more rapid and efficient to use, and also documents other aspects of wear than the degree of occlusal crown loss, this study uses the eight category method devised by Molnar (1971) and applies principle axis analysis to the ordinal data it produces.

To compare wear rates, the principle axis equation was determined by plotting the wear score of M1 on the Y1 (x) axis, and M2 on the Y2 (y) axis (Sokal and Rohlf 1981:594–601). Principle axis equations and 95% confidence limits (CL) were calculated according to Sokal and Rohlf (1981:596–599) using Microsoft Excel. Since this method avoids the effects of age on the degree of dental wear, significant differences between the rate of wear (the principle axis slopes) of different sites can be taken to indicate differences in food consistency or food preparation techniques. Rapid rates of wear are usually associated with tough, abrasive diets (often hunter-gatherer or hunter-fisher diets). Slower rates of wear are more often associated with refined, less abrasive diets (processed agricultural produce) (Smith 1984; Larsen 1997; Lukacs 1996; Watson et al. 2011).

Dental chipping

Dental chipping is related to both alimentary and non-alimentary activities.

Tough, abrasive foods and the inclusion of contaminants such as sand and grit, and stone particles from grinding tools are thought to cause chipping and fracturing of dental enamel and dentine (Bonfiglioli et al. 2004; Budinoff 1991; Molleson and Jones 1991). Non-alimentary causes include cracking nuts (Mickleburgh 2007), cracking crab shells (Budinoff 1991), chewing seal hides and preparing sinew (Merbs 1968; Pedersen 1947), cracking bones (de Poncins 1941), retouching chert artefacts (Gould 1968), and holding objects between the teeth (Bonfiglioli et al. 2004; Merbs 1968; de Poncins 1941; Schour and Sarnat 1942). Both alimentary and non-alimentary dental chipping are, like other types of dental wear, related to age and affect the individual dental elements differently (Molnar 2008). Differences in degree and location of chipping on the dental elements and throughout the dentition between the sexes, or at different sites and occupation periods may also indicate (gender-based) divisions of labour or craft activities or differences in diet composition or food preparation techniques (Molnar 2008).

In this study, the presence and severity of dental chipping was documented according to a grading system developed by Bonfiglioli et al. (2004). They define a dental chip as "an ante mortem irregular crack, involving enamel or enamel and dentine, situated on the buccal, lingual or interproximal edge or crest of the tooth" (Bonfiglioli et al. 2004:449). Their grading system defines three categories of dental chipping, based on size and depth of the lesion in the enamel surface. Grade 1 comprises a "slight crack or fracture (0.5 mm), or larger but superficial enamel flake loss". Grade 2 is characterized as a "square irregular lesion (1 mm) with the enamel more deeply involved". Grade 3 is a "crack bigger than 1 mm involving enamel and dentine of a large, very irregular fracture that could destroy the tooth" (Bonfiglioli et al. 2004:449).

The location of the chip(s) on the tooth was also recorded, using the following categories defined by the author: buccal, lingual, interproximal mesial, interproximal distal, occlusal, occlusal buccal, occlusal lingual, occlusal interproximal mesial, occlusal interproximal distal.

Ante mortem dental chipping is distinguished from post mortem dental chipping based on the smoothing of the sharp edges of the break area as the tooth continues to wear after damage, and the lack of the characteristic colour difference between the crown surface and a freshly broken area (which is generally lighter in appearance) (Belcastro et al. 2007; Milner and Larsen 1991). Smoothing and colouration of the chip area were assessed both macroscopically and microscopically.

Dental notching

Occlusal surface and interproximal grooves or notches are caused by the repeated action of drawing an object across the surface of a tooth or teeth. Notching may be intentionally created, in which case the anterior teeth are usually affected and the overall appearance of the modification is symmetrical. Non-alimentary activities which cause notching/grooving of the teeth are crafting activities, such as basketry and cordage manufacture, but also habitual activities such as tooth picking or the clamping of an object (such as a needle, nail, pen, of pipe stem) between the teeth. The location, size, shape, direction, and microwear patterns of a notch or groove may indicate its cause (Alt and Pichler 1998; Brown and Molnar 1990; Larsen 1985; Milner and Larsen 1991; Pedersen 1949; Schulz 1977; Ubelaker et al. 1969; Wallace 1974).

Dental notching/grooving is assessed and documented in this study according to guidelines set out by Bonfiglioli et al. (2004). Although the presence of a dental notch is recorded in Molnar's scoring system, the severity of the notch is not. To distinguish between large and small notches, any notches observed were graded according to Bonfiglioli et al.'s system. They define a notch as "an indentation involving the tooth's incisal/occlusal edge, sometimes extending across all the surface. The depression is broader than it is deep and both the enamel and dentine are smooth and polished; it runs in a vestibulo-lingual direction and the orientation may be perpendicular or transverse to the mesial/distal axis of the tooth" (Bonfiglioli et al. 2004:449). Like dental chipping, notches are categorized according to a three-grade system. Grade 1 comprises a "slight superficial indentation affecting only the enamel". Grade 2 is characterized by a "wider and deeper indentation with polished dentine". Grade 3 is a "very deep and equally wide depression with heavily polished dentine" (Bonfiglioli et al. 2004:449).

The orientation of the notch(es) on the tooth is also recorded, using the following categories defined by the author: occlusal traversal, occlusal parallel, occlusal other, interproximal.

LSAMAT

Lingual surface attrition of the maxillary anterior teeth (LSAMAT), is a pattern of wear which exclusively affects the lingual surfaces of the upper front teeth (without corresponding wear on the lower front teeth), and has variably been described as the result of alimentary or non-alimentary activities (Comuzzie and Steele 1988; Hartnady and Rose 1991; Irish and Turner 1987, 1997; Larsen et al. 2002; Liu et al. 2010; Pechenkina et al. 2002; Robb et al. 1991; Turner and Machado 1983). Turner and Machado first documented the pattern in 1983. They describe LSAMAT as "the occurrence of progressive wearing with age of upper anterior lingual tooth surfaces without corresponding lingual or labial surface wear on any lower teeth. It is not the result of any manner of occlusal overbite, overjet, malocclusion, or other normal or abnormal anatomical consideration" (Turner and Machado 1983:126). LSAMAT was found to be correlated with a high rate of caries. Since the precise aetiology of this pattern of wear is currently unknown, it is posited here that in-depth analysis of the affected teeth, affected individuals, macrowear and microwear patterns, and association with other patterns of wear or dental pathology will benefit our understanding of LSAMAT.

The presence of LSAMAT (lingual surface attrition of the maxillary anterior teeth) was recorded but not evaluated for its severity. This type of dental wear involves the loss of enamel on the lingual surfaces of the maxillary anterior teeth. According to previous studies, teeth affected by LSAMAT have enamel that is worn away on the lingual surface, often leaving the dentine exposed, and the remaining structure tends to have a polished appearance. No corresponding wear is found on the mandibular teeth. These criteria were used here to assess the presence or absence of LSAMAT (Irish and Turner 1997; Robb et al. 1991; Turner and Machado 1983; Turner et al. 1991).

Other

In a relatively small number of cases, patterns of dental macrowear were observed which in the opinion of the author could not be adequately documented using only the dental wear scoring method (Molnar 1971), and the methods for documenting other categories of wear described above. An example is a small number of cases in which individuals showed wear on the lingual surfaces of the mandibular anterior teeth, which in all aspects apart from its location appeared identical to patterns of wear identified here as LSAMAT. Another example is a small number of individuals in which odd buccal wear facets were found on the anterior teeth, perhaps indicating the use of labrets or other facial jewellery around the mouth, or non-alimentary uses of the teeth.

In all such cases the patterns of wear on each individual tooth were described at length in the remarks section on the standard form, and were photographed from a number of different angles.

4.2.3 Dental pathology

Dental pathology was assessed both macroscopically and microscopically using a BMS 143 Trino Zoom stereo microscope with attached digital camera and a digital Dino Lite 413TZ polarizing microscope.

Caries

High caries rates have been attributed to a carbohydrate rich diet. The global increase in caries rates over time has been attributed to sociopolitical and cultural developments associated with the adoption of agriculture (Cohen and Armelagos 1984; Klatsky and Klatell 1943; Larsen 1997; Larsen et al. 1991; Littleton and Fröhlich 1993; Meiklejohn et al. 1984; Milner 1984; Turner 1979). The rate of caries in any population is related to the type of diet consumed. Dental anthropological research has shown that the ‘hunter-gatherer/forager’ diet is associated with a very low caries percentage, while ‘mixed economies’ and ‘agricultural economies’ have much higher caries rates (Koca et al. 2006; Larsen et al. 1991; Powell 1985; Scott and Turner 1988; Turner 1979; see Figure 2.1). Furthermore, the location of caries on the individual dental elements and throughout the dentition is known to be related to diet composition and food preparation techniques (Caglar et al. 2007; Larsen 1988; Lingström et al. 2000; Powell 1985; Vodanovic et al. 2005).

However, caries rates are also known to be related to age, with rates increasing as people grow older. This means that comparison of caries prevalence rates between populations of differing age profiles is problematic: differences in caries rates derived from the simple tooth count and individual count methods could (at least in part) result from differing age profiles. For this reason, this potential source of variation must be controlled for in order to assess foodways based on caries prevalence. Furthermore, the individual dental elements are differentially susceptible to caries, with molars more frequently affected than incisors and canines and premolars, and premolars in turn more frequently affected than incisors and canines (Hillson 2001, 2008b; Wasterlain et al. 2009). For this reason, differential preservation of individual dental elements between populations may render them incomparable with regards to simple caries prevalence. Both AMTL and PMTL affect the separate tooth classes differently. In order to assess differences in caries rates as a result of the consumption of cariogenic foods, age, differential susceptibility, and differential preservation must be taken into account. Comparisons must be made between the same age groups and tooth classes in each population (Hillson 2001, 2008b; Wasterlain et al. 2009).

In this study, dental caries were evaluated macroscopically, and were diagnosed only when a distinct cavity had formed with evidence of demineralization (as opposed to for example fracturing or intentional modification), affecting at least the enamel, and often also the dentine, and in the case of cement-enamel junction caries or root surface clearly affecting the cement (Hillson 1996:269). The location and type of carious lesion was also documented according to Hillson (2001, 2008b). He distinguishes between pit and fissure caries, smooth surface caries, and root surface caries. Here, this distinction is followed in the following categories defined by the author: occlusal (pit/fissure), buccal (smooth surface), lingual (smooth surface), interproximal mesial (smooth surface), interproximal distal (smooth surface), cervix buccal (root surface), cervix lingual (root surface), cervix interproximal mesial (root surface), cervix interproximal distal (root surface).

Caries prevalence was calculated using both the tooth count method [(total number of carious teeth / total number of teeth] x 100 and the individual count method [(number of individuals affected by caries / total number of individuals) x 100] (Lukacs and Thompson 2008). Furthermore, population caries rates were assessed and compared by age group, tooth class, and sex.

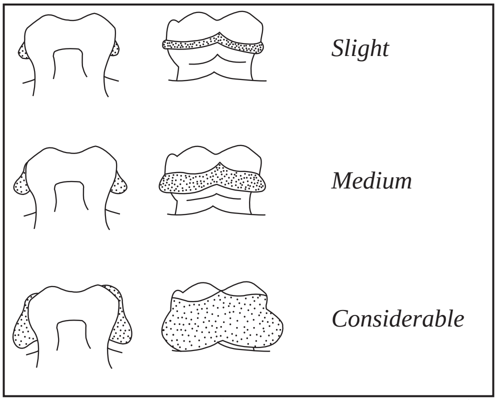

Figure 4.1 Degree of calculus formation. After Brothwell (1981).

Dental calculus

The formation of calculus is heavily influenced by oral hygiene and diet composition. Nonetheless, its formation is a complicated process, involving numerous biological and environmental factors, such as age, sex, fertility, hormonal imbalances, hereditary predisposition, salivary constitution, mineral composition of drinking water, and fluid intake (Hillson 1996; Lieverse 1999).

In this study, the presence and degree of dental calculus formation was documented per individual tooth according to the three basic categories (slight, medium, considerable) as distinguished by Brothwell (1981:155; Figure 4.1).

Periapical abscesses

Periapical abscesses tend to be associated with exposure of the pulp chamber, allowing bacteria and the toxins they produce to enter and travel through the pulp chamber and cause infections once trapped in the chamber or at the root apex. Exposure of the pulp chamber is caused either by a carious lesion, severe dental wear, or trauma. This can trigger an inflammatory response within the tooth, leaving a void in the bone filled with pus. As pressure continues to build the pus breaks through the thin layer of outer alveolar bone (usually on the buccal surface). In archaeological specimens, in which periapical abscesses are commonly found, this results in a clearly exposed cavity in the alveolar bone, with signs of periapical inflammation and bone resorption (Hillson 1996, 2008b).

Care was taken to distinguish signs of periapical bone inflammation and resorption when a periapical cavity was observed. Furthermore, the edges of the cavity area were assessed macroscopically, and where possible, microscopically, for the presence of sharp fracture edges to establish whether the cavity could have been the result of post mortem damage to the material and breakage of the thin cortical bone surface (Hillson 1996, 2008b).

Periapical lesions were recorded on a presence absence basis. The location of each individual periapical lesion was recorded using the dental notation of the associated tooth and whether the lesion was positioned on the buccal or lingual side of the alveolar bone (Buikstra and Ubelaker 1994).

AMTL

Ante mortem tooth loss (AMTL) is often treated as a dental disease, although in actual fact it may result from disease processes such as caries and periodontal disease, or from infections related to pulp exposure due to extreme dental wear or traumatic injury. Dental anthropological research has shown that, while various conditions may cause AMTL, and all human populations suffer from AMTL, there is a marked tendency for higher AMTL rates in populations that consume refined, carbohydrate rich diets (Larsen 1995; Larsen 1997; Scott and Turner 1988). As such, high rates of AMTL may be related to the consumption of a refined, carbohydrate rich diet. However, AMTL is also very strongly related to age, with rates increasing as people grow older. Similar to the case of dental caries, when comparing AMTL rates between groups, the effects of age, differential preservation of individual dental elements, and differential susceptibility of individual dental elements to ante mortem loss must be taken into account (Hillson 2001, 2008b; Wasterlain et al. 2009). Differences observed between populations could (at least in part) result from differing age profiles and differentially preserved/affected dental elements. For this reason, these potential sources of variation must be controlled for.

AMTL was assessed firstly on the basis of the presence or absence of each individual dental element, and subsequently recorded when the alveolar bone showed clear signs of resorption at the location of a particular dental element (Hillson 1996). AMTL was only recorded when resorption was so extensive that the alveolus could no longer accommodate a tooth at that location. Caution was applied when recording AMTL of the third molars, since congenital absence may give the appearance of AMTL if there appears to be enough space in the alveolar arch to accommodate the third molars. The rate of AMTL is calculated as follows: number of AMTL / total number of observed tooth positions (= observed teeth + unerupted teeth + AMTL + PMTL) = AMTL rate. Furthermore, population AMTL rates were assessed and compared by age group, tooth class, and sex.

Hypercementosis

Hypercementosis is the accumulation of excessive cementum on the roots of the teeth, due to heavy dental wear, malocclusion, periodontal inflammation, Paget's disease, or trauma (Corruccini et al. 1987; Hillson 1996, 2008b). The tooth root becomes enlarged as layers of cementum are deposited, and hypercementosis can be recognized by the bulbous appearance of the roots, particularly the apices. Hypercementosis may be associated with periapical granulomas, since the increasing thickness of cementum may cause pressure and inflammation of the periodontal tissues. Loss of bone around the root apices may also result from hypercementosis, without inflammatory response (Hillson 2008b). Hypercementosis was recorded on a presence/absence basis, and potentially associated dental pathology (e.g., periapical lesions) or excessive dental wear were noted.

4.2.4 Dental defects

Enamel hypoplasia

Enamel hypoplasia are disruptions in the formation of the dental enamel. Hypoplasia are known to be related to a wide range of physiological and psychological conditions, although they are most often attributed to systemic disorders and physiological stress including particularly metabolic disorders and nutritional deficiency (but also infectious disease, and physical and emotional trauma), occurring during the formation of the tooth. Research has shown that (linear) enamel hypoplasia are useful indicators of changes in nutritional status over extended periods of time, such as the transition from hunter-gatherer subsistence to agriculture. As such, the rate of (linear) enamel hypoplasia in a population is used to indicate physiological condition, and extremely specialized or monotonous diets or infectious disease is often inferred. Depending on the location of the enamel defect in the dentition and on the tooth crown(s), the age at which the defect occurred may be estimated. The dental elements most frequently affected by LEH are the upper canines (Goodman and Rose 1991; Hillson 1996, 2008b; King et al. 2005; Smith et al. 1984).

Enamel hypoplasia were recorded on a presence/absence basis per dental element. Affected elements were photographed. A distinction was made between furrow-type defects, pit-type defects, and plane-type defects as defined by Hillson (1996:166–167). In this classification, furrow-type defects are defined as furrow-shaped defects in the enamel which follow the perikymata, and are generally arranged in a linear formation around the tooth crown (also Linear Enamel Hypoplasia or LEH). Pit-type defects are pits in the enamel surface of varying size and shape. Pits may be distributed across the surface of the crown or arranged in bands around the crown sides, sometimes following LEH. Plane-type defects are large exposed areas of damaged enamel marked with brown striae.

Discolouration and Opacities

Discolouration of the enamel may result from intrinsic or extrinsic factors, such as deficiencies during mineralization (Hillson 1996) or smoking (Davies 1963).

Discolouration and opacities were recorded on a presence/absence basis per individual dentition. If extrinsic staining was present, the colour was noted and photographs were taken. When the coloured or opaque area appeared mottled white or yellow/brown, and pitting was present, a tentative diagnosis of dental fluorosis was made (Hillson 1996).

4.3 METHODS OF DOCUMENTING

4.3.1 Dental notation

There are numerous labelling systems, also known as dental notations, which have been used in the past and remain in use today to identify the individual teeth in the human dentition. The system used here was introduced by the Fédération Dentaire Internationale (FDI) or World Dental Federation in 1971. This system is used for reasons of its widespread international recognition and its convenient numerical notation which is well suited to use in databases (FDI 1971). The FDI system divides the dentition into quadrants and numbers the teeth in each quadrant in mesial-distal direction (for both the adult and deciduous dentition). However, the FDI system also numbers the quadrants in clockwise direction (as seen from a frontal perspective) from 1 to 4, starting with the upper right quadrant. The combination of both numbers produces a unique two-digit code for each individual tooth. To distinguish between the adult and the deciduous dentition the quadrants in the deciduous dentition are numbered from 5 to 8. The FDI two-digit system is depicted in Figure 4.2.

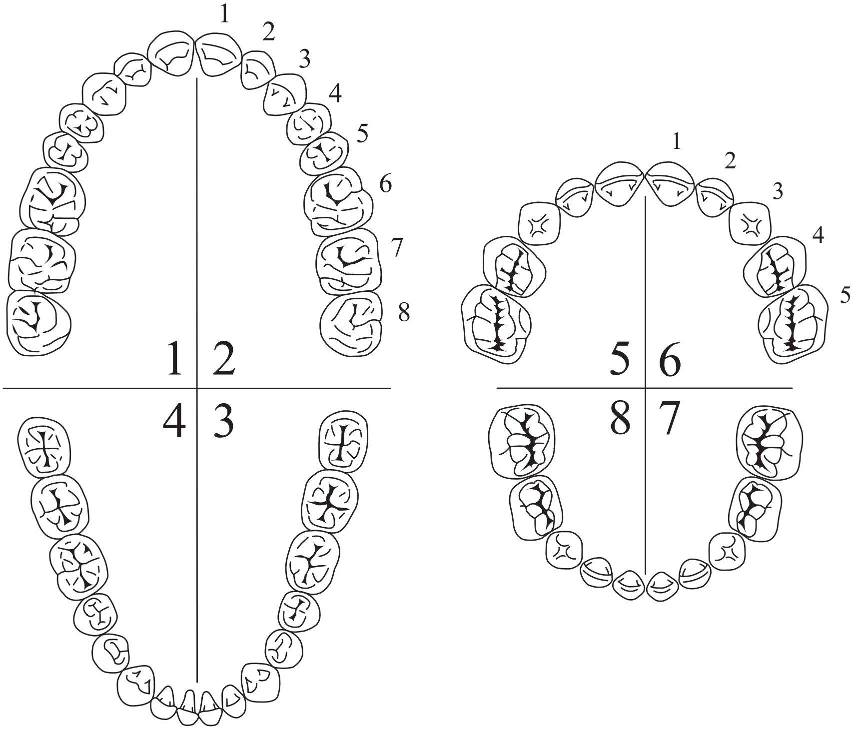

Figure 4.2 FDI notation.

4.3.2 Standard documentation forms

Dental wear and pathology were documented on a standard form, developed by the author. The form consists of depictions of the complete set of dental elements in buccal, occlusal, and lingual view. These depictions can be coloured in according to the presence or absence of (parts of) the dental elements as a result of dental wear or ante mortem tooth loss. In the same manner dental chipping, dental notching, LSAMAT, and caries are drawn in the figures.

The individual dental elements are numbered according to the Fédération Dentaire Internationale (FDI) or World Dental Federation (1971).

The three-digit dental wear scores (Molnar 1971), and both chipping and notching grades for each individual tooth (Bonfiglioli et al. 2004) are scored in a table at the bottom of the sheet. The age and sex of the individual (where known), along with total number of teeth, number of caries, number of chipped teeth, number of notched teeth, the presence of alveolar bone resorption and hypercementosis, are recorded above the table. Above the table on the right hand side of the sheet, there is room for remarks and additional observations.

4.3.3 Photography

Due to time constraints, high quality photographs for illustration purposes were taken only of certain dental elements chosen for their typical or exceptional dental wear. General overview photographs were taken of each dentition for later reference. The photographs were taken using a BMS 143 stereo microscope with a BMS tCam 1,3 Mpixel USB 2.0 CMOS digital camera attached, with a digital Dino Lite 413TZ polarizing microscope, and with an Olympus Pen E-PL1 with macro lens. In some cases the digital photos were altered using Adobe Photoshop, in order to make the image clearer. In all cases the alterations concerned increasing/decreasing the contrast or the brightness of the pictures.

4.3.4 Scanning Electron Microscopy (SEM)

For the purpose of this study, ten teeth have been subjected to SEM analysis, in order investigate patterns of wear indicating non-alimentary use of the teeth, for example for crafting activities. Here, only qualitative analysis was used, as the results of the analyses are further contextualized using information on dental macrowear and the vegetable component of the diet based on ancient starch grain analysis.

The individuals were selected for SEM analysis on the basis of a number of different characteristics. Firstly, six teeth from two individuals from the Site of Punta Macao present either exceptional or anomalous patterns of anterior dental wear, warranting further investigation as to the cause(s) of the patterns of dental wear. Secondly, two individuals from the site of Anse à la Gourde were selected for the LSAMAT present in their upper anterior teeth. A further juvenile individual from Spring Bay 1c was selected on the basis of lingual wear of the central incisors that resembles LSAMAT. As discussed in more detail in Chapter 6 and Chapter 7, this pattern of wear is enigmatic, in the sense that its precise cause is debatable, and as there appears to be a great deal of variety present in the cases identified as LSAMAT worldwide. Samples were selected here based on the author's distinction two types of LSAMAT, which the author proposes may have different aetiologies. Of the two main types of LSAMAT distinguished by the author, two teeth for each type were selected for SEM analysis.

4.3.5 Database

A database was developed using Microsoft Access to assess and organize the data, alongside the standard form. The database essentially records the same information as the dental wear form, while allowing statistical analysis of the data.

The database consists of two linked tables, each containing a different level of information about the individual feature numbers. The first table Teeth Feature contains the general information per feature number (individual person): sex, age, presence of LSAMAT, presence of dental chipping, presence of dental notching, presence of caries, remarks, and the site name.

The second table Teeth Element is linked to each individual feature in Teeth Feature, and contains the data on each separate dental element belonging to that individual. Starting with the element number, this table lists the element's status (present, deciduous present, not present, not gradable, cast, un-erupted), degree of wear, direction of wear, occlusal surface shape, presence of LSAMAT, degree of chipping, location of the chip, whether the chip area is worn smooth, presence of caries, location of caries, presence of notching, location of notching, and remarks. By using two linked tables in such a way, different 'layers' of information are created, which can then be analyzed in a straightforward manner. This means that statistical analysis of inter- and intra-individual dentitions can be performed separately or combined with ease.

4.4 Methods of Analysis

4.4.1 Sampling and representativeness

In working with archaeological remains we must be aware of the great variety in types of data, issues of preservation, and differing excavation strategies, which affect the composition of the dataset we have at hand. Firstly, archaeological remains recovered at a single site, area, or region can always be said to be merely a selection of the entire material culture remains of a past population, as perishable materials will be absent or underrepresented, and human activities such as construction work, and natural processes of erosion will affect the amount and type of materials recovered at any location. Excavation strategy and research questions will likewise affect the size and composition of the dataset, as archaeological sites are rarely entirely excavated, and depending on the size and location of excavation units, certain materials and sociocultural contexts will be overrepresented and others will be underrepresented. This can bring up certain issues regarding the use of statistical methods to analyze data, as many statistical methods, used for example to compare different categories and results, rely on the assumption that the sample was randomly selected. In this context, random selection refers specifically to the fact that each individual case in the population has an equal chance of being selected for the sample. It is generally accepted that in this way the chances of the sample accurately reflecting the character of the population are as great as possible. But of course, random selection, just as any other method of selection, never guarantees that the sample accurately reflects the population from which it is derived. Even working from the assumption that a randomly selected sample accurately reflects the population (which is what we must inevitably do), an archaeologist rarely has this kind of control over his dataset and sampling strategies. Nonetheless, statistical tests are an important tool in the analysis of (bio)archaeological data, and although they must be used with due caution and regard for the underlying assumptions of each method, their importance in a field with rapidly increasing datasets and sample sizes is paramount (Drennan 2010; Madrigal 2012; Sokal and Rohlf 1981, 2012).

The skeletal assemblages used in this study are often referred to as a 'population', where in actual fact of course they are samples of the prehistoric living population which were not randomly selected. A large number of factors influence the composition and size of an assemblage, including mortuary practices, (differential) preservation, and excavation techniques and strategy (e.g., which parts of the burial area(s) were excavated). Treatment of the dead naturally affects the composition of the skeletal assemblage, especially in cases were certain individuals are excluded from burial (i.e., the remains are disposed of in another way), or are buried at a different location. This may affect the ratio of the sexes and different age groups, in which case it may be very clear that burial practices have affected the composition of the skeletal assemblage. Alternatively, burial or other forms of disposal of the corpse may not be related to biological sex or age, but to social status or rank, sometimes making it more difficult to determine whether burial practices have affected the composition of the assemblage. The composition of a skeletal assemblage may also be affected after excavation of the material, as over the years parts of the skeletons are sent for (destructive) analyses. In this study, earlier and simultaneous isotope studies dealing with the geographical origins of individual persons, and in a few cases radiocarbon and AMS dating, meant that dental elements were sampled for most individuals (Booden et al. 2008; Laffoon 2012; Laffoon and De Vos 2011; Laffoon and Hoogland 2010, 2011; Laffoon et al. 2012). Where possible, these dental samples were studied prior to these analyses.

To reiterate, the relation between a skeletal assemblage and the living population at a site at any given time is highly complex, and is influenced by a large number of factors which cannot be compensated for in the statistical methods used to organize and interpret the dataset. In this study, a large amount of comparative analyses are done (e.g., independent and dependant samples t-test, Mann-Whitney U test, and Kruskal-Wallis test), in order to define potential differences between groups of individuals of different ages and sex, and of course between individuals from different sites and periods. In comparing the male and female adult population at a particular site, for example, ideally the numbers of individuals in each group would be similar. This makes the application of certain statistical methods simpler and more appropriate, as many statistical tests rely on similar sizes of the groups to be compared (along with other characteristics such as similar variances and normal distribution) in order to produce reliable results. In practice this is often not the case, for example at the site of Tutu, St. Thomas, USVI, where the adult population consists of six males and fourteen females. Let's assume that the living adult population during the period of occupation at Tutu most likely consisted of approximately 50% males and 50% females, or thereabout. At Tutu, the excavated burial population consisted of over twice as many females than males. The cause of this apparent disparity is hard to determine. Perhaps only a portion of the burial population was excavated? In actual fact Tutu represents one of the most completely excavated sites in the Caribbean, as the construction of a shopping mall at the location of the site meant that large scale open excavation was necessary to salvage the cultural remains at the site (Righter 2002). Burial practices could of course have entailed the interment of most males at a different location on or near the site, or perhaps most males were disposed of in a different manner upon death. Alternatively, males could have partaken in far riskier activities (i.e., hunting or warfare), which meant they more frequently died away from the settlement and were disposed of elsewhere. Yet another possibility is that the methods used to determine biological sex at the site were inappropriate for this particular population, i.e., that sexual dimorphism was not strongly (or differently) expressed in the skeletal frame, or that based on the criteria used the female sex was favoured. We can continue along these lines, exploring the possible reasons for the disparity in numbers of males and females at Tutu, however, no definitive answer can be obtained, and consequently we have no way of correcting for the cause of this disparity in our choice of statistical methods to analyse potential sex based differences. So it appears we are stuck with a male population which is represented by only six individuals, as opposed to a female population which is represented by fourteen individuals. This brings us to the subjects of representativeness and bias. In this context, representativeness refers to the accuracy with which the sample reflects the population from which it is derived, or in other words, how representative the sample is for the population as a whole. As mentioned above, even when there is control over the sampling procedure, a sample may or may not accurately represent the population. A stringent sampling procedure, particularly when random sampling is used, increases the chances of the sample accurately reflecting the population, but does not guarantee it (Drennan 2010). When the sampling procedure is beyond the researcher's control, as is the case at Tutu, where both sexes are not equally represented, there is simply no way of knowing how representative the sample may be of the whole population. This is equally true for the six males, and the fourteen females. Both groups may or may not accurately represent the population they are derived from (i.e., the males population versus the females population), regardless of the number of individuals in each sample.[5]

4.4.2 Statistical methods

The data produced in this study are both parametric and non-parametric, meaning that both parametric statistical tests and non-parametric tests are used. The statistics computer package IBM SPSS (Statistical Package for the Social Sciences) Statistics 20.0.0 was used to run all statistical analyses. The level of significance for all tests used here is $p \leq 0.05$.

Parametric tests

Parametric tests are used when the data to be analysed is assumed to be normally distributed, or distributed according to another common distribution such as the t distribution (t-tests), and when the variables are continuous or interval. Parametric tests used here consist of basic descriptive statistics, independent samples t-tests, and analyses of variance (Drennan 2010; Madrigal 2012; Sokal and Rohlf 1981, 2012).

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[5] Generally speaking, as the sample size increases, the chance of accurate representation of the population increases, although again this depends heavily on the sampling strategy.

Independent samples t-test (a.k.a. unpaired samples t-test)

The independent samples t-test tests the hypothesis that two groups are derived from the same population. The t-test assumes that the data are normally distributed, and compares the means of both groups in order to test the hypothesis. The more similar the means are, the greater the chance that the null hypothesis (no significant difference) is accepted. Other assumptions of the t-test are that the samples were collected using random sampling (meaning each individual in the population has an equal chance of being selected), and that there is independence of variates (meaning that all samples are independent from each other, and that sampling of one does not affect the others) (Drennan 2010; Madrigal 2012; Sokal and Rohlf 1981, 2012).

Dependent samples t-test (a.k.a. paired samples t-test)

The dependent samples t-test tests the hypothesis that matched pairs show no significant difference in their means. In other words, it compares the means of two variables for a single group. The more similar the means are, the greater the chance that the null hypothesis is accepted. The t-test assumes that the data are normally distributed. Other assumptions of the t-test are that observations for each pair should be made under the same conditions (Drennan 2010; Madrigal 2012; Sokal and Rohlf 1981, 2012).

Non-parametric tests

Non-parametric tests are used when the data are not normally distributed and/or include ordinal variables. They may also be more appropriate when sample sizes are small (under 20) regardless of the normal distribution of the data. In this study, the Mann-Whitney U test is used to test whether one of two independent samples differ significantly with regards to an ordinal variable. The Kruskal-Wallis non-parametric test for independent samples is used to determine whether two or more groups differ significantly with regards to a particular ordinal variable. The chi-square test, which is based on the $\chi 2$ distribution, is used to test the independence of two variables represented by frequencies (Drennan 2010; Madrigal 2012; Sokal and Rohlf, 1981, 2012).

Mann-Whitney U test

The Mann-Whitney U test is the non-parametric alternative to the independent samples t-test. It assesses whether one of two samples of independent observations tends to have larger values than the other. This test's assumptions are that the observations in both groups are independent of each other, the distributions are equal in both groups, and the observed variables are ordinal. The data need not be normally distributed. This test can also be used for continuous variables when the requirement of normal distribution for the independent samples t-test is not met (Drennan 2010; Madrigal 2012; Sokal and Rohlf, 1981, 2012).

Kruskal-Wallis test

The Kruskal-Wallis test is similar to the parametric one-way ANOVA test, in the sense that it tests the hypothesis that two or more groups were obtained from the same population, however as the Kruskal-Wallis test is designed to analyze non-parametric data, it does so by ranking the data and comparing ranks as opposed to parameters (such as the mean). The Kruskal-Wallis test does not assume the data are normally distributed, making it appropriate for the analysis of ordinal data. Where it is possible to use parametric analyses, a one-way ANOVA is preferred over the Kruskal-Wallis test, as parametric tests are more powerful than non-parametric tests and can detect more subtle differences between samples (Drennan 2010; Madrigal 2012; Sokal and Rohlf, 1981, 2012).

Chi-square tests

The chi-square test for goodness of fit tests whether observed frequencies differ significantly from expected frequencies as defined for the null hypothesis. The chi-square test for goodness of fit assumes that the samples were randomly selected, and the observed frequencies must be at least five. If this is not the case, a Fisher's exact test is more appropriate (Drennan 2010; Madrigal 2012; Sokal and Rohlf, 1981, 2012).

The chi-square test for independence of variables tests whether the observed frequencies differ significantly from expected frequencies as defined for the null hypothesis. As such, it is the same as the chi-square test for goodness of fit in its null hypothesis and in its computation. Essentially, the null hypothesis is reversed from stating the two variables are not significantly different, to the two variables are independent. In practice this means the test, which makes use of the $\chi 2$ distribution, now focusses on the $\chi 2$ value for $p= 0.95$ as opposed to $p= 0.05$ (Drennan 2010; Madrigal 2012; Sokal and Rohlf, 1981, 2012).

CHAPTER 5 MATERIALS

5.1 INTRODUCTION

This chapter presents an overview of the skeletal assemblages incorporated in this study, and the sites they are derived from. Figure 1.1 depicts the location of the 49 sites in the Caribbean region. Figure 5.1 shows the chronology of the individual sites and skeletal assemblages. Contextual information on these sites is presented in this chapter, and broadly placed within the regional cultural framework discussed in Chapter 3.

The selection process of skeletal assemblages used for the purposes of this study requires some explanation, as the reader will immediately notice a disparity in the numbers of individuals representing the various sites. In an ideal world of course, skeletal assemblages used in the study of the human past in large cultural and chronological areas would consist of hundreds of individuals, with equal numbers of males and females, and a perfect distribution of sites across time and space. Although this is never the case in archaeology, this scenario appears to be even less applicable to the Caribbean archipelago. Certain islands in the region have enjoyed a very long history of archaeological research, with a heavy focus on human skeletal remains and mortuary practices (i.e., Cuba and the Dominican Republic), but on others very little skeletal material has been excavated, studied, or securely dated to a particular timeframe. Furthermore, the lack of larger numbers of skeletons (pertaining to a single site and/or occupation phase) considerably hampers statistical analyses of burial populations with regard to their demographic composition and other characteristics such as pathological conditions. Research at some of the larger burial sites in the Caribbean (i.e., Punta Candelero) has shown that although the entire burial population pertaining to a particular occupation phase in some cases is quite considerable, the chances that any of the individuals actually lived at the same time are small (Pestle 2010). This means that defining a culturally and socially representative burial population for a single settlement, or the various phases of occupation thereof is difficult. This especially affects those skeletal assemblages for which no or few radiocarbon dates are available (which, as we will see, is often the case), and which are dated on the basis of ceramic typologies, as these generally lead to a broader time range for the material and have the added complication of being subject to change and redefinition. The statistical analyses used in this study are discussed in detail in Chapter 4 (section 4.3).

5.2 SITES

Discussed here are the 49 sites from which the samples incorporated in this study are derived per island. Table 5.1 presents an overview of the numbers of males, females, individuals of unknown sex, and juveniles per site. Appendix A contains a complete table of the 458 individuals included in this study, listing sex, age, and relative or absolute dating where known. Below, background information on the

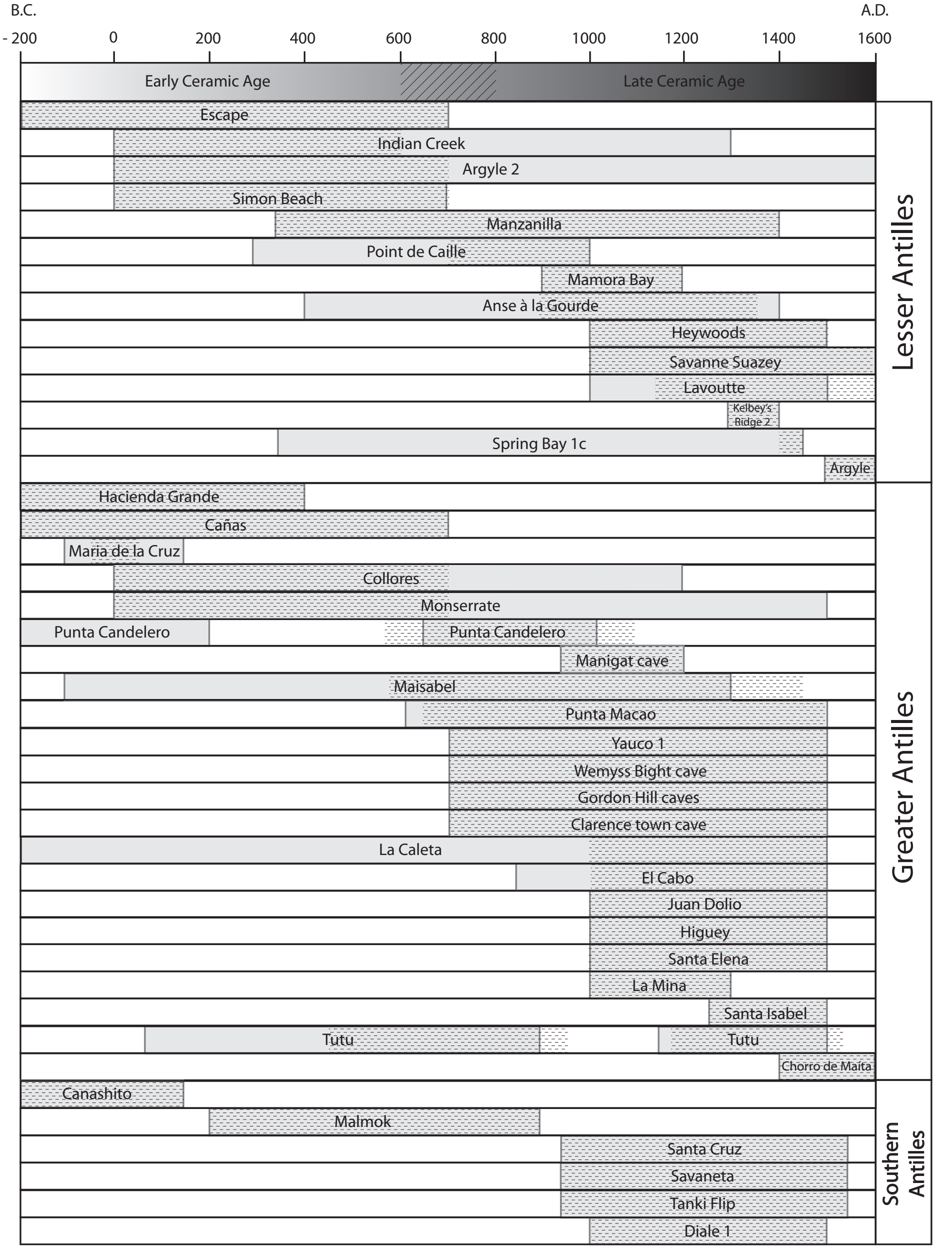

Figure 5.1 Diagram depicting the chronology of the sites and skeletal remains.

natural and cultural setting, the history of excavations and research, and the skeletal population, is given for each site. Considering the different histories of research at the various sites, this information is in some cases highly detailed, and in others superficial.

5.2.1 Aruba

Canashito

Canashito is an Archaic Age limestone rock-shelter site in the central part of Aruba, close to the Late Ceramic Age (Dabajuroid) settlement of Santa Cruz. Archaeological remains recovered at the site comprise predominantly shell food remains which appear to have been washed down the slope leading to the entrance of the rock-shelter, and a small number of human skeletal remains. Radiocarbon dating of one of the skeletons revealed a date of 1960 ±65 B.P. (cal. A.D. 83–394). This, together with the lack of ceramic material at the site, led investigators to believe Canashito is exclusively associated with the Archaic Age occupation of the island (Wagenaar Hummelinck 1959). Some shell material was collected during later investigations from the base of a slope in the rock-shelter and radiocarbon dated, however the results gave a very broad time range, most likely due to the intermixture of material from different phases through slope wash (Gould 1971).

Skeletal remains

Five burials were excavated at Canashito by Ringma in 1950. Similar to the slightly later Malmok burials, four of the Canashito the burials appear to have been arranged in a cluster around a central male (burial C2) [Versteeg et al. 1990]. Like at Malmok, one of the burials was found to be associated with a large limestone rock. The burial position of all five individuals is strongly flexed, while three individuals have one hand placed on the head/face.

Osteological analysis of the remains was undertaken by Tacoma (1959). His findings also indicate similarities with the Malmok burial population, based on morphometrical characteristics of the skeletons. Specifically, the generally dolichocranic (long) and acrocranic (high in relation to breadth) shape of the Canashito skulls, a characteristic also observed among the Malmok skeletons was taken as evidence of some kind of association between the populations.

Malmok

Malmok is an Archaic Age cemetery site situated on north-western tip of Aruba, in the modern town of Malmok. The site is bordered by a salina to the east and the coast facing the Caribbean Sea to the west, ideally positioned to exploit a variety of ecological zones. A brackish water source was found around 1 km to the east of the site, which would have been partly supplied by rainwater, perhaps indicating the closest source of drinkable water in the vicinity of the site. Investigations at the site show that the cemetery was used during the first millennium A.D.

Although the site is considered to have functioned as a formal burial area, an oval shaped shell midden of approximately 20 m in length was found just north of the cemetery. The midden consisted of a very shallow deposit of food remains, and was thus thought not to have been the result of long-term exploitation of the area or permanent habitation at this location. Radiocarbon dating of shell material from

Site	Island/Country	Male	Female	Unknown	Child	Total
Anse à la Gourde	Guadeloupe	24	34	3	8	69
Argyle	St. Vincent			2		2
Argyle 2	St. Vincent	2		1		3
Buccament West	St. Vincent			1		1
Cañas	Puerto Rico		1	2		3
Canashito	Aruba	2	1	1		4
Chorro de Maíta	Cuba	26	26	3	18	73
Clarence town cave	Long Island, Bahamas	1	1			2
Collores	Puerto Rico		1		1	2
Coto	Puerto Rico			1		1
Diale 1	Haiti	2	3		2	7
El Cabo	Dominican Republic	1	1			2
Escape	St. Vincent	2	6	16	1	25
Esperanza	Vieques, Puerto Rico				1	1
Gordon Hill caves	Crooked Island, Bahamas	1		1		2
Hacienda Grande	Puerto Rico	1	1			2
Heywoods	Barbados		1	2		3
Higuey	Dominican Republic	1				1
Indian Creek	Antigua		1			1
Juan Dolio	Dominican Republic	3	4			7
Kelbey’s Ridge 2	Saba	1	2		3	6
La Caleta	Dominican Republic	1				1
La Mina	Vieques, Puerto Rico		1			1
Lavoutte	St. Lucia	11	10	7	3	31
Maisabel	Puerto Rico	15	8	3	6	32
Malmok	Aruba	1	1	2		4
Mamora Bay	Antigua			4		4
Manigat cave	Île de la Tortue, Haiti	1		2		3
Manzanilla	Trinidad	10	4		4	18
María de la Cruz cave	Puerto Rico			1		1
Monserrate	Puerto Rico	1		1		2
Point de Caille	St. Lucia	2	2			4
Punta Candelero	Puerto Rico	20	11	19	6	56
Punta Macao	Dominican Republic	6	6	3	4	19
Saladero	Venezuela			3		3
Santa Cruz	Aruba	1	1	2	2	6
Santa Elena (Toa Baja 2)	Puerto Rico		1		1	2
Santa Isabel (Cayito)	Puerto Rico	1				1
Savaneta	Aruba	2	3		2	7
Savanne Suazey	Grenada	2	2		1	5
Simon Beach	Grenada			1		1
Spring Bay 1c	Saba				1	1
Unknown	St. Croix, USVI	1				1
Unknown	St. Kitts	1		1		2
Tanki Flip	Aruba			2		2
Tocorón	Venezuela	3	1	2		6
Tutu	St. Thomas, USVI	6	14	1	5	26
Wemyss Bight cave	Eleuthera Island, Bahamas	1				1

Site	Island/Country	Male	Female	Unknown	Child	Total
Yauco 1	Puerto Rico			1		1
Total	**49**	**153**	**148**	**88**	**69**	**458**

Table 5.1 List of the samples per site.

the centre of the midden initially provided a date roughly contemporary with the dates obtained from shells from the cemetery area, however, at a later stage the investigators concluded that the midden area pre-dates the burials by at least two centuries. Open-plan excavation of the area revealed no soil features indicating any form of permanent structures (Versteeg 1991, 1993; Versteeg et al. 1990).

Skeletal remains

The cemetery area stretches approximately 200 m in north-south direction along the salina, and is around 50 m in breadth. In this area, 40 burials were excavated by Versteeg and Tacoma in 1989. Previously, two skeletons had been excavated in the same area by Diemont in 1968 (Versteeg 1991). In 1972 Boerstra excavated 16 skeletons. The individuals included in this study are derived from Boerstra's excavations. In total 60–70 burials had been identified at the site up to 1989 based on observations during both excavations, however not all individuals were excavated. Osteological analysis of the individuals recovered during the 1989 excavations was undertaken by Jouke Tacoma (Versteeg 1991, 1993; Versteeg et al. 1990).

Most individuals were buried on the side (usually the right side), in a strongly flexed position. A very small number of individuals were found in a flexed supine position. Over half of the individuals had one or both hands positioned on the head or face. The majority of skeletons were oriented in east-west direction, with the head directed toward the east. Around half of the excavated individuals had large amounts of red dye on or around the back of the cranium. Many burials were covered with a number of large limestone blocks which were procured in the close vicinity of the site, and a small number were buried on or under a turtle carapace. The investigators suggest that the stone grave coverings signified the social status of the individuals buried underneath (Versteeg 1991, 1993; Versteeg et al. 1990).

The burials were distributed over the entire cemetery area, although several clusters were distinguished. One cluster comprising seven burials in close proximity to one another was found in the northern part of the site. A similar cluster of ten burials was found in the southern part of the site. Smaller 'satellite' clusters comprising two to five individuals were found around the larger southern cluster. Most clusters were comprised of a central male figure, around which females and other males were placed, leading the investigators to suggest that the clusters reflect household or band ties, with the central males likely being band headmen. The spatial patterning was thought to have resulted from the different successive headmen marking their own space within the cemetery area (Versteeg 1991, 1993; Versteeg et al. 1990).

Santa Cruz

Santa Cruz is a primarily Late Ceramic Age (Dabajuroid) habitation site covering around 10 hectares and located approximately halfway between the windward an leeward coasts of Aruba, close to and between the contemporaneous sites of Tanki Flip and Savaneta. While most radiocarbon dates indicate the main period of use of the site was during A.D. 950–1250, it is thought to have been inhabited up to the arrival of the Spaniards in the early 16th century. The site is situated near the confluence of two guts (rooien), on arable land, making this area particularly attractive for agriculture in the dry Aruban environment (Versteeg 2001).

Skeletal remains

Human skeletal remains were recovered at the site during excavations by Boerstra in 1971 and by Versteeg in 1991–1992. Looters are thought to have disturbed and damaged some of the burials, and some skeletal remains (particularly skulls) may have been removed.

Excavations by Leiden University and the Archaeological Museum Aruba in 1991–1992 under the direction of Aad Versteeg uncovered 31 burial features in nine clusters. Many burial features contained the skeletal remains of multiple individuals. Burial position and orientation was variable, and a relatively large number of the graves contained burial goods, often items of personal adornment (Versteeg 2001). Osteological analysis of these remains was undertaken by Jouke Tacoma.

The individuals included in this study are thought to derive from the excavations by Boerstra in 1971 (Raymundo Dijkhoff, personal communication 2010).

Savaneta

Savaneta is a primarily Late Ceramic Age (Dabajuroid) habitation site located on the south-western coast of Aruba. It is one of the largest Late Ceramic Age sites on the island, together with the contemporary village sites of Santa Cruz and Tanki Flip. The main occupation of the site is thought to have taken place between A.D. 950–1250, but there is evidence that it was still in use upon the arrival of the Spaniards in the early 16th century. The site is situated on a limestone substrate, in the middle of an area with some of the best land for agriculture in the south of Aruba (Versteeg 2001; Versteeg and Rostain 1997; Versteeg and Ruiz 1995). Human skeletal remains were recovered at the site during excavations by Boerstra in the early 1970's. Sadly, most of Boerstra's field notes and reports were lost in a fire, meaning little information on the context of these remains is available (Raymundo Dijkhoff, personal communication 2010).

Tanki Flip

Tanki Flip is a primarily Late Ceramic Age (Dabajuroid) habitation site in the north-western part of Aruba around 3 km form the west coast, and is one of the largest ceramic age sites on the island, together with the contemporary sites of Santa Cruz and Savaneta. The main occupation of the site is thought to have taken place between A.D. 950–1250, although it may have been in use up to the arrival of the Spaniards in the early 16th century (Versteeg 2001; Versteeg and Rostain 1997). Excavations at the site were undertaken by Leiden University and the Archaeological Museum of Aruba in 1994–1995, under the direction of Aad Versteeg. Thirteen oval and circular house structures were reconstructed, based on spatial patterning of the documented postholes. The site is situated on moisture-retaining diorite subsoil, making it particularly suited to agriculture in the predominantly dry Aruban environment. The site borders a number of guts (rooien) to the north, south and west. At least one gut and a number of its sub-channels and gullies appear to be man-made, suggesting the inhabitants of the site actively engaged in irrigation of the site surroundings for agricultural purposes. Next to being an ideal location for agriculture, the site is located only 3 km from the coast, allowing easy access to marine resources (Versteeg and Rostain 1997).

Skeletal remains

Seven burial features containing human skeletal material belonging to 15 individuals were excavated during the 1994–1995 excavations. The degree of diversity in burial practices at the site is striking. Most features contained the remains of multiple individuals. Some features contained inverted 'burial urns', associated with either adults or children. One feature comprised a burial urn covered by an inverted bowl with the skeletal remains of at least 7 individuals inside. Four of the 7 graves were associated with one of the house structures. Earlier excavations at the site under the direction of E. Boerstra in 1977 also uncovered the remains of a large number of human skeletons (Versteeg and Rostain 1997). The individuals included in this study were most likely derived from these excavations (Raymundo Dijkhoff, personal communication 2010).

5.2.2 Antigua

Indian Creek

Indian Creek is a multi-component Ceramic Age habitation site located on a gentle slope just west of a creek of the same name in south-eastern Antigua, around 800 m from the coast (Faber Morse and Rouse 1997). The site is characterized by five large mounded middens which are not contemporaneous, but represent occupation of the site from A.D. 35–1305 (Faber Morse and Rouse 1997; Nicholson 1994; Petersen et al. 1999; Rouse 1974; Rouse and Faber Morse 1999).
Large scale excavations at the site in 1973 by Yale University and the Antigua Archaeological Society under the direction of Benjamin Irving Rouse, revealed the site was occupied during three distinct phases throughout the Early and Late Ceramic Ages, characterized by pottery complexes: Indian Creek (A.D. 1–600), Mill Reef (A.D. 600–900), and Mamora Bay (A.D. 900–1100) (Faber Morse and Rouse 1995, 1997; Nicholson 1994; Rouse 1974; Rouse and Faber Morse 1999). Most deposits pertain to the Indian Creek phase.

Skeletal remains

The Yale Peabody Museum of Natural History, New Haven, Connecticut, holds the fragmented remains of an adult human skeleton of unknown sex (catalogue number: ANTPA 254343), which were recovered from Excavation 6, level 3, section P2 of the Indian Creek site. No human burials or bone fragments are mentioned in any publications on the site, which may be due to the fact that Rouse was taken ill at the time of the excavation of this pit, and consequently very little is known of the context of materials recovered from it (Rouse 1974; Rouse and Faber Morse 1999). It is known, however, that levels 3 to 6 of this pit pertain to the Indian Creek period of occupation of the site, and therefore the remains of the single individual incorporated into this study can be assigned to this period, i.e., the Early Ceramic Age (Rouse and Faber Morse 1999).

Mamora Bay

Mamora Bay is a multi-component Ceramic Age habitation site located on the south-eastern coast of Antigua, close to the site of Indian Creek, which lies to the west of Mamora Bay. The site gave its name to the Mamora Bay ceramic complex, which is the most common pottery found at the site. Due to its similarities to Santa Elena style pottery from eastern Puerto Rico, Rouse placed the Mamora Bay complex in the Elenoid series, i.e., the Late Ceramic Age. The main period of habitation at the site took place between A.D. 900–1200 (Faber Morse and Rouse 1999; Murphy 2004; Nicholson 1994; Rouse 1976). The site was discovered in 1960 by Fred Olsen and subsequently excavations under the direction of Charles Hoffman took place prior to the construction of a The Mamora Bay Hotel in 1963. During these excavations a small number of human skeletal remains were uncovered. Burial positions were semi-seated, with the legs drawn up to the chest (Nicholson 1994).

5.2.3 Bahamas

Clarence Town caves, Long Island

The Clarence Town caves are situated close to Clarence Town along the north-eastern coast of Long Island, the Bahamas. Excavations at the site by Froelich G. Rainey took place in 1934 (Yale Peabody Museum of Natural History archive). Rainey unearthed the skeletal remains of two individuals in the caves (an adult male and an adult female), which he interpreted to have served both as a habitation and burial area (Drew 2009; Yale Peabody Museum of Natural History archive). Since the Bahamas were not populated until the Late Ceramic Age (around A.D. 700–1500), the skeletal material is assumed to pertain to this period (Keegan 1982; Morsink 2012).

Gordon Hill caves, Crooked Island

The Gordon Hill caves are situated along the north-eastern coast of Crooked Island. The caves are positioned on a limestone ledge about 500 m from the shore.

Excavations at the site by Froelich Rainey took place in 1934. During extensive excavations covering 47 m2, Rainey unearthed the skeletal remains of three individuals in two different chambers of the caves (Granberry 1978). Since the Bahamas were not populated until the Late Ceramic Age (around A.D. 700–1500), the skeletal material is assumed to pertain to this period (Keegan 1982; Morsink 2012).

Skeletal remains
Two adult inhumations were uncovered in chamber 1 (these are the individuals incorporated into this study), and another in chamber 3. The burials in chamber 1 consisted of two primary depositions. One individual was found on its left side, with the legs partially flexed, and the hands placed on the pelvis. The other skeleton, found at the south end of the cave, was highly damaged and burial position was not recorded (Granberry 1978).

Wemyss Bight caves, Eleuthera Island

The Wemyss Bight cave is located close to the town of Wemyss Bight, on the western coast of the southern tip of Eleuthera Island, the Bahamas. Excavations at the site by Froelich G. Rainey took place in 1934 (Yale Peabody Museum of Natural History archive). Rainey unearthed the skeletal remains of a single adult male in the caves (Drew 2009; Yale Peabody Museum of Natural History archive). Since the Bahamas were not populated until the Late Ceramic Age (around A.D. 700–1500), the skeletal material is assumed to pertain to this period (Keegan 1982; Morsink 2012).

5.2.4 Barbados

Heywoods

Heywoods is a multi-component habitation site located along the western shore of the northern tip of Barbados. The occupation of the site spans the Archaic Age through to the Late Ceramic Age which is characterized at Heywoods by Suazoid ceramics (Drewett 1993). During the Early Ceramic Age (Saladoid) occupation the site developed into a large village. Three round house structures dating to the Saladoid/Troumassoid period have been identified, yielding the waterlogged remains of wooden posts. A number of burials were associated with the house structures in the Saladoid portion of the site, and a number of burials were found in the Late Ceramic Age (Suazoid) part of the site. Construction work at the site revealed a remarkable number of stacked pottery deposits, which would have functioned as wells, trapping freshwater. Most of the pottery stacks seem to date to the terminal (late) Saladoid (A.D. 400–600/800), although they appear to have been in use for a few hundred years at least. One of the pottery stack wells had been used as a grave pit for the burial of an individual dated to A.D. 210–420 (Drewett 1991; Drewett and Bennell 2000).

Skeletal remains

Human skeletal remains were excavated at the site during a number of consecutive field seasons between 1995–1999 under the direction of Peter Drewett and Maureen Bennell. Burial positions are generally flexed, supine, with the legs drawn up to the chest. Grave goods are extremely rare, with only one (Suazoid) burial yielding grave goods in the form of two stone beads which were apparently worn on the chest (Drewett and Bennell 2000).

The three individuals included in this study were excavated during the 1998–1999 field season. During this season a large 95 x 25 m area of the site was excavated. This part of the site contained an area of Saladoid habitation, and an area of Suazoid use. It is unclear where precisely the three individuals studied here were located within the 1998–1999 unit, and thus is it unclear to which phase of occupation they belong (Drewett and Bennell 2000).

5.2.5 Cuba

Chorro de Maíta

Chorro de Maíta is a habitation and cemetery site located in the province of Holguín, approximately 4 km from the northeast coast of Cuba on the slope of a hill known as Cerro de Yaguajay. The site belongs to the cultural type known locally as Etapa agroalfarera (Tabio and Rey 1984) or Fase agricultores (Guarch Delmonte 1988). Ceramics found at the site belong to a local variant of the Meillacan Ostionoid subseries (Rouse 1992; Valcárcel Rojas 2002), however the site and cemetery are known to have been used up to and during the Contact period (in the 16th and 17th centuries). The focus of studies and excavations at the site has been the cemetery area in the central western part of the site, although some non-funerary spaces were also investigated. In both areas, small quantities European materials, primarily ceramics and pig remains were found together with indigenous materials (Guarch Delmonte 1996). European ceramics known to have been used between A.D. 1490–1650 have been recovered in recent investigations of non-funerary spaces (Persons et al. 2007; Valcárcel Rojas et al. 2007).

Skeletal remains

Recent osteological analysis of the skeletal material from the site by Darlene Weston revealed a total of 133 individuals (Valcárcel Rojas et al. 2011; Weston in prep.). Seventy three individuals are incorporated into this study (the disparity in numbers is due to the lack of dental material in many individuals). European materials (i.e., metals) were found in some of the burials, and a number of individuals were found in an extended supine position as opposed to the typical flexed position found in most pre-Columbian Amerindian burials in Cuba and the Caribbean in general. Furthermore, some highly elaborate bodily ornaments have been recovered from a small number of the graves. The restricted distribution of these ornaments has been interpreted as an indication of clear social differentiation at the site, perhaps associated with the cacical elite (Valcárcel Rojas and Rodríguez Arce 2005).

Radiocarbon dates and other contextual information have been used in an attempt to define temporal variation in the burial populations of the site. Most radiocarbon dates, however, span the period immediately before and immediately after contact (cal. A.D. 1420–1640), and therefore do not help distinguish pre-Columbian individuals from Contact period individuals. Based on the presence of European materials in some burial pits, and the burial of a number of individuals in a 'Christian type' position (extended, sometimes with the arms folded over the chest), 32 individuals can clearly be placed in the Contact period occupation. The remaining individuals cannot be securely placed in the pre-Columbian period based only on the lack of European influences in the mortuary treatment, and Valcárcel Rojas has suggested that there is a distinct possibility that the entire burial population pertains to the Contact period (Valcárcel Rojas 2012). For these reasons, comparison of early and later patterns of dental wear and pathology at Chorro de Maíta are not deemed possible, making an estimation of changes in diet and subsistence over time impossible.

5.2.6 Dominican Republic

El Cabo

El Cabo is a Late Ceramic Age habitation site on the coast of the eastern tip of the Dominican Republic. The site was occupied from around A.D. 850 to approximately two decades after first contact with Europeans. Excavations at the site revealed a very large number of postholes cut into the bedrock, allowing the reconstruction of over fifty round structures, many interpreted as houses (Samson 2009, 2010, 2011). El Cabo would have comprised a town consisting of a number of clusters of houses arranged along the coastline (Samson 2009, 2010, 2011).

Skeletal remains

Four human burials were uncovered at the site. One consisted of the deposition of a neonate (84-29-F261) in a posthole dug into the bedrock. Three other burials of adult individuals were found, one within the confines of house 6 (although association with this structure is unclear), and two in the midden areas (Samson 2010). None of the skeletons have been radiocarbon dated, however based on their contexts they are thought to post-date the 10th century. One of the burial pits, 85-34-F06, contained a deep pink bead, made of Chama sarda shell. This individual was found in flexed position in a small oval burial pit dug into the Ostionoid midden of the site and the underlying the bedrock in the northern part. A boat-form vessel was recovered in an earlier field season, which was later thought to have been associated with this individual. Individual 85-40-F17 was interred in a small, pit covered with stones. This person was interred in a flexed position. Finally, burial 85-31-F01 was found in an oval burial pit cut into the bedrock in the northern part of the site (Samson 2010).

Higuey

This represents the incidental find of a single pre-Columbian human cranium obtained from a private collector (Dario Yune), and found somewhere near the modern day city of Higuey in the eastern Dominican Republic, approximately 35 km from the site of El Cabo to the (south)east. The cranium is currently housed at the Museo del Hombre Dominicano, Santo Domingo. The precise provenance and context of this individual is unknown, although it is thought to pertain to the Late Ceramic Age occupation of the region (Glenis Tavarez María, personal communication 2011).

Juan Dolio

Juan Dolio is a Late Ceramic Age habitation site, located on the southern coast of the Dominican Republic, approximately 70 km to the east of the capital city of Santo Domingo. It is known as one of the most important Boca Chica complex sites in the southern and south-eastern Dominican Republic, however, as excavations at the site focused predominantly on the cemetery area little is known about the house structures and material culture at the site. The large number of skeletal remains uncovered at the site during excavations in 1974 reportedly date predominantly late 15th century (Drusini et al. 1987; Veloz Maggiolo 1972).

Skeletal remains

One hundred and two burial contexts were identified during excavations at Juan Dolio under the direction of Fernando Luna Calderón in 1974, however, many of these individuals were comprised of only a few fragmentary bones. Further analysis of the skeletal assemblage yielded and estimated MNI of 78 persons, of which 31 adult males 29 adult females, 18 individuals of unknown sex, and 11 juveniles (Drusini et al. 1987; Veloz Maggiolo 1972).

La Caleta

La Caleta is a multi-component habitation site with a large burial population situated in the town of La Caleta, approximately 17 km east of Santo Domingo, Dominican Republic. The site was inhabited during the Archaic Age, with radiocarbon dates indicating occupation at 545 B.C., and throughout the Early and Late Ceramic ages, with the most recent radiocarbon dates at A.D. 1280 (Morbán Laucer 1979; Ortega 2005). Numerous excavations have been undertaken at the site over the years, uncovering at least 373 human skeletal remains (Morbán Laucer 1979). Most of the latter were excavated in 1970–1971 by Chanlatte Baik and Morbán Laucer among others.

Skeletal remains

The human skeletons excavated at La Caleta are now housed at the Museo del

Hombre Dominicano, Santo Domingo. At some point in the 1980's the dentitions (including mandibles and maxillae) of most of these remains were removed for a dental study by Morbán Laucer, and their current whereabouts is unknown. For this reason, only a single adult male individual is included in this study, as the teeth of this person were still present.

Individuals were interred both as primary and secondary depositions in the midden area and other parts of the site. Primary interments consisted mainly of flexed, supine skeletons, with the legs drawn up to the chest. In a small number of cases, individuals were interred in a seated, flexed position. A large number of juvenile skeletons (foetuses and infants) were recovered from the site. In one case, two juveniles pertaining to the Ostionoid occupation of the site, were found buried with seven ceramic vessels of different sizes and a dog. Other grave goods include sherds of Ostionoid pottery, stone axes, shell amulets and vomiting spatulas, and the remains of marine foods. Secondary burial of juveniles sometimes consisted of interment in a ceramic vessel. Some individuals, both adults and juveniles, were found buried with a ceramic vessel placed over the head and/or face (Morbán Laucer 1979).

Punta Macao

Punta Macao is a multi-component but predominantly Late Ceramic Age habitation site on the north-eastern coast of the Dominican Republic, in the province of La Altagracia. The site is situated on a rocky promontory called El Morro, and is near the modern day town of Macao. The site is mentioned in Las Casas' Apologética Historia, in which he claims to have visited the town and notes that a large population inhabited the area (de las Casas 1992; Olsen 2004). Excavations at the site were undertaken by De Booy in 1915, Rainey in the 1940's, Veloz Maggiolo and Ortega in 1972, and a team from the Museo del Hombre Dominicano in 2004. The site has been extensively looted over the decades (Atiles 2004; Olsen 2004; Veloz Maggiolo and Ortega 1972).

Evidence for a number of round (house) structures was found at the site, with postholes cut into the underlying bedrock, similar to those documented at the Late Ceramic Age site of El Cabo, Dominican Republic, and the Ceramic Age site of Anse à la Gourde, Guadeloupe (Menno Hoogland, personal communication 2012; Hofman et al. 2001b; Samson 2010).

Skeletal remains

Fifteen burial pits containing the remains of 26 individuals were excavated by the Museo del Hombre Dominicano in 2004. Most burial pits contained the remains of a number of individuals, who seemed to have been deposited simultaneously in primary depositions. The majority of the individuals were males (11) and juveniles (8), with only 6 females present. Bodies were generally interred in small round or oval burial pits in supine positions, or reclined on the side. All skeletons were flexed, with the legs drawn up to the chest. Grave goods were rare: in total 9 individuals were found with materials, mostly ceramic fragments, faunal remains, and unworked lithics. Burial 2 was found interred with a large Chicoid ceramic vessel placed upside down on the head. The majority of the burials were located in the southern part of the site, leading investigators to suggest this part of the site comprised the cemetery area. Many burials remained unexcavated in this part of the site, which has since been transformed into a golf course (Atiles 2004; Olsen 2004; Tavarez María 2004).

Radiocarbon dates were obtained for three of the skeletons (it is not clear which three) excavated in 2004 (Table 5.2). These dates, along with ceramic finds associated with the burials, indicate a predominantly Late Ceramic Age, Ostionoid and Chicoid, chronology for the burials. However, some Spanish colonial ceramics (majolica) were found in the cemetery area of the site, perhaps indicating that the cemetery was still in use during the early contact period. The precise relation between these ceramic remains and the burials is unclear.

Burial	Lab code	uncal. B.P.	cal. A.D. 2σ
?	1-Beta-198072	790 ±60	1160–1300
?	5-Beta-198073	1240 ±40	640–770
?	6-Beta-198074	1070 ±40	820–1030

Table 5.2 Punta Macao radiocarbon dates of human skeletal remains (Hofman et al. 2007).

5.2.7 Grenada

Savanne Suazey

Savanne Suazey is located on the north-eastern end of Grenada. The site is comprised of three distinct physical environments, an elevated area in the north, a medium elevation in the south, and a low valley in between which extends toward the beach. The ceramic assemblage recovered from the site was characterized by Bullen (1964) as belonging to the Suazey series, with a small Caliviny component, which he thought to be earlier than the Suazey material. The southern part of the site, where five human burials were found, is considered to have been used to a much later date, with fragments of iron and Spanish olive or olive oil jars indicating the site was occupied in the Contact period. The site is thought to have been inhabited by Amerindians during the early colonial period, and some of the Suazey pottery – Suazey Finger Indented – was assigned to the colonial period occupation (Bullen 1964). Later, both Suazey and Ciliviny were assigned the same chronological period, and identified as perhaps representing a ceremonial wear and common wear belonging to the same series (Bullen and Bullen 1972). Later still, Suazey was no longer recognized as a distinct series, but as a continuation of many Troumassoid traits, and was therefore allocated to the subseries Suazan Troumassoid. Caliviny was considered by many to be merely a decorative mode, which persists over an extended period of time throughout the Late Ceramic Age (Bright 2011). Currently, many researchers have realized that the distinctions between the earlier Troumassan Troumassoid and the later Suazan Troumassoid are much less apparent than originally thought, and most pottery originally classified as one of these subseries is now all placed under the nomer of 'Suazoid'.

The site thus dates to around A.D. 1000–1500, i.e., the Late Ceramic Age, but potentially existed well into the colonial occupation of the island in the 17th and even 18th centuries (Bullen 1964).

Skeletal remains

Five individual skeletons were excavated at the site, all of which potentially date to the period spanning first contact with Europeans. Nonetheless, burial practices and grave goods all appear indigenous, with all five individuals buried in small pits in flexed positions, and grave goods consisting only of stone beads found with two individuals.

The skeletal remains were in poor, fragmentary condition. Osteological analysis was performed by Adelaide K. Bullen, William F. Enneking, J.L. Kirkland, and L.J. Marchand. This analysis revealed a high percentage of caries in all individuals, which Bullen interpreted to possibly be the result of the introduction of sugar cane to the island in the 17th century (Bullen 1964:13–17).

Simon Beach

Simon Beach is an Early Ceramic Age habitation site on the east coast of Grenada. Bullen (1965) characterizes the site as a pre-Arawak habitation site that was purposefully selected for is proximity to good agricultural land, with Saladoid-Barrancoid pottery (or Modified Saladoid) (Boomert 2000; Bullen 1965). A single human skeleton, presumably excavated by Ripley P. and Adelaide K. Bullen, is currently stored at the Florida Museum of Natural History, Gainesville (catalogue no. 98025).

5.2.8 Guadeloupe

Anse à la Gourde

The multi-component Ceramic Age habitation site of Anse à la Gourde is located on the eastern tip of the limestone island of Grand-Terre, Guadeloupe. The site, which covers approximately 4.5 hectares, is situated on the lower coastal limestone terrace in a large bay facing north into the Atlantic Ocean. It seems that its location was strategically selected for maritime activities such as travel to other locations and fishing (Delpuech et al. 1999; Hofman and Hoogland 2011).

A number of occupation phases, between roughly A.D. 400–1400, are distinguished at the site based on ceramic styles and radiocarbon dates. The Early Ceramic Age occupation of the site dates to around A.D. 400–600/800, and is represented by a Cedrosan Saladoid ceramic assemblage. The parts of the site pertaining to the

Saladoid period are located closer to the sea, and have been severely damaged by coastal erosion. The presence of burnt house posts and ash layers suggest that the site was suddenly abandoned after the Saladoid period, and was later re-occupied. In the period around A.D. 600–1000 the coastal environment changed due to a rise in sea level (Delpuech et al. 1999; Hofman and Hoogland 2011; Hofman et al. 1999; Hofman et al. 2002). The Late Ceramic Age at Anse à la Gourde spans the period between cal. A.D. 900–1400. Radiocarbon dates indicate this period of occupation can be divided into three main phases: cal. A.D. 900–1100, cal. A.D. 1100–1250, and cal. A.D. 1250–1350. Throughout these phases the ceramic assemblage is characterized by Mamoran/Troumassan Troumassoid to early and late Suazan Troumassoid materials. Some ceramics displaying Cayo and Morne Cybele traits were recovered (Delpuech et al. 1999; Hofman et al. 1999, 2001b). The ceramics revealed a great diversity of influences from both the northern and southern Lesser Antilles, which the investigators interpret as the result of the site's unique position in a "transition zone between two influence spheres, where ceramic styles of different origins amalgamated" (Hofman and Hoogland 2011:26).

The remains of around 24 round and oval houses, ranging between 5 and 12 m in diameter were found at the site in the form of postholes which were carved into the underlying bedrock. The houses were extremely densely spaced within the occupation area, most likely indicating the rebuilding of the same house structures at the same location over time. The settlement or village area, comprising the remains of houses, hearths and refuse pits, drying racks, hammock supports and barbacoas, encircled what would have been an open place at the centre, which likely functioned as a plaza. The village area was surrounded by a doughnut-shaped refuse midden (Hofman and Hoogland 2011).

Artefacts recovered from the site include exotic materials and objects, such as a range of lithic artefacts such celts, axes, adzes, scrapers and polishing stones of non-local origin (Knippenberg 2006). Some ceremonial objects showed similarities to those found in Late Ceramic Age cultures of the Greater Antilles (Hofman and Hoogland 2011).

Skeletal remains

Approximately 83 graves containing a total of 92 individuals were excavated at Anse à la Gourde. Human skeletal remains excavated at the site pertain only to the Late Troumassoid period occupation (A.D. 1000–1350). Radiocarbon dates of most burials fall between A.D. 1000–1400 (Menno Hoogland, personal communication 2012). The graves were located within the habitation area, and were distributed in clusters of 3 to 10 individuals. Many graves were closely associated with the postholes dug into the bedrock, most likely indicating that some individuals were buried under the floors of the houses, or just outside a house structure. Some individuals were interred in postholes, perhaps indicating household ties with older (ancestral) constructions (Bright 2003; Delpuech et al. 1999; Hofman and Hoogland 2011; Morsink 2006). A great variety in mortuary treatment of the dead was observed at Anse à la Gourde, with primary, secondary, single and composite burials, and post mortem manipulation of the remains. In many cases the dead seem to have been wrapped in some kind of perishable container (most likely a hammock), sometimes after the body was desiccated. There are indications that many individuals were interred in an open or partially open grave. The pit remained open during (at least part of) the decomposition of the soft tissues. At a later stage, certain bones were removed or reburied (Hofman et al. 2001a, 2001b; Hofman and Hoogland 2011; Hoogland et al. 1999).

The burial population is largely comprised of adults, with children clearly underrepresented. The excavators interpret this as a reflection of clear differences in social status between children and adults. Children were most likely disposed of in a different manner or buried elsewhere (Hofman and Hoogland 2011). Based on stable isotope studies, a large proportion of the adults were found to be of non-local origin (Hoogland et al. 2010; Laffoon 2012; Laffoon and de Vos 2011). Some differentiation in burial gifts was observed, with some non-local individuals being buried with materials of non-local origin (e.g., greenstone artefacts from St. Martin, flint from Long Island, Antigua) (Hofman et al. 2001a, 2001b; Hofman and Hoogland 2011; Hoogland et al. 1999).

Stable isotope analysis of human bone collagen samples from Anse à la Gourde found indications of a mixed diet of terrestrial food resources combined with an extensive amount of reef fish estimated at around 50%), with the rest of the protein being obtained from terrestrial C3 sources. No differences were found between males and females (Laffoon 2012; Laffoon and de Vos 2011; Stokes 1998).

5.2.9 Haiti

Diale 1

Diale 1 is a Late Ceramic Age habitation site located in the Fort Liberté area on the south-eastern shore of the large Baie de Fort Liberté, in north-eastern Haiti. The site is characterized by 29 large mounded shell middens and Meillacoid pottery. Rainey excavated a large part of middens 1, 2, 5, 6, 8, and 17 in 1934–1935. Some human burials were excavated in the 1934 field season. The following year excavations in midden 5 produced a number of human burials, which were deposited in the shell refuse layer all within 50 cm from the surface (Rainey 1941; Rouse 1939).

Skeletal remains

Burial 1 contained the remains of an adult female in flexed position lying on the left side, next to a juvenile whose burial position could not be determined due to damage. Burial 2 likewise contained the remains of two individuals, both primary interments of adult males in flexed positions. Burial 2 also contained some secondary bone deposits, and an intact ceramic vessel. Burial 3 contained the remains of an adult female in supine, highly flexed position. Burial 4 consisted of the remains of an infant, interred in extended supine position. Burial 5 was a secondary deposit of an adult (Rainey 1941; Rouse 1939).

Manigat cave, Île de la Tortue

The Manigat cave is located on the southern coast of Île de la Tortue, a small island around 6 km north of the north-western coast of Haiti. The cave is situated at 4 mamsl in a limestone rock formation, only 8 m from the shore. The cavern is around 11 x 8 m large, and roughly circular in shape. Excavations led by Paul Barker took place in the cave in 1959–1960. Over 50.000 human bones and bone fragments were recovered from the cave, and although the precise number of individuals was difficult to determine, Barker mentions at least 168 individuals. The cave yielded only a small assemblage of pottery (mostly undecorated), however, Barker suggests that it appears similar to Meillacoid pottery collected by Rouse in Cuba (Barker 1961).

Skeletal remains

Barker uncovered an enormous amount of human bone material from the Manigat cave in 1959–1960. Most of the material was disarticulated and dispersed across the cave. Barker indicates finding evidence for both primary and secondary burial, despite the disarray in which the remains were found. He established a MNI of 168 based on the number of complete mandibles that were found. The material was thoroughly studied, with particular attention for pathological conditions (including dental pathology), and demographic composition. Barker notes a high frequency of caries and ante mortem tooth loss. He also mentions large accumulations of dental calculus, which was present in many of the recovered dentitions.

Barker furthermore notes that the number of juvenile remains is relatively low, where he expected it to be high “dans les cultures primitives” (Barker 1961:54). He suggests either low infant mortality, disposal of juvenile remains in another manner, or poor preservation of small juvenile bones as potential causes.

5.2.10 Puerto Rico

Cañas

Cañas is a large, multi-component Ceramic Age habitation site located on the south central coast of Puerto Rico, in the municipality of Ponce. The results of large scale excavations at the site in 1934 led by Froelich G. Rainey played a key role in the development of his Crab–Shell culture dichotomy theory. Rainey found clear stratigraphic differences between deposit layers of predominantly crab remains associated with elaborated decorated white-on-red painted pottery, and layers of mainly shell remains associated with unpainted, rough, incised pottery at Cañas, and subsequently at the sites of Coto and Monserrate too. This led him to conclude the two ‘cultures’ represented two phases of occupation of Puerto Rico. Later work revealed that the association of food remains and pottery styles was a local phenomenon (Rainey 1935, 1940; Rodríguez Ramos 2010; Rouse 1952b).

Skeletal remains

Rainey excavated 24 skeletons from the mounded midden areas of the site in 1934 (Crespo Torres 2010; Rainey 1940; Rouse 1952b). The two individuals included in the study here are derived from the earlier 'Crab culture' occupation phase, or in other words, the Saladoid period (Drew 2009). The location of the remaining 22 skeletons is unclear.

Burial practices observed by Rainey consisted mainly of primary flexed interment, although he mentions a small number of primary extended burials. Also, there were a few secondary interments. None of the burials yielded grave goods (Rainey 1940; Rouse 1952b).

Collores

Collores is a multi-component habitation site located in the municipality of Juana Díaz, along the south central coast of Puerto Rico. Excavations were undertaken there by Froelich G. Rainey in the 1930's (Rouse 1952b). The surface of the site is covered with marine food refuse and pottery sherds. Rainey found two large mounded middens containing charcoal, shell, faunal remains, and predominantly Ostiones style pottery. Two burials were encountered in the lowest layer of Midden A (Rouse 1952b).

Skeletal remains

The two individuals included in this study pertain the Early Ceramic Age ([late] Saladoid) occupation of the site, based on Cuevas style pottery found with one individual, and observations by Rainey on the stratigraphic position of the other ('red culture layer'). The first burial consists of an adult female in flexed position on the left side. The second consists of the poorly preserved remains of an infant which were found close by (Drew 2009; Rouse 1952b).

Coto

Coto is a large, multi-component Ceramic Age site located on a low hill on the northwest coast of Puerto Rico, between the city of Isabela and the mouth of the Guajateca river, in the municipality of Isabela. The site had already been extensively looted by the time Froelich G. Rainey started large scale excavations there in 1934. Similar to the sites of Cañas and Monserrate, he identified different cultural layers which he assigned to the 'Crab culture' and the 'Shell culture' (Rainey 1940).

Skeletal remains

Rainey uncovered 60 burials from highly disturbed (due to looting and slope erosion) refuse deposits and the sterile subsoil of the site in 1934 (Crespo Torres 2010; Rainey 1940; Rouse 1952b). The single individual included in the study here is derived from the later 'Shell culture' occupation phase, or in other words, the Late Ceramic Age. The location of the remaining skeletons is unclear.

Burial practices consisted mainly of primary flexed interment, on the side or back, and in one case in prone position. Rainey observed that many of the bodies appeared to have been tightly bound upon burial. A single secondary 'bundle of sticks' burial was found. Also, a single urn burial of an infant was recovered, which Rainey interpreted as a secondary interment, since the vessel would have been too small to contain the fleshed remains of a child. Three burials were found with intact pottery vessels, and a number of artefacts of worked bone and stone, and beads were found associated with the skeletons (Rainey 1940).

Esperanza, Vieques

This represents the incidental find of juvenile human skeletal remains during excavations prior to works on the sewer system on the site of Esperanza, on the south coast of the small island of Vieques to the east of Puerto Rico. Previous finds close by include numerous human burials, stone artefacts, and shell middens. Ceramic materials at the site formed the basis for the identification of the Esperanza ceramic style of the Chican Ostionoid subseries of Eastern Puerto Rico (Rouse 1952b).

Hacienda Grande

Hacienda Grande is a multi-component Ceramic Age habitation site in north-eastern Puerto Rico, around 25 km east of San Juan by the mouth of the river Loíza. The site lies between two hills at a distance of approximately 2 km from the north-eastern Atlantic coast, and is bordered to the south by the Old Oxbox lake, which would have provided fresh water to its inhabitants (Roe 1985; Rouse and Alegría 1990). The site gave its name to the Hacienda Grande ceramic complex of the Cedrosan Saladoid, as it served as the type site for this style. The Hacienda Grande period of occupation at the site dates to between 200 B.C. and A.D. 400 (Rouse and Alegría 1990).

Excavations at the site focused mainly on the midden areas, and attempted to deal with the extensive stratigraphic damage to the site due to looting, agricultural ploughing, and the use of the area as a coconut plantation. As a result, little is known about the house structures and village layout (Roe 1985; Rouse and Alegría 1990).

Skeletal remains

Skeletal material has been excavated at Hacienda Grande during various excavations by trained archaeologists, amateurs, and looters over the last century or so (Roe 1985; Walker 1985). The current whereabouts of much of this material is unknown, such as the 18 skeletons excavated at the site by Alegría in 1948 and 1954. The two individuals included in the current study are housed at the Laboratory of Forensic Anthropology and Bioarchaeology at the University of Puerto Rico. It is unclear from which excavations these individuals are derived, and it is therefore not possible to assign them to a particular phase of occupation (Hacienda Grande, although type site for the early Saladoid pottery of the same name, is a multi-component habitation site, presumably including burials related to the Ostionoid period). It is possible, however, that these two individuals are derived from the later period of occupation of the site, i.e., post-Hacienda Grande period, as both crania display modification in the fronto-occipital parallel type (Anne van Duijvenbode, personal communication 2011), which has been suggested to have been a post-Hacienda Grande phenomenon, possibly related to the La Hueca culture (Crespo Torres 2005a; Rodríguez Ramos 2010).

La Mina, Vieques

La Mina is located around 500 m from the site of Esperanza, on the south coast of the small island of Vieques to the east of Puerto Rico. The site is characterized by a number of shell middens of varying sizes. During excavations in 1938 Rouse recovered predominantly Santa Elena style pottery of the Elenan Ostionoid subseries, and subsequently placed the site in the his Period IIIb, or around A.D. 1300–1400 (Rouse 1952b). A single pre-Columbian human skeleton from La Mina is currently housed at the Yale University Peabody Museum of Natural History, New Haven, Connecticut. The context of this skeleton is unknown.

Maisabel

Maisabel is a multi-component Ceramic Age habitation site located on the central-northern coast of Puerto Rico, approximately 30 km to the west of San Juan. Initial excavations at the site by Ovidio Dávilla in 1979–1980, of the Instituto Cultura Puertorriqueña, revealed a large Saladoid component, with several middens. Dávilla excavated the largest Saladoid midden deposit. In 1985 Peter Roe conducted large scale excavations at the site in cooperation with the Centro de Estudios Avanzados de Puerto Rico y el Caribe (CEAPR) and the Centro de Investigaciones Indigenas de Puerto Rico (CIIPR). Later excavations under the direction of Peter Siegel, together with the CIIPR, revealed Saladoid (Hacienda Grande [100 B.C. – A.D. 400] and Cuevas [A.D. 400–600]) and Ostionoid (Monserrate [A.D. 600–900] and Santa Elena [A.D. 900–1200]) components, showing the site was occupied continuously for approximately 1200 years (Siegel 1992, 1996).

A large roughly rectangular plaza and cemetery area, measuring approximately 90 x 60 m, was found at the centre of the site. Twenty-four Saladoid and Ostionoid period burials were found in the central plaza, indicating a continued use of this ceremonial part of the site as a cemetery (Siegel 1992). AMS dating of burials in the cemetery area indicated it was in use from cal. A.D. 210–1148 (Siegel 1992:178). Ten burials were recovered outside of the central occupation zone, in an area described as the “macroblock” (Siegel 1992:168). These were thought to be associated with a single house structure dated to the Ostionoid period, as postholes were found near these burials (Siegel 1992:126). With the exception of two secondary burials, all interments were primary. Of the primary burials, 22 individuals were buried in a flexed position, 5 were placed in an extended supine position, and 6 had burial positions which were unrecorded. The skeletal remains are currently stored in San Juan, in the care of Mike Roca, director of the Puerto Rican newspaper El Vocero.

Skeletal remains

Osteological analyses of the human skeletal remains have been undertaken by Linda Budinoff (1991) and Darlene Weston (Weston and Schats 2010). The original osteological assessment recorded a total of 34 individual skeletons, however, recent re-analysis of the material revealed that burial 18 contained the remains of a foetus, next to the adult individual. Based on this finding, the MNI of the skeletal sample has been changed to 35 (Weston and Schats 2010).

Most of the material is poorly preserved, showing severe fragmentation, erosion, rodent gnawing and damage due to burrowing fauna.

Siegel (1992) distinguishes a Saladoid period group of burials and an Ostionoid group of burials, based on uncalibrated radiocarbon dates from human skeletal material. Here, these radiocarbon dates have been calibrated using Calib 6.1.0, producing the calibrated dates shown in Appendix A. While the re-calibrated dates differ from the dates originally presented by Siegel (they are all around 150–200 years later), a distinct division between burials belonging to an early and a late phase is still clear. These phases are A.D. 600–950 and A.D. 950–1250. The individuals originally assigned by Siegel to the Saladoid now fall within the Early burial population (A.D. 600–950), while Siegel's Ostionoid individuals are now part of the Late burial population (A.D. 950–1250) (Siegel 1992:179, 247–266).

The majority of individuals recovered from the cemetery area were assigned to the Saladoid or Early period of occupation, although there were number of individuals found in the cemetery who dated to the Ostionoid or Late phase of occupation. Siegel (1992, 1996) interpreted this as an indication that the cemetery represented an important sacred and ideological central point of the village throughout its occupation. Burials found outside of the cemetery area, were mostly associated with the Late phase of occupation. In the interest of potentially distinguishing culturally or temporally distinct groups for comparison, a chi-square test was performed, to test whether there is any significant difference between the location of the burials in the Early and Late phases of occupation. The results indicate that there is a significant difference between the distribution of early and late individuals across the cemetery and non-cemetery areas (Table 5.3; $\chi2= 5.1341$ $p= 0.02$). This difference is interpreted here as a confirmation that the cemetery area was used throughout

	Early (A.D. 600–950)	**Late (A.D. 950–1250)**
Cemetery	11	8
Non-cemetery (macroblock)	2	10

Table 5.3 Maisabel number of skeletons by period and location.

the occupation of the site (i.e., both phases), while interment outside of the central plaza area was a predominantly late phenomenon (Hofman and Hoogland 2004; Righter 2002; Siegel 1999; see also Curet and Oliver 1998). In this study, therefore, comparisons are made between the Early and Late burial populations, and the cemetery versus non-cemetery burials.

María de la Cruz cave

The María de la Cruz site is a large rock shelter located around 500 m west of the Hacienda Grande site in the northeast of Puerto Rico, near the town of Loíza, in the municipality of Loíza. Excavations at the site were undertaken by Alegría in 1948 and Alegría and Nicholson in 1954. The site was identified as belonging to the Archaic Age occupation of Puerto Rico (specifically it was attributed to the Coroso culture), thus dating it to between 1000–200 B.C., although radiocarbon dating of charcoal remains at the site revealed two dates from 90 B.C. – 150 A.D, and 60 B.C. – 140 A.D. (Alegría et al. 1955; Rodríguez Ramos 2010; Rouse and Alegría 1990). In the past 5 years Rodríguez Ramos has undertaken new excavations at the site in order to determine the relation between the Archaic Age populations of the island and the earliest Ceramic Age people.

Skeletal remains

Two burials were excavated by Alegría and Nicolson in 1954. One comprised a primary interment, in an extended supine position. The comprised a highly fragmented secondary burial. The excavators note that both individuals had unmodified crania (Alegría et al. 1955; Rouse and Alegría 1990). The burials date to between cal. 50 B.C. – A.D. 40, again indicating that the Archaic Age cultural remains identified by Alegría and colleagues overlap temporally with the later Hacienda Grande occupation (Rodríguez Ramos 2010).

Monserrate

Monserrate is large multi-component Ceramic Age habitation site located in the municipality of Luquillo in north-western Puerto Rico at the mouth of a small lagoon, close to the town of Luquillo. The site was first discovered by Froelich G. Rainey, who excavated there in 1934–1935 (Rainey 1935, 1940). The site is situated in a shallow bay, which is protected from the Atlantic Ocean by a reef. The site extends around 300 m along the shore and 200 m inland, and is characterized by marine food refuse, and potsherds which are scattered across the area. Five mounded shell middens (not contemporaneous) were identified at the site, of which three were partially excavated by Rainey in 1934. Human burials were found in the lower levels of the mounded middens (Rouse 1952a). The site forms the type site for the Monserrate style of the Elenan Ostionoid subseries as defined by Rouse (1992).

Skeletal remains

Rainey (1935, 1940) reports finding numerous human skeletal remains in the lower levels of the mounded middens which he excavated in 1934–1935. These remains were very densely deposited, and burial practices were diverse, with primary flexed interments, prone burials, and burial urns with juvenile skeletal material inside. The two individuals incorporated into this study are thought to have derived from Rainey's excavations, and one is thought to date to the Early Ceramic Age (Saladoid) based on Cuevas ceramics found with the skeletal remains (Drew 2009).

Punta Candelero

Punta Candelero is a multi-component Ceramic Age habitation site located on the south-eastern coast of Puerto Rico. The site was occupied during two periods, the first associated with La Hueca complex ceramics, and the second with Cuevas ceramic complex of the Cedrosan Saladoid. The Rio Candelero, currently positioned approximately 0.5 km from the site, would have bordered the settlement during its occupation (Pestle 2010b). The site is optimally situated to exploit surrounding freshwater and marine environments and the adjacent coastal plain.

From approximately 350 B.C. to A.D. 210 the village evidently comprised a number of houses placed in linear arrangement along a dune, and was characterized by La Hueca ceramics, with predominantly zone incised crosshatched (ZIC) decoration. Between A.D. 660–1010 the village developed a semi-circular configuration, with houses situated around a central plaza. During this period, ceramics at the site belong to the Cuevas style and are generally plain, with some painted sherds (Pestle 2010b).

Skeletal remains

In total 106 human burials were recorded in the field, all of which appear to be clearly associated with the Cuevas cultural component,[6] however, Crespo Torres (2000) describes only 78 individuals. This discrepancy in numbers was apparently caused by field documentation methods (Edwin Crespo Torres, personal communication 2011; Pestle 2010b). Most of the skeletons have been radiocarbon dated, showing that individuals were buried at the site over a period of eight centuries (A.D. 388–1206). The majority of the burials comprised primary interments, although there were a number of secondary interments. Around half were single interments and half multiple interments, some of which contained the remains of 10 individuals. Most individuals were found in a highly flexed position, on the back or on the side, with the legs drawn up to the chest, suggesting the bodies had been wrapped tightly prior to burial. A smaller number of individuals were found

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[6] Edwin Crespo Torres mentions an individual (Burial 13, Block B?, Pozo B-1, Area Huecoide) who may pertain to the La Hueca occupation at the site, however, the context of the burial does not allow for a secure identification, and radiocarbon dating puts this individual in the later (Cuevas) period of occupation at the site along with the other burials (Edwin Crespo Torres, personal communication 2011; Pestle 2010). Incidentally, Pestle (2010) mentions that the only burials that, based on context and location, were associated with the earlier La Hueca component consisted of six dog interments, one of which was radiocarbon dated to the La Hueca period of occupation.

in flexed, ventral position (i.e., face down). Grave goods are rare, and generally consist of pottery, with some cases of lithic materials and one individual found with the remains of a freshwater turtle carapace (Crespo Torres 1991, 2000; Edwin Crespo Torres personal communication 2011; Pestle 2010b).

Overall the burial population at Punta Candelero consisted of a relatively small number of sub-adult individuals, and a larger number of males than females. This has been interpreted as evidence for the site having been inhabited by a founding community (Crespo Torres 2000; Curet 2005; Pestle 2010b).

Santa Elena (Toa Baja 2)

Santa Elena is a multi-component habitation site located close to the town of Toa Baja, in the municipality of Toa Baja, around 5 km from the northern coast of Puerto Rico, and around 12 km to the west of San Juan. The site was visited by Rouse in 1937 and 1938, when he excavated four 2 x 2 m test pits. The site, as defined by surface scatter of faunal material and pottery, covers an area of around 5 acres, and is semi-circular in shape. The Santa Elena pottery style of the Elenan Ostionoid subseries was named after this site, which has a significant Santa Elena component (Rouse 1952a).

Skeletal remains

Rouse uncovered the remains of three human burials, all of which pertain to the Santa Elena division of the site. Burial 1 consisted of young female in flexed position lying on her right side. Burial 2 consisted of an infant in flexed position lying on its right side who appeared to have been deposited between the arms and legs of a flexed adult lying on its left side (this was discovered too late to be documented adequately). Burial 3 similarly consisted of a flexed adult lying on its right side with a poorly preserved infant placed between its arms and legs. Rouse mentions that the adult skeleton appeared to be that of a male, which is corroborated by recent osteological analysis by Drew (2009). No grave goods were found with the remains (Rouse 1952a). The juvenile remains from burial 2 and the adult remains from burial 3 are incorporated into this study.

Santa Isabel (Cayito)

Santa Isabel or Cayito is located on Punta Cayito, around 2 km southwest from the town of Santa Isabel, in the municipality of Santa Isabel on the south central coast of Puerto Rico. The site is characterized by a thick layer of shells and Boca Chica style pottery, placing it in the Late Ceramic Age, which is more commonly found in the Dominican Republic. Surface scatter extends over around 6 acres, however the precise extent of the site could not be determined due to modern habitation of the area. Rouse dug a 2 x 2 m test pit at the site in 1936, recovering large amounts of Boca Chica pottery, faunal remains, and human bones including eight tibias and fibulas, tarsals, metatarsals, phalanges, and fragments of mandible and ribs. The bones were interpreted as the remains of a secondary interment of numerous individuals. No grave goods were found (Rouse 1952b).

Yauco 1

Yauco 1, also known as Diego Hernandez, is a Late Ceramic Age site located in the foothills adjacent to the coastal plain around 4 km north of the town of Yauco in the municipality of Yauco on the south-western coast of Puerto Rico. Rouse visited the site in 1937 and excavated a small test pit in the densest part of the midden area. The site has reportedly yielded a rich repertoire of stone objects, including beads, pendants, and threepointers, leading Rouse to suggest the inhabitants of the site may have been specialized in stonework, although he does not mention the presence of stone debitage from the production process or tools related to stonework. The site is situated on a flat hilltop, which according to Rouse may have functioned as a ball court area. A single human burial was recovered from the lower levels of the midden. Rouse dates the site to his Period IIIa, around A.D. 1200–1300 (Rouse 1952b). The single human burial of an adult of unknown age and sex was excavated at the site. The skeleton was found in a flexed position on the left side. The cranium was destroyed, presumably during ploughing activities. No burial goods were found (Rouse 1952b).

5.2.11 Saba

Kelbey's Ridge 2

Kelbey's Ridge 2 is a small 14th century habitation site situated on a plateau 140 mamsl in the north-eastern part of the small volcanic island of Saba. The elevated position of the site allows for a clear view of neighbouring islands and approaching seafaring traffic, while its occupants had the large fishing grounds of the Saba Bank at their disposal. The site is thought to have been a short-lived eastern outpost of the Taíno, potentially specializing in the exploitation of the valuable marine resources of the Saba Bank and controlling a 'gateway' for interaction between the Greater and Lesser Antilles. Material remains at the site reflect Taíno influences, with an assemblage of locally manufactured pottery with Chican Ostionoid decoration, and a jadeite axe head and a snuff-inhaler of manatee bone with distinct Greater Antillean influences (Hofman, personal communication 2012; Hofman and Hoogland 1991, 1993b; Hoogland and Hofman 1999).

Five round houses, between 5– 8 m in diameter were identified. Based the slope of the terrain and differences in depths of postholes, the houses appear to have been placed on elevated platforms. Over the approximately 50 years of occupation at the site house structures seem to have been repeatedly rebuilt and moved, with at least 4 phases in the household trajectory (Corinne Hofman, personal communication 2012; see also Samson 2010).

Skeletal remains

Seven grave pits containing the remains of at least 11 individuals were excavated.

Five graves were closely associated with some of the house structures; the other two graves were associated with hearth features. The individuals were buried in small round or oval burial pits in a seated, strongly flexed position with the legs flexed toward the chest. Mortuary practices at Kelbey's Ridge 2 are unique for the Caribbean, with the only documented case of cremation in the Lesser Antilles, and the secondary interment of (cremated) infants with older adults (Corinne Hofman, personal communication 2012; Hoogland and Hofman 1999; Weston 2010). Osteological analysis of the skeletal material revealed that the inhabitants of Kelbey's Ridge 2 led a strenuous lifestyle, with heavy physical activity. Trauma on the skeletal frame of a female individual (F148) indicates interpersonal violence, perhaps during inter-group raiding and attacking, or alternatively from domestic violence (Weston 2010).

Spring Bay 1c

Spring Bay is a multi-component Ceramic Age habitation site, which was abandoned and reoccupied a number of times after its initial settlement around A.D. 350. The site is situated adjacent to the 14th century site of Kelbey's Ridge 2, and consists of an extensive midden area, comprised predominantly of faunal food refuse, particularly crab. The single burial of an infant was recovered from the upper levels of one of the trenches. The child was found in flexed, seated position, with the legs drawn up to the chest. Chican Ostionoid type pottery was found associated with the skeleton, and radiocarbon dating of this individual indicated a date of 535 ±85 B.P., or around A.D. 1450, making it roughly contemporaneous with the Kelbey's Ridge 2 occupation (Hofman and Hoogland 1991, 1993a, Hoogland and Hofman 1999; Corinne Hofman, personal communication 2012).

5.2.12 St. Lucia

Lavoutte

Lavoutte is a Late Ceramic Age habitation site characterized by predominantly Suazoid ceramics located in the northern part of the bay of Cas-en-Bas on a promontory which partly blocks the bay entrance, in the north-eastern tip of St. Lucia. Original investigations at the site by Bullen and Bullen (1970) led to the interpretation of Lavoutte as a 'Carib ceremonial center' with considerable (long-distance) contact and exchange networks with Taíno groups in the Greater Antilles, as reflected in a number of artefacts recovered from the site which appear to emulate Taíno decorative modes (Allaire 1999). Investigations at the site during the mid-1980s by the University of Vienna, under the direction of Dr. Herwig Friesinger, uncovered four human burials close to or in the midden area (Fabrizii-Reuer and Reuer 2005).

Recent investigations at the site between 2009–2010 by researchers from Leiden University and the St. Lucia Archaeological and Historical Society (SLAHS) revealed a large number of human burials mostly located in the habitation and adjacent cemetery area, which were heavily damaged by erosion at the site as a result of recent hurricane activity and construction works in the vicinity (Hofman and Branford 2011; Hofman et al. 2012).

Skeletal remains

Including human burials excavated by the University of Vienna in the mid-1980's, a total of 48 graves with at least 53 individuals have been excavated at the site. Although a number of posthole features were recorded, reconstruction of (house) structures was hampered by the severe erosion and damage to the site. Nonetheless, the close association between a number of the buried individuals and the posthole features suggests that some may have been interred in (or near) the houses, as has been documented elsewhere in the Caribbean (Hofman et al. 2001b; Hofman et al. 2012; Hoogland and Hofman 1999). Some degree of uniformity in burial practices is evident at the site, particularly when contrasted with other (contemporaneous) sites in the region (e.g., Anse à la Gourde, Guadeloupe). Individuals were generally interred in small round or oval burial pits, in a seated or supine flexed position. Most skeletons were positioned facing east, northeast, or southeast, with all east facing individuals dated to the middle period (cal. A.D. 1300–1400). Seven cases of secondary interment were identified: three solitary depositions, and four depositions with an existing primary interment. There are taphonomical indications that some of the burial pits were left open after deposition. Twelve skeletons were radiocarbon dated (Appendix A), leading investigators to distinguished three main periods of deposition of the human burials at the site: cal. A.D. 1150–1300, cal. A.D. 1300–1400, and cal. A.D. 1400–1600 (Hofman et al. 2012).

Point de Caille

The Ceramic Age habitation site of Point de Caille (also known as Saltibus Point) is situated on the south-eastern coast of St. Lucia, at the southern tip of a promontory, to the west of which lies the large Savannes Bay. Several fresh water ponds are now present in the vicinity of the site. Excavations in 1983 and 1984 led by researchers from the Österreichischen Akademie der Wissenschaften, Vienna, revealed the site originally comprised a settlement of around 300 by 400 m, with a number of large buildings with midden areas location around them. Based on faunal remains recovered from the midden areas, the inhabitants of Point de Caille consumed a predominantly marine oriented diet. Based on ceramic styles recovered at the site, investigators date the site to A.D. 300–1000, with an early component from A.D. 300–700, and a later component from A.D. 700–1000. The burials are thought to pertain mainly to the later phase of occupation (Fabrizii-Reuer and Reuer 2005; Friesinger et al. 1986).

Skeletal remains

Burials were recovered from both the house and midden areas. A certain degree of clustering was observed in the locations of the grave pits, leading investigators to conclude that the clusters may have represented individuals with family ties. Most individuals were interred in extremely flexed position on the back or on the side, with the legs drawn up to the chest. Investigators concluded that the bodies must have been wrapped in a highly flexed position prior to burial. Some individuals were buried in a flexed semi-seated or upright seated position. The majority of burials appear to have been primary, single interments (Fabrizii-Reuer and Reuer 2005; Friesinger et al. 1986).

5.2.13 St. Thomas, U.S. Virgin Islands

Tutu

The multi-component Ceramic Age habitation site of Tutu is located in the inland valley of the Turpentine Run river, about 1.75 km from the eastern coast St. Thomas, U.S. Virgin Islands. Tutu was inhabited during two major occupation phases: an Early Ceramic Age (Cedrosan Saladoid) occupation between cal. A.D. 65–900 and a Late Ceramic Age (Chican Ostionoid) occupation between cal. A.D. 1150–1500. During both phases the village consisted of a central plaza/cemetery area, surrounded by houses, behind which the refuse areas were located. The site, which comprised about 2.2 hectares of pasture land, is situated in one of the few areas of flat land on the volcanic island of St. Thomas, providing fertile soil for agriculture. Various lines of evidence have indicated that the inhabitants of Tutu subsisted on a mixed diet, with root crops serving as a staple food (Righter 2002).

Skeletal remains

A total of 42 individuals were excavated, 22 of which are adults and 20 of which were sub-adults. Twenty-seven individuals were radiocarbon dated, revealing the burials were clearly associated with both occupation phases. Nine individuals were associated with the early period and dated between cal. A.D. 450–960, while a further 18 individuals were dated to the later phase between cal. A.D. 1170–1535. These dated individuals are distributed across the chronological time frames distinguished, indicating it is highly unlikely that they were alive at the same time. Interestingly, based on its radiocarbon date burial 39 dates to the Contact period, however this subadult was found interred with a late Ostionoid vessel (Righter 2002; Sandford et al. 2002). Osteological analysis of the Tutu skeletal remains was undertaken by Sandford et al. (2002).

Mortuary treatment at Tutu is characterized by distinct differences between the early and late phases of occupation. In the earlier phase, all individuals were buried with one or more ceramic vessels, and burials were located in a central cemetery area and the habitation area. In the later phase, only a small group of individuals (only subadults) were buried with ceramic vessels, and the burials are clearly associated with the house structures, with clusters of burials arranged around structures. Investigators interpret the early mortuary practices as a structured by kinship relations, while the late phase appears to express increased social (sociopo-

litical) complexity, with increasing importance of individual households.
Investigators furthermore identified a shift toward a higher degree of status differentiation in the later occupation phase. The latter was not reflected in dietary patterns, as the results of stable isotope analysis suggest that in both phases individuals had equal access to the range of available foods (Righter 2002).
There is evidence of stress in the skeletal remains, with indications of on-going iron deficiency and hard physical labour. Also, they played host to treponemal diseases which resulted in bone lesions and diffuse pitting. The mean number of lesions associated with treponemal disease per individual increases in the later phase of occupation. Also, more locations in the skeletal frame appear to be affected. However, this does not necessarily mean that the later group were more severely affected by this disease. Although the number and type of lesions recorded for the later group may indicate more severe infection, the differences may be influenced by the Osteological Paradox (Wood et al. 1992), and likely reflect changes in the relation between disease and host, i.e., resistance (Righter 2002; Sandford et al. 2002).

5.2.14 St. Vincent

Argyle

The site of Argyle is located on the southeast coast of St. Vincent, on a ridge of around 15–20 mamsl, facing the Atlantic Ocean. The site area and the surrounding landscape are known to have been intensively used throughout prehistory and in colonial times. The site dates to the late pre-Columbian and early colonial period, and is interpreted to have been an Island Carib village, comprising a small number of small round houses and a larger oval structure which is thought to have been the men's house (Hofman, Hoogland and Roux 2011). The larger Saladoid sites of Escape and Argyle 2 are adjacent to Argyle, to the north and south of the site.
European materials dating to the 16th and 17th centuries were recovered at the site, and were found in association with Cayo pottery, supporting earlier identifications of this type of pottery as belonging to the colonial period Island Carib occupation (Allaire 1994; Boomert 1986; Hofman, Hoogland and Roux 2011).

Skeletal remains

The preservation of organic materials at the site was extremely poor, meaning hardly any food remains and bone were recovered. However, based on the size and shape of a number of features located within the house structures, it is thought individuals were interred at the site. In two of the features the highly fragmented and weathered remains of two adult human dentitions were recovered, confirming the interpretation of these pits as graves. Only the enamel of the teeth survived, however partial analysis of dental wear and pathology was possible.

Argyle 2

Argyle 2 is a large multi-component Ceramic Age site on the southeast coast of St. Vincent bordering the Argyle and Escape sites, and extending from the coast around 1 km inland and 0.5 km north to south. The amount of cultural remains (including numerous postholes; some of which may have been part of a long house structure; see section on the Escape site) and the size of the site, along with the close proximity to other important archaeological sites, may indicate that Argyle 2 was a significant settlement from the Early Ceramic Age (Saladoid) onward (Guzman and MacKay 2011).

Skeletal remains

Six human burials were identified by Kathy Martin and Royden Lampkin of the St. Vincent and the Grenadines National Trust at the site between May 2010 and January 2011, including the three individuals skeletons incorporated into this study. Burial positions were flexed, and a number of zoomorphic beads were recovered from the burial pits. In 2011, as a part of the SVG Public Archaeology Program at the Argyle 2 site a large number of features were mapped and 21 human burials were identified (11 excavated). Burial practices of these 13 individuals were diverse, with secondary interment, prone interment, and flexed and extended positions recorded. A rich array of burial goods was recovered, including numerous stone artefacts, body ornaments, and debitage, and a complete Saladoid period ceramic vessel (Guzman and MacKay 2011). The latter indicates these burials most likely belonged to the Saladoid occupation of the island, between A.D. 150 and 600/800.

Buccament West

The site is located in the Buccament Bay and valley area on the south-western coast of St. Vincent. Previous excavations in this area by the Bullens (among others) have revealed that this part of the island was occupied throughout Ceramic Age. A single human burial was excavated by Kathy Martin and Royden Lampkin of the St. Vincent National Trust. The individual was interred in a large, undecorated ceramic vessel, with some faunal remains perhaps belonging to a dog (Kathy Martin, personal communication 2010).

Escape

Escape is a multi-component habitation site, occupied during both the Early and Late Ceramic Age, as shown by the presence of the early and modified Saladoid, and Suazoid ceramics in different areas of the site. The site and the surrounding archaeological landscape were under threat from landscaping works for the construction of a new airport along the south-eastern coast of St. Vincent. Excavations at the site took place between 2009–2010 by a team from the University of Calgary, Canada, under the direction of Dr. Richard Callaghan, and Kathy Martin of the St. Vincent and the Grenadines National Trust.

Researchers excavated a large number of posthole features, and identified seven oval structures and one large rectangular structure, which they suggest may be the first documented long-house in the Caribbean. Alternatively, it has been suggested that this structure is a colonial period tobacco drying house or another colonial period structure of some sort (Arie Boomert, personal communication 2010; Petitjean Roget, personal communication 2011; Moravetz and Callaghan 2011).

Skeletal remains

Excavations at Escape revealed 36 human burials. The burials were all found in a central, possible cemetery area of around 20 x 25 m. In this same area, investigators identified a number of possible house structures, perhaps indicating burial close to or in the houses. Most burials were primary interments, with a small number of secondary depositions. At least two individuals were interred in a flexed, dorsal position, while the rest were buried in a flexed to highly flexed position, on the back or on the site with the legs drawn up to the chest. A number of burials yielded grave goods, including highly decorative body adornments, such as stone and shell beads and pendants, and in one case a St. Lucia Zoned Incised (Saladoid) bowl place next to the skull of one of the primary, flexed interments. One extended individual was found buried with items of personal adornment, four axes, and a number of stone flakes, which were deposited between the feet. The stone flakes were refitted to the core, showing they were most likely purposely fabricated in one sitting for the burial of this individual. In the absence of radiocarbon dates, it is assumed in this study that the burials all pertain to the (late) Saladoid period of occupation, based on the grave goods that were recovered from the Escape burials (Moravetz and Callaghan 2011).

5.2.15 Trinidad

Manzanilla

Manzanilla is a multi-component habitation site with at least four habitation areas – some of which may have existed simultaneously – occupied during both the Early Ceramic Age (Late Palo Seco period [A.D. 350–650]) and Late Ceramic Age (Arauquinoid period [A.D. 650–1400]). The site is located on the central-eastern coast of Trinidad, in the county of St. Andrew, close to the small town of Lower Manzanilla. The location of the site is ideal for the exploitation of a variety of ecological zones. It borders two geologically distinct zones; the Central Range of Cretaceous hills to the south-west of the site, and the Miocene and Pliocene sandstone Naparima plains and Nariva swamp to the south. Where the Central Range meets the site, the inhabitants would have had access to a forested area. North of the site, the l'Ebranche river provides a freshwater habitat with mangrove tidal forest formation, while the larger freshwater environment of the Nariva swamp is located to the south. Lastly, the site's proximity to the beach and Atlantic Ocean, allows access to marine resources (Boomert et al. 1997; Dorst et al. 2003).

The period of habitation at the site and use of the cemetery area (A.D. 350–1400), largely spans the period of horticulturalist habitation of the island, represented by the Saladoid and Arauquinoid ceramic series. Ceramic styles found at the site belonged to the Saladoid Late Palo Seco complex (A.D. 350–650) and the Arauquinoid Bontour complex (A.D. 650–1400). The Palo Seco complex, divided into an early (A.D. 1–350) and a late component (A.D. 350–650), is characterized by clear stylistic influences from the Barrancoid ceramic style of the Orinoco region in the South American mainland. Influences from the Barrancoid complex increased during the Late Palo Seco period (Boomert et al. 1997; Dorst 2008; Dorst et al. 2003). The Arauquinoid complex, starting around A.D. 600–650, differs greatly from the preceding Late Palo Seco complex, however despite the apparent dramatic change in ceramic style influences it appears that pronounced social and cultural relationships between Manzanilla and areas of the mainland were upheld in the later phase of occupation at the site (Boomert et al. 1997; Dorst 2008; Dorst et al. 2003). A number of stone artefacts found in the (probably) Arauquinoid midden on the south western hill slope are thought to show clear influences from mainland groups. During the Late Palo Seco/Arauquinoid transition phase, and throughout the Arauquinoid period, the inhabitants of Manzanilla either engaged in exchange with mainland communities, obtained objects from this region, or copied the stylistic traits of such objects (Boomert 2000:315; Dorst 2008).

Skeletal remains
A large number of burials were found associated with both the Saladoid and Arauquinoid components of the site. The Saladoid period burials were found in and around a midden area, while the Arauquinoid period burials were associated with two house structures (Boomert 1984, 1985; Dorst 2000, 2006, 2008; Dorst and Altena 2005). The human skeletal remains (n= 21) used in this study were excavated during the 2006 and 2007 field campaigns. Preliminary osteological observations were made in the field, including identification of age, sex, and pathological conditions (Dorst 2008). In-depth osteological analysis has been undertaken by Darlene Weston (in prep.).

Mortuary treatment at the site is varied, with a number of primary single interments, primary multiple interments, secondary interments, and mixed primary and secondary interments. Most individuals were buried in a flexed, supine or semi-seated position, with the legs drawn up to the chest, however a small number of individuals were interred in extended supine position. The investigators suggest that the extended burial position may be associated with the Late Palo Seco phase of occupation. Grave goods are rare, with one individual found buried with a shell bead, and one juvenile found with a fragment of quartz, and a piece of Strombus gigas shell carved into the shape of a dog or jaguar tooth (Dorst 2008).

5.2.16 Venezuela

Saladero

Saladero is a large multi-component habitation site located along the Lower Orinoco River, around 40 km to the northeast of the modern day city of Guayana in Venezuela. The site is the type site for Saladoid pottery, as this style was first identified there, although it appears to have begun slightly earlier at the site of Ronquín on the Middle Orinoco around 1200 B.C. Saladoid pottery makers later introduced this pottery style to the Caribbean islands (see also Chapter 3). Excavations were undertaken at the site in 1950 by José M. Cruxent and Benjamin Irving Rouse. The excavators specifically mention not having found any human burials during their excavations, meaning the material incorporated into this study, currently housed at the Yale Peabody Museum of Natural History, New Haven, Connecticut, must have derived from other excavations. The museum catalogue does not specify how the material was obtained, but it is assumed here that it must have been excavated by Osgood and Howard who surveyed and excavated in the area in 1942 (Cruxent and Rouse 1958/1959; DaRos and Colten 2009). Consequently, the context of the material is unknown.

Tocorón

Tocorón is a large Valencioid (A.D. 900–1500) habitation site on the south-eastern shore of the Lake Valencia in northern Venezuela. This area is thought to have been part of the 'Valencioid Interaction Sphere' (Antczak and Antczak 1999), which included the Lake Valencia Basin, and the islands offshore (e.g., Los Roques). The site is characterized by numerous large mounds. Yale University was invited to survey and excavate sites in the Lake Valencia region by the president of the Venezuelan Republic in 1933. Consequently, Cornelius Osgood undertook excavations in one of the mounds (number 53) at the site in 1933. The site is close to a similar site, La Mata, which had previously been excavated by the American Museum of Natural History (DaRos and Colten 2009; Osgood 1943). Osgood wished to compare his results with this previous study. He retrieved the remains of a small number of human burials from mound 53, which are currently stored at the Yale Peabody Museum of Natural History, New Haven, Connecticut. Little is known of the context of these burials, save for the fact that some elaborate grave goods, including body ornamentation, were found with them (Osgood 1943).

5.3 Samples for Scanning Electron Microscopy

A small sample of teeth was sent for analysis by Saskia M. Kars using Scanning Electron Microscopy (SEM) at the Free University, Amsterdam. These teeth were selected for their patterns of wear which were indicative of the use of the teeth as tools. The aim of this study was to obtain further information on the type of materials being processed by the teeth, and the precise action (i.e., direction of movement, degree of force) involved, and to potentially link specific wear patterns to certain activities and or materials. To this end, ten teeth were selected that presented with LSAMAT (see Chapter 6 and Chapter 7), and with other types of non/alimentary wear (Table 5.4).

Site	Burial	Tooth	VU Amsterdam lab code	Wear pattern
Anse à la Gourde	430	1.1		LSAMAT
Anse à la Gourde	430	1.2		LSAMAT
Anse à la Gourde	2215	2.1		LSAMAT
Punta Macao	1	1.1	PM1 bovenkaak tand B1	Severe lingual and incisal edge abrasion; severe dentine exposure; almost complete loss of enamel
Punta Macao	1	2.2	PM1 bovenkaak tand A1	Labial 'dent' (no dentine exposure); lingual abrasion with some dentine exposure
Punta Macao	1	3.1	PM1 onderkaak tand A1	Labial and incisal abrasion; dentine exposure
Punta Macao	1	4.2	PM1 onderkaak tand B1	Labial and incisal abrasion
Punta Macao	11	1.1	PM11 Upper jaw dent A1	Severe rounded abrasion of entire occlusal surface; enamel completely worn away
Punta Macao	11	1.2	PM11 Upper jaw dent B1	Groove along labial/incisal edge
Spring Bay 1C	1	5.1		LSAMAT

Table 5.4 Samples sent for analysis with Scanning Electron Microscope.

5.4 Chronological, Sociopolitical, and Geographical Comparisons

Broad scale chronological comparisons of dental wear and pathology are restricted by the resolution of available dates for sites and human skeletal remains. As is clear from the above, and as stated in Chapter 1 (section 1.4), the skeletal remains incorporated into this study vary considerably with regards to the amount of available contextual information. At some sites, large numbers of the individual human skeletons have been radiocarbon dated, while at others, dating of the skeletons is based on general site dating and associated material culture. The latter have been a matter of debate in the past few years, as researchers in the region have been critically reassessing the established cultural chronology in the region (Keegan 2010a; Pestle 2010b; Rodríguez Ramos 2010; Rodríguez Ramos et al. 2010). In attempting to divide the sample into temporal groups, I was constrained by differences in resolution (i.e., absolute radiocarbon dates of individuals versus broad time periods assigned to sites or burials based on pottery style), and the lack of available Archaic Age material. Broadly speaking, the majority of the material pertains to the Late

Ceramic Age, although a significant proportion pertains to the Early Ceramic Age. At many sites, the dating resolution reflects precisely this dichotomy: either Early

	Site	Island	Dating
Early Ceramic Age	Argyle 2	St. Vincent	Saladoid
	Cañas	Puerto Rico	"Crab culture"
	Canashito	Aruba	A.D. 100–400
	Collores	Puerto Rico	Saladoid
	Escape	St. Vincent	Saladoid
	Indian Creek	Antigua	Indian Creek period
	Maisabel	Puerto Rico	A.D. 600–950
	Malmok*	Aruba	A.D. 200–900
	Manzanilla	Trinidad	Late Palo Seco
	María de la Cruz	Puerto Rico	50 B.C. – A.D. 40
	Monserrate	Puerto Rico	"Crab culture"
	Punta Candelero	Puerto Rico	Early: 400–600 Middle: 600–800
	Simon Beach	Grenada	Saladoid / pre-Arawak
	Tutu	St. Thomas	Early: A.D. 450–960
Late Ceramic Age	Anse à la Gourde	Guadeloupe	A.D. 1000–1400
	Argyle	St. Vincent	A.D. 1500–1700
	El Cabo	Dominican Rep.	A.D. 1000–1500
	Chorro de Maíta	Cuba	A.D. 1400–1600
	Clarence town cave	Bahamas	A.D. 700–1500
	Coto	Puerto Rico	"Shell culture"
	Diale 1	Haiti	Meillacoid
	Gordon Hill caves	Bahamas	A.D. 700–1500
	Higuey	Dominican Rep.	Late Ceramic Age
	Juan Dolio	Dominican Rep.	Boca Chica
	Kelbey's Ridge 2	Saba	A.D. 1300–1400
	La Caleta	Dominican Rep.	Ostionoid
	La Mina	Vieques, Puerto Rico	Santa Elena
	Lavoutte	St. Lucia	A.D. 1150–1600
	Maisabel	Puerto Rico	A.D. 950–1250
	Mamora Bay	Antigua	Elenoid
	Manigat cave	Île de la Tortue, Haiti	Meillacoid
	Manzanilla	Trinidad	Arauquinoid
	Punta Candelero	Puerto Rico	Late: A.D. 800–1200
	Punta Macao	Dominican Rep.	Ostionoid / Chicoid
	Point de Caille	St. Lucia	A.D. 700–1000
	Santa Cruz	Aruba	A.D. 950–1250
	Santa Elena (Toa Baja 2)	Puerto Rico	Santa Elena
	Santa Isabel (Cayito)	Puerto Rico	Boca Chica
	Savaneta	Aruba	A.D. 950–1250
	Savanne Suazey	Grenada	A.D. 1000–1600
	Spring Bay 1c	Saba	A.D. 1450
	Tanki Flip	Aruba	A.D. 950–1250
	Tocorón	Venezuela	Valencioid
	Tutu	St. Thomas	Late: A.D. 1170–1535
	Wemyss Bight cave	Bahamas	A.D. 700–1500
	Yauco 1	Puerto Rico	Ostiones / Period IIIa

Table 5.5 The sites per chronological group.

Ceramic Age or Late Ceramic Age, while at other sites individual skeletons can be assigned absolute dates. This has led me to divide the assemblages into two 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. This group also represents sites (or particular occupation periods at sites) that can arguably be assigned to the Early Ceramic Age sociopolitical type of organization as described in Chapter 3, i.e., village-based and kinship oriented organization. This means that in some instances individuals will be incorporated into the early period, while their radiocarbon dates do not concur with those defined for it. An example is the early group at Tutu. These individuals have been radiocarbon dated to between A.D. 450 and 960, which is in part slightly later than the Early Ceramic Age group defined here (i.e., 400 B.C. – A.D. 600/800). But since contextual information from the site (e.g., burial location and material culture, including Saladoid pottery) indicates these individuals belonged to a village-based community in which kinship formed the basis of social organisation, they are incorporated into the early group.

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. This group also represents sites (or particular occupation periods at sites) that can arguably be assigned to the Late Ceramic Age form of sociopolitical organization as described in Chapter 3, i.e., ingrained hierarchical status differentiation, institutionalized inequality – with an elite class – and regional scale political organisation in (complex) 'chiefdoms'.

Table 5.5 presents the sites in each of the two temporal groups for the entire dataset. This division into groups is not just a sociopolitical and chronological division: it partly coincides with a geographical and geological division. The Early Ceramic Age groups in the sample are all located in the Lesser Antilles and the southern Caribbean Islands and a small part of the eastern Greater Antilles. No assemblages from sites in the Greater Antilles, such as some 'proto-agroalfarero' sites documented in Cuba, that based on absolute or relative dating, or on socio-political organization could be included in the Early Ceramic Age group were available for analysis. The Late Ceramic Age sites in the sample are located throughout the Greater and Lesser Antilles, the southern Caribbean Islands, and the Bahamas. As a 'chronological entity' the Late Ceramic Age pervades the entire region, however the sociopolitical organization associated with it, as described above and in Chapter 3, is associated predominantly with the Greater Antilles, although parts of the northern Lesser Antilles may have been involved in the chiefdom structure of the Greater Antilles. This is very important in the context of dietary studies, since the biogeography and geology of the region has been shown to influence dietary practices (Laffoon 2012; Laffoon, Valcárcel Rojas, and Hofman 2012; Newsom and Wing 2004; Stokes 1998). Next to chronological, sociopolitical, and geographical differences between the Early and Late Ceramic Age groups, there are clear environmental and geological differences between the two areas (Chapter 3).

	Site	Island	Dating
Early Ceramic Age	Argyle 2	St. Vincent	Saladoid
	Canashito	Aruba	A.D. 100–400
	Escape	St. Vincent	Saladoid
	Indian Creek	Antigua	Indian Creek period
	Malmok*	Aruba	A.D. 200–900
	Manzanilla	Trinidad	Late Palo Seco
	Simon Beach	Grenada	Saladoid / pre-Arawak
Late Ceramic Age	Anse à la Gourde	Guadeloupe	A.D. 1000–1400
	Argyle	St. Vincent	A.D. 1500–1700
	Kelbey's Ridge 2	Saba	A.D. 1300–1400
	Lavoutte	St. Lucia	A.D. 1150–1600
	Mamora Bay	Antigua	Elenoid
	Manzanilla	Trinidad	Arauquinoid
	Point de Caille	St. Lucia	A.D. 700–1000
	Santa Cruz	Aruba	A.D. 950–1250
	Savaneta	Aruba	A.D. 950–1250
	Savanne Suazey	Aruba	A.D. 1000–1600
	Spring Bay 1c	Saba	A.D. 1450
	Tanki Flip	Aruba	A.D. 950–1250

Table 5.6 The Lesser and Southern Antillean sites per chronological group.

CHAPTER 6 RESULTS

6.1 INTRODUCTION

The results presented in this chapter are organized into data pertaining to dental wear, dental pathology, and dental defects. Within these main categories, each individual subject is discussed at sample, site, and intra-site levels. Intra-site sex-based and chronological differences are discussed for those sites with at least four adult individuals of known sex.[7] This minimum number has been arbitrarily chosen, to include as many sites and individuals in the statistical analyses as possible. Rate and type of wear and frequencies of pathology at the different sites – such as caries and AMTL – are compared with each other and, in Chapter 7, with published results from studies across the globe. Next to the assessment of chronological differences on an individual site basis, differentiating between different phases of occupation per site (intra-site), broad scale comparisons over time throughout the region are made (section 6.6), based on the division of the sample into two main groups (Early and Late Ceramic Age) as explained in Chapter 5 (section 5.4).

6.2 PRESERVATION AND COMPLETENESS

The state of preservation and the completeness of the dental material influence collection of the data, statistical analysis, and interpretation of the results. Table 6.1 shows the completeness of the individual assemblages as a ratio between the prevalence of teeth that are accounted for (i.e., observed, or ante mortem loss) and teeth

Site	Observed + AMTL	Missing + PMTL	Ratio
Buccament West	30	2	0.07
Esperanza	18	2	0.11
El Cabo	53	11	0.21
La Caleta	25	7	0.28
Heywoods	69	24	0.35
Higuey	23	9	0.39
Spring Bay 1c	14	6	0.43
La Mina	21	11	0.52
St. Kitts	41	23	0.56
Argyle 2	61	35	0.57
Chorro de Maíta	1430	830	0.58
Mamora Bay	80	48	0.60
Malmok	78	50	0.64

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[7] Intra-site chronological comparisons are made based on the time periods established by the author in Chapter 5 using calibrated radiocarbon dates of the skeletal individuals. For Maisabel and Tutu, early and late phases are compared. At Punta Candelero, three phases are distinguished, however in all calculations in this chapter only middle and late are compared, since the number of individuals dated to the early period is too small to allow for reliable testing with statistical analyses. For Lavoutte and Manzanilla numbers in one or more occupation phases were too small to reliably test for differences using statistical analyses.

Site	**Observed + AMTL**	**Missing + PMTL**	**Ratio**
Hacienda Grande	37	27	0.73
Anse à la Gourde	1164	960	0.82
Manzanilla	305	254	0.83
Tanki Flip	34	30	0.88
Kelbey's Ridge 2	93	86	0.92
Maisabel	492	463	0.94
Point de Caille	66	62	0.94
Lavoutte	476	457	0.96
Punta Candelero	856	827	0.97
Escape	398	390	0.98
Argyle	31	33	1.06
Tutu	381	404	1.06
St. Croix, USVI	15	17	1.13
Savanne Suazey	68	80	1.18
Santa Cruz	81	99	1.22
Savaneta	94	120	1.28
Monserrate	28	36	1.29
Santa Elena	22	29	1.32
Collores	22	30	1.36
Punta Macao	233	316	1.36
Canashito	52	74	1.42
Wemyss Bight cave	13	19	1.46
Diale 1	59	142	2.41
Saladero	27	69	2.56
Manigat cave	25	71	2.84
Juan Dolio	52	156	3.00
Tocorón	44	148	3.36
Clarence town cave	14	50	3.57
Gordon Hill caves	11	53	4.82
Cañas	15	81	5.40
Coto	5	27	5.40
Indian Creek	5	27	5.40
Yauco 1	4	28	7.00
Simon Beach	3	29	9.67
María de la Cruz	1	31	31.00
Santa Isabel	1	31	31.00
Total	**7170**	**6814**	**0.95**

Table 6.1 The completeness ratios of the individual assemblages as a ratio between the prevalence of observed + AMTL and missing + PMTL, displayed in order of completeness (high to low).

that are unaccounted for (i.e., missing [absent, no socket observed] and post mortem loss [empty socket observed]). As can be seen in this table, the completeness of the different assemblages varies considerably. The completeness ratios for the entire assemblage ranges between 0.07 (Buccament West) and 31.00 (Santa Isabel). The completeness ratios for the larger sites range between 0.58 (Chorro de Maíta) and 1.36 (Punta Macao), and therefore represent intermediate completeness within this sample.

The state of preservation of the teeth at the individual sites differs considerably (Figure 6.1). Anse à la Gourde, for example, is relatively poorly preserved, most likely due to soil conditions at the site (soft sandy substrate). Many teeth are fragmented, with large parts of the enamel cracked or broken off completely. Root surfaces often appear cracked or fragmented, or the outer surface appears exfoliated, perhaps due to soil acidity. Punta Candelero and Chorro de Maíta are in exceptionally good condition; tooth crowns are rarely cracked or damaged in other ways, root surfaces are intact, and the alveolar bone is generally intact.

The most poorly preserved teeth in the sample are from Argyle. During excavations here and at neighbouring Escape and Argyle 2, almost no faunal remains were recovered. It appears that soil conditions (acidity) are not conducive to the preservation of organic materials, something which is often the case in volcanic substrates. Many dental remains at Escape, Argyle, and Argyle 2 consist only of (fragmented) enamel caps.

Other factors that influence the condition of the material and the ability to document dental wear and pathology are storage conditions, cleaning techniques, and restorative work. Air humidity after excavation greatly influences the condition of particularly the enamel cap of tooth crowns. This part of the tooth, due to its hardness and brittle nature, is highly susceptible to changes in humidity in the environment. The result is cracking, chipping and flaking of the enamel, as it expands and contracts at a different rate than the underlying dentine. This is also the reason that teeth sometimes crack or split as soon as they have been excavated; the change from the relatively moist, cool surroundings in the soil to the much dryer (and hotter) air causes the enamel to break. Cleaning techniques involving water may damage teeth for the same reasons; the introduction of moisture onto a dry tooth causes breakage. Other cleaning techniques, both during and after excavation, may damage dental material when inappropriately hard (tooth) brushes or non-wooden (i.e., metal) picks are used. Such cleaning often results in the loss of

Figure 6.1 State of preservation of the dental material. Left to right: good preservation of teeth and alveolar bone (Chorro de Maíta 51); post-deposition and post-excavation cracking and fragmenting of teeth and roots due to changing humidity conditions (Anse à la Gourde 450); very poor preservation of teeth with only fragmented enamel caps preserved (Argyle F42-15).

dental calculus, a valuable source of microremains of plants and other foods. Another common reason for the loss of calculus is the fact that it is mistaken for dirt adhering to the tooth, and subsequently removed (Roberts 2009; Williams 2001). Restorative work on skeletal and dental material may include gluing various fragmented elements together, and painting numbers and letters onto material with nail varnish, typo correction fluid, and permanent markers. Gluing material sometimes obstructs analysis of the material when teeth are glued into sockets, or, rarely, when jaws are glued together in occlusion. Fortunately only a very small number of individuals incorporated into this study have been subject to such restorative work.

6.3 DENTAL WEAR

6.3.1 Macrowear

Rate of wear

As discussed in Chapter 2, food consistency and food preparation techniques strongly influence the abrasivity of foods and as such significantly affect occlusal dental wear. The degree of dental wear is also known to be strongly associated with age. In order to compare the rate of dental wear for different groups, this relationship between age and degree of wear must be taken into account. Any comparisons

Site	**M1**	**M2**
Anse à la Gourde	(*t*= 1.16, p= 0.27)	(*t*= 1.48, p= 0.17)
Chorro de Maíta	(*t*= 0.29, p= 0.77)	(*t*= 1.73, p= 0.10)
Diale 1	-	-
Escape	(*t*= 0.21, p= 0.84)	(*t*= 0.00, p= 1.00)
Juan Dolio	-	-
Lavoutte	(*t*= -0.82, p= 0.43)	(*t*= 0.43, p= 0.68)
Maisabel	(*t*= -0.80, p= 0.45)	(*t*= 0.43, p= 0.68)
Malmok	-	-
Manzanilla	(*t*= 0.00, p= 1.00)	(*t*= -1.00, p= 0.37)
Punta Candelero	(*t*= 0.62, p= 0.54)	(*t*= 0.33, p= 0.75)
Punta Macao	-	-
Santa Cruz	-	-
Savaneta	-	-
Tutu	(*t*= -1.53, p= 0.17)	(*t*= 0.00, p= 1.00)
All sites	**(t= = -1.38, p= 0.17)**	**(t= 0.54, p= 0.59)**

Table 6.2 The results of paired samples t-test comparisons of mean degree of wear of right and left mandibular first and second molars. The sample sizes at Diale 1, Juan Dolio, Malmok, Punta Macao, Santa Cruz, and Savaneta were too small to allow for comparison.

must be based on factors that can be assessed independently of estimated ranges of age-at-death, and independently of group age profiles, which may differ significantly (see also Chapter 4).

The adult age distributions of the sites with at least four aged adults can be found in Appendix B. As can be seen in Appendix B, some sites clearly differ with regards to their age distribution. For example, the site of Diale 1, with predominantly young adult individuals, and the site of Tutu, with predominantly old adult individuals, show quite different age distributions. For these reasons, this study compares intra-individual rates of wear, measured using the difference in degree of wear between the adjacent permanent molars.

This is possible due to the fact that these teeth erupt at approximately 6-year intervals in all humans, which means inter-individual and inter-group comparisons can be made (Bernal et al. 2007; Chattah and Smith 2006; Hillson 1996; Scott and Turner 1988; Smith 1972; Watson et al. 2011). Although some studies have used both adjacent M1–M2 and adjacent M2–M3 comparisons, this study is restricted to only adjacent M1–M2 comparisons (see Chapter 4, section 4.2.2).

The degree of occlusal surface wear was recorded for all teeth of the adult maxillary and mandibular dentition in the sample according to the dental wear scoring method devised by Molnar (1971), but only the left mandibular first and second molars were used in this analysis. Potential differences in degree of wear of the right and left mandibular first and second molars was assessed by comparing mean wear scores to identify if gross differences in wear exist between the right and left mandibular dentition. This method can be used for general comparisons (Watson et al. 2011). No significant differences in mean degree of wear were observed between right and left dentitions using a dependent (or paired) samples t-test (Table 6.2). For this reason, if a left first or second molar was absent, it was substituted by its antimere.

A total of 159 adjacent first and second mandibular molars (n= 318) was selected to assess potential differences in the rate of occlusal surface wear between sites using principle axis analysis. The equations of principal axes were calculated for adjacent first and second left mandibular molars. To compare wear rates, the principle axis equation was determined by plotting the wear score of M1 on the Y1 (X) axis, and

Site	B	Principle Axis Equation	CL (95%)
Punta Candelero	0.835	1.726 + 0.835Y	0.443 < b < 1.475
Tutu	0.874	1.116 + 0.874Y	0.631 < b < 1.193
Lavoutte	1.016	0.706 + 1.016	0.676 < b < 1.532
Maisabel	1.094	0.370 + 1.094Y	0.861 < b < 1.396
Chorro de Maíta	1.302	-0.548 + 1.302Y	0.696 < b < 2.760
Escape	1.551	-0.381 + 1.551Y	0.987 < b < 2.710
Anse à la Gourde	1.669	0.062 + 1.669Y	0.951 < b < 3.625

Table 6.3 Principle axis slope (b), equation, and 95% confidence limits per site.

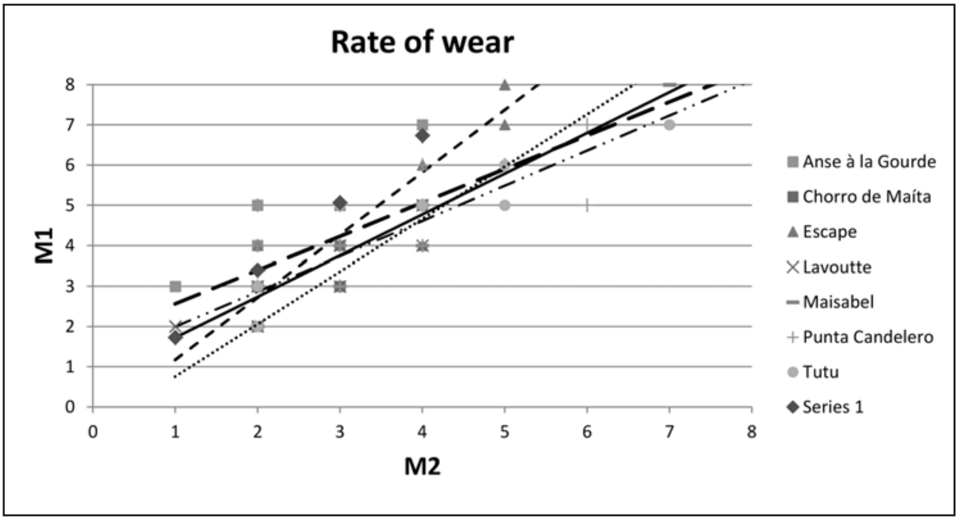


Figure 6.2 Scatterplot of M1–M2 wear scores by site, shown with principle axes. Note differences in slope steepness.

M2 on the Y2 (Y) axis (Sokal and Rohlf 1981:594–601). A steep principle axis slope (b) indicates a rapid rate of wear, whereas a gentle principle axis slope indicates a slow rate of wear. Since this method avoids the effects of age on the degree of dental wear, significant differences between the rate of wear (the principle axis slopes) of different sites can be taken to indicate differences in food consistency or food preparation techniques. Rapid rates of wear are usually associated with tough, abrasive diets (often hunter-gatherer or hunter-fisher diets). Slower rates of wear are more often associated with refined, less abrasive diets (processed agricultural produce) (Smith 1984; Larsen 1997; Lukacs 1996; Watson et al. 2011). Principle axis analysis was performed for the seven largest assemblages in the sample, which included at least ten adults with observed adjacent first and second left mandibular molars. The slopes, equation and confidence limits of the principle axis analyses can be found in Table 6.3. As can be seen in this table, the gradients of the slopes differ, reflecting differences in the rate of wear at each site. This suggests that food consistency and/or food preparation techniques differed per site. At some sites, the rate of wear was clearly more rapid than at other sites. For example, the sites of Anse à la Gourde, Chorro de Maíta, and Escape show relatively high rates of wear, with principle axis slopes of 1.302 and above. The remaining sites show lower rates of wear, with slopes of 1.094 and below.

As discussed by Scott (1979a), who compared the results of both the Scott (1979b) and Molnar (1971) dental wear scoring methods when used in principle axis analysis, the use of the 8 category Molnar method may lead to (greater) overlap in the confidence limits for the different groups in the comparison (see also Chapter 4 section 4.2.2). The results in Table 6.3 show that the slopes (b) for Lavoutte, Maisabel, Punta Candelero, and Tutu do indeed fall within the confidence limits for all seven sites in the sample. However, the slope (b) for Chorro de Maíta is distinct

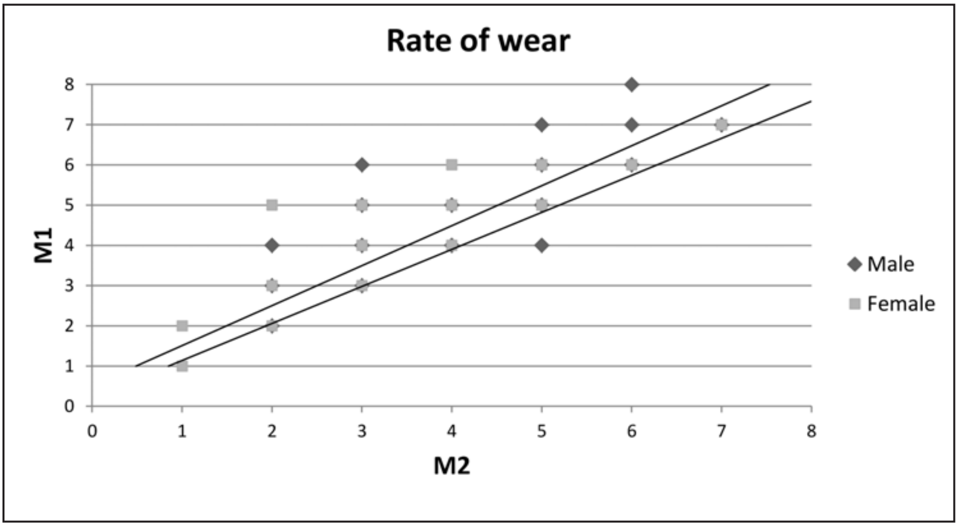


Figure 6.3 Scatterplot of M1–M2 wear scores by sex, shown with principle axes. Note the very slight difference in slope steepness.

(i.e., higher) from the highest confidence limit for Tutu. The slopes (b) for Anse à la Gourde and Escape are distinct (i.e., higher) from the highest confidence limits for Lavoutte, Maisabel, Punta Candelero, and Tutu. The use of the Molnar (1971) dental wear scoring system in principle axis analysis has thus revealed distinct differences in rate of wear in different groups; these differences are visualized in Figure 6.2. This figure shows the principle axis slopes for these seven sites, together with the plotted wear scores of adjacent first and second molars (M2 on the x-axis, and corresponding M1 on the y-axis), and thus visually displays the differences in rate of wear at these seven sites. Note in particular the differences in slope steepness, which indicate variation in rate of wear.

Chronological comparisons

Sample sizes of the separate occupation phases defined at some of the sites were deemed too small to make reliable comparisons regarding rate of wear.

Sex-based comparisons

Principle axis analysis was performed for the total of males and females in the sample. The slopes, equation and confidence limits of the principle axis analyses for males are: 1.087; 0.240 + 1.087Y; 0.7643 < b < 1.563. The slopes, equation and confidence limits of the principle axis analyses for females are: 1.007; 0.5208 + 1,007Y; 0.708 < b < 1.433.

The gradients of the slopes differ very slightly, reflecting differences in the rate of wear between males and females (Figure 6.3). Males have a very slightly higher rate of wear than females overall. This could indicate that food consistency and/or food preparation techniques differed by sex, or that differences in robusticity between the sexes contributed to the higher rate of wear in males.

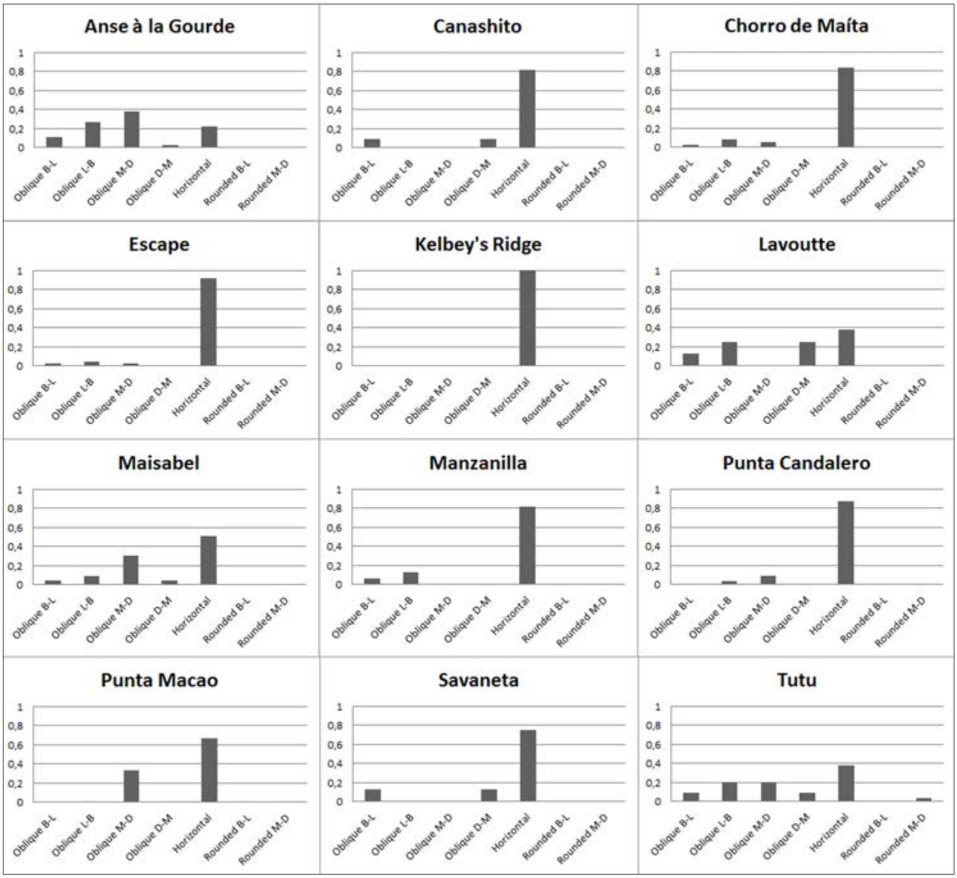


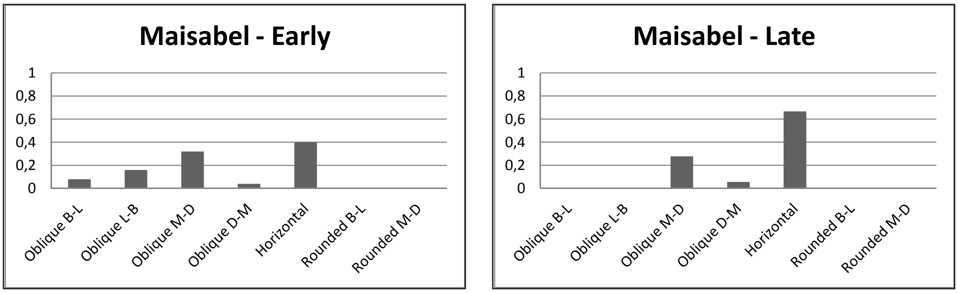
Figure 6.4 Bar charts depicting the proportion of molars by direction of wear, for each site with at least 16 molars graded in categories 2–8. Category 1, which represents the natural tooth shape and generally only occurs in unworn teeth, is excluded.

Sample sizes of adults of known sex at each site were deemed too small to make reliable comparisons regarding rate of wear.

Direction of wear

The direction of wear, which is related to the consistency (abrasiveness) and preparation methods of food, is measured in eight categories. Since category 1 represents the natural tooth shape, which generally only occurs in unworn teeth, this category is excluded from the calculations here. Figure 6.4 shows a number of bar charts for each site with at least 16 molars graded in categories 2–8 of direction of surface wear. The sites not included either have less than four adults in the assemblage, or have retained their natural molar shape overall.

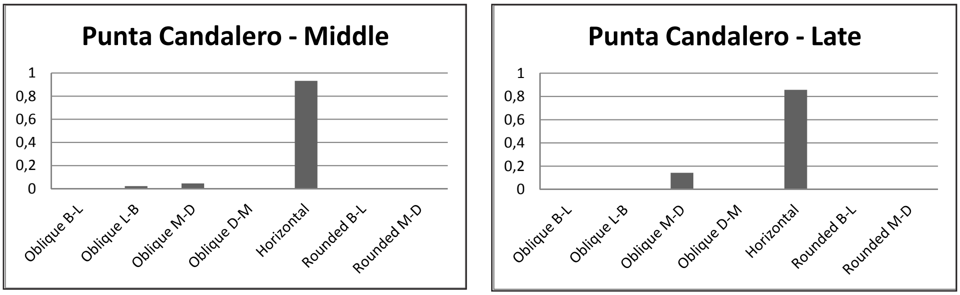
Examination of the frequency distributions of the direction of wear categories shows that there are two distinct ‘types’ of sites in the entire sample. The first type consists of sites that are characterized by predominantly horizontal molar wear, in some cases with a very small component of obliquely worn molars. The sites of Canashito, Chorro de Maíta, Escape, Kelbey's Ridge 2, Manzanilla, Punta Candelero, Punta Macao, and Savaneta belong to this type. The second type consists of sites in which the four different categories of obliquely worn teeth together


Maisabel - Early

Maisabel - Late

Figure 6.5 Proportions of direction of molar wear Maisabel: Early/Late.

outnumber the number of horizontally worn teeth. Anse à la Gourde, Lavoutte, Maisabel, and Tutu belong to this type.

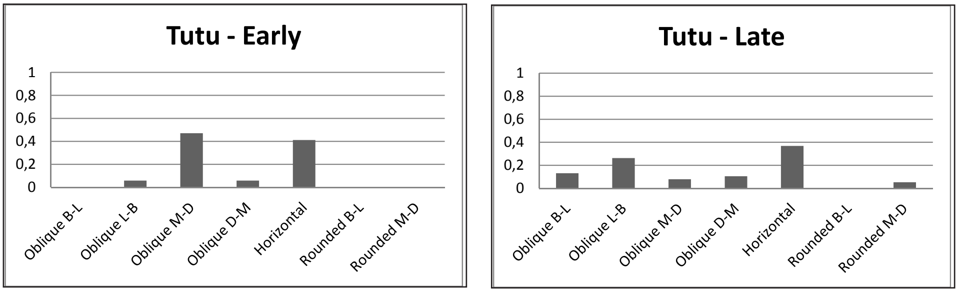

Punta Candalero - Middle

Punta Candalero - Late

Figure 6.6 Proportions of direction of molar wear Punta Candelero: Middle/Late.

Chronological comparisons

Maisabel –As the bar charts in Figure 6.5 shows, the proportion of horizontally worn molars increases in the late phase, while the proportion of obliquely worn molars both drops and shows less variation in types. A chi-square test shows the difference is not statistically significant ($\chi 2(1, N=63)= 2.98, p= 0.12$).


Tutu - Early

Tutu - Late

Figure 6.7 Proportions of direction of molar wear Tutu: Early/Late.

Punta Candelero – No significant differences were found between the middle and late phases of occupation ($\chi^2(1, N= 99)= 2.64, p= 0.17$). As the bar charts in Figure 6.6 show, the distribution of numbers across the categories of wear stays almost the same, notably with horizontal wear as the most common category.

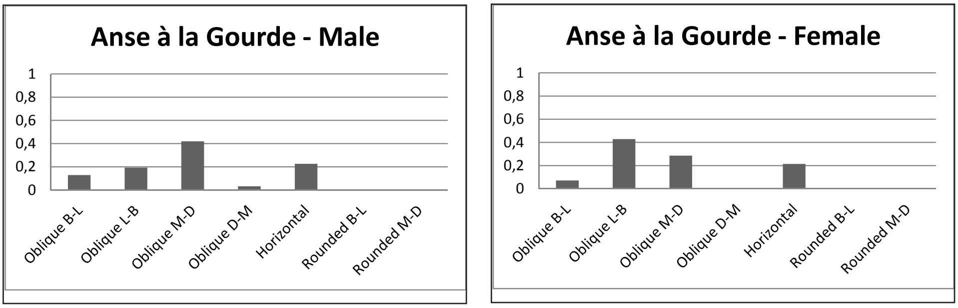


Figure 6.8 Proportions of direction of molar wear Anse à la Gourde: Male/Female.

Tutu – While the proportions of horizontally and obliquely worn molars in the early and late phases of occupation, do not differ significantly ($\chi^2(1, N= 53)= 0.15, p= 0.70$), the composition of the obliquely worn group does clearly differ. As the bar charts in Figure 6.7 show, in the early phase mesial-distal oblique wear predominates. In the late phase lingual-buccal oblique wear is most prevalent, al-

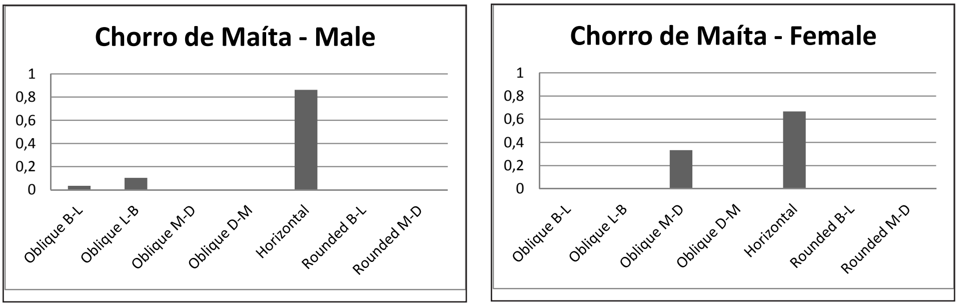


Figure 6.9 Proportions of direction of molar wear Chorro de Maíta: Male/Female.

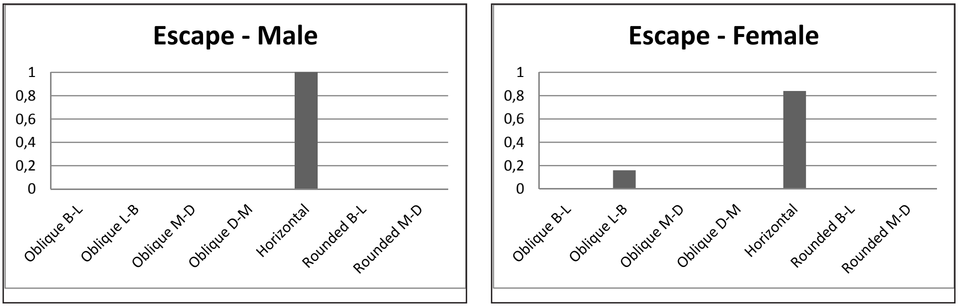
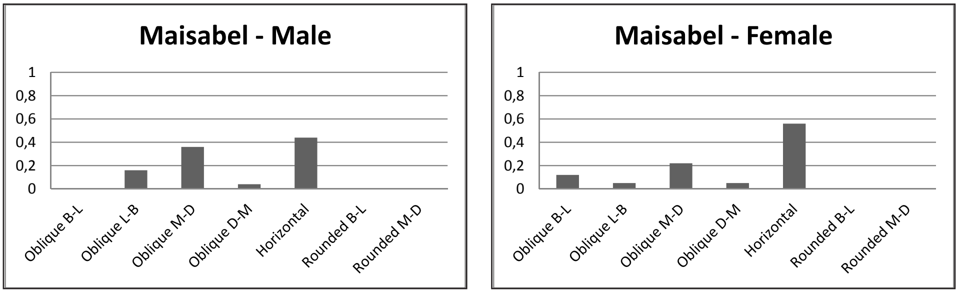


Figure 6.10 Proportions of direction of molar wear Escape: Male/Female.

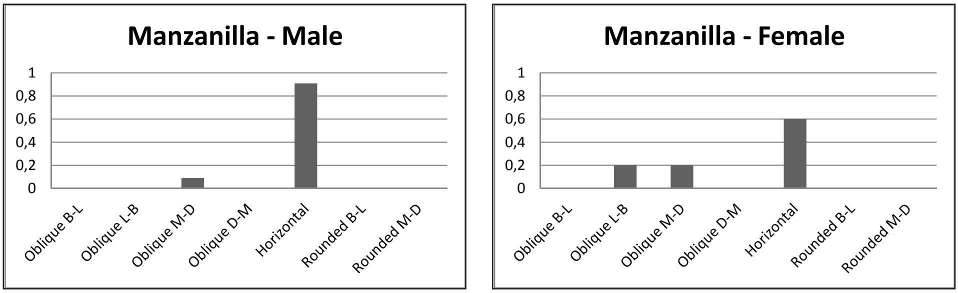
though the margin of difference is smaller. A chi-square test shows this difference is statistically significant ($\chi^2(4, N= 53)= 5.12, p= 0.28$).


Maisabel - Male

Maisabel - Female

Figure 6.11 Proportions of direction of molar wear Maisabel: Male/Female.

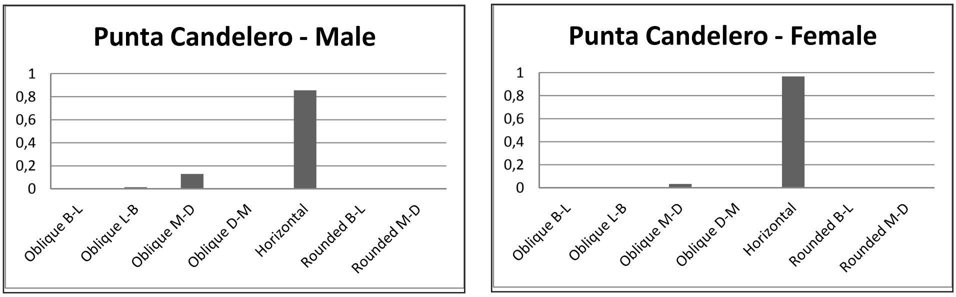
Sex-based comparisons
Anse à la Gourde – As can be seen in Figure 6.8, the frequencies of the categories of direction of molar wear differ slightly between males and females. While the proportions of oblique versus horizontal are practically equal, within the obliquely worn group males have a higher frequency of mesial-distal wear, whereas females have a higher frequency of lingual-buccal wear. The difference is not statistically significant based on the results of a chi-square test ($\chi^2(4, N= 55)= 3.20, p= 0.53$).


Manzanilla - Male

Manzanilla - Female

Figure 6.12 Proportions of direction of molar wear Manzanilla: Male/Female.

Chorro de Maíta – Figure 6.9 shows that males have a greater proportion of hori-


Punta Candelero - Male

Punta Candelero - Female

Figure 6.13 Proportions of direction of molar wear Punta Candelero: Male/Female.

zontally worn molars, and females a greater proportion of obliquely worn molars (in particular mesial-distal). The difference is not statistically significant (χ^2(1, N= 35)= 1.34, p= 0.27), most likely due to the small sample size.

Escape – Although Figure 6.10 suggests a small difference between males and females with regards to the proportion between oblique and horizontal surface shape, this is most likely the result of the very small number of males is the assemblage.

Lavoutte – Since most teeth have retained their natural shape, numbers are too small at Lavoutte to reliably test differences between males and females (n= 8).

Maisabel – Slight differences in the frequencies of the oblique categories of wear are present, although the proportion of oblique and horizontal direction of wear is almost equal in both sexes (Figure 6.11).

Manzanilla – In both males and females horizontal wear is clearly the predominant direction of wear (Figure 6.12), but numbers were too small to reliably test for significant differences (n= 16).

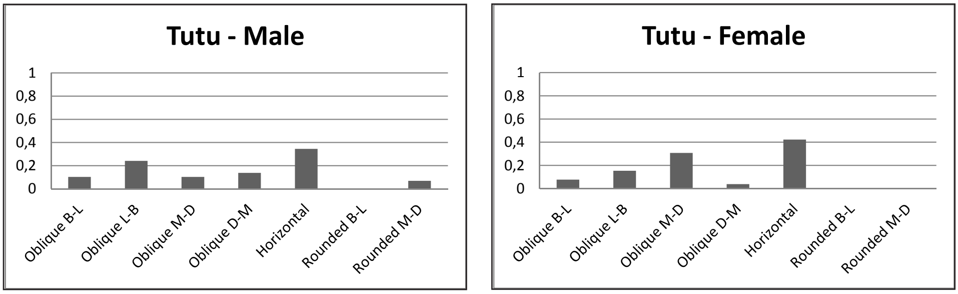


Figure 6.14 Proportions of direction of molar wear Tutu: Male/Female.

Punta Candelero – Figure 6.13 shows that both males and females have predominantly horizontally worn molars. Although males have a very slightly larger proportion of oblique mesial-distal molar wear, the difference is very subtle, and is not statistically significant (χ^2(1, N= 65)= 0.95, p= 0.38).

Punta Macao – Since most teeth have retained their natural shape, numbers are too small to reliably test differences between males and females (n= 6).

Tutu – Figure 6.14 shows that the proportion of oblique and horizontal molar wear is very similar for both sexes, however the composition of the group of obliquely worn teeth differs slightly. In males, most obliquely worn molars slant lingual-buccal, whereas in females the most common type of oblique wear is mesial-distal. The difference is only slight, however, and is not statistically significant (χ^2(4, N= 53)= 5.12, p= 0.28).

For the sites of Canashito, Diale 1, Juan Dolio, Kelbey's Ridge 2, Malmok, Point de Caille, Santa Cruz, Savaneta, Savanne Suazey and Tocorón numbers are too small to reliably test differences between males and females. For Mamora Bay there is no information available on biological sex, meaning no comparisons could be made

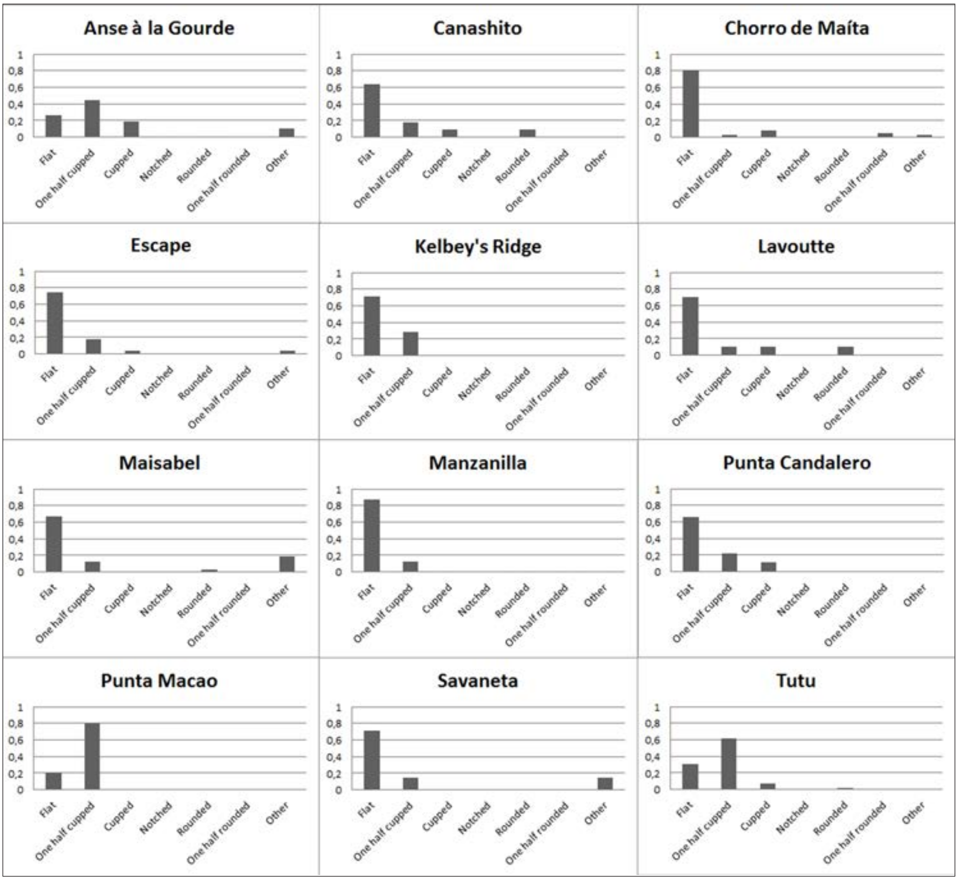


Figure 6.15 Bar charts depicting the proportion of molars by occlusal surface shape, for each site with at least 16 molars graded in categories 2–7. Category 1, which represents the natural tooth shape and generally only occurs in unworn teeth, is excluded.

between males and females.

Occlusal surface shape

The occlusal surface shape is similarly related to the consistency (abrasiveness) and preparation methods of food, and is measured in seven different categories. Since category 1 represents the natural tooth shape, which generally only occurs in unworn teeth, this category is excluded from the calculations here. Figure 6.15 shows a number of bar charts for each site with at least 16 molars graded in categories 2–7 of occlusal surface shape. The sites not included either have less than four adults in the assemblage, or have retained their natural occlusal surface shape overall.

The frequency distributions of the occlusal surface shape categories similarly show two 'types' of sites. The first type consists of sites that are characterized by predominantly flat molar wear, in some cases with a small component of cupped or half cupped molars. The sites of Canashito, Chorro de Maíta, Escape, Kelbey's Ridge 2, Lavoutte, Maisabel, Manzanilla, Punta Candelero, and Savaneta belong to this type. The second type consists of sites in which the two different categories denoting cupped occlusal surfaces together outnumber the number of horizontally

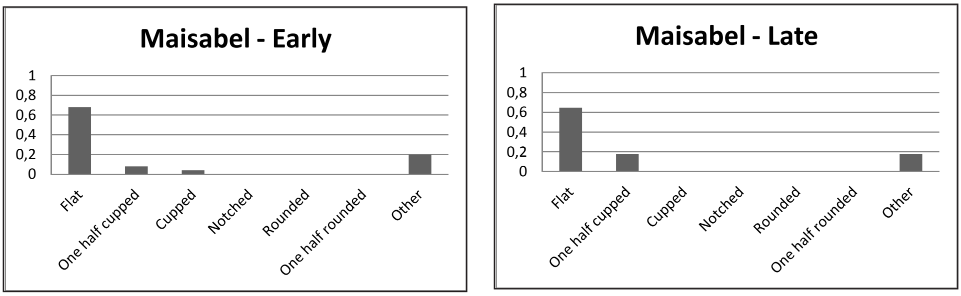


Figure 6.16 Proportions of molar occlusal surface shape Maisabel: Early/Late.

worn teeth. Anse à la Gourde, Punta Macao, and Tutu belong to this type.

Chronological comparisons
Maisabel – Figure 6.16 shows that the frequencies of occlusal surface shapes are almost identical for the early and late phase of occupation.

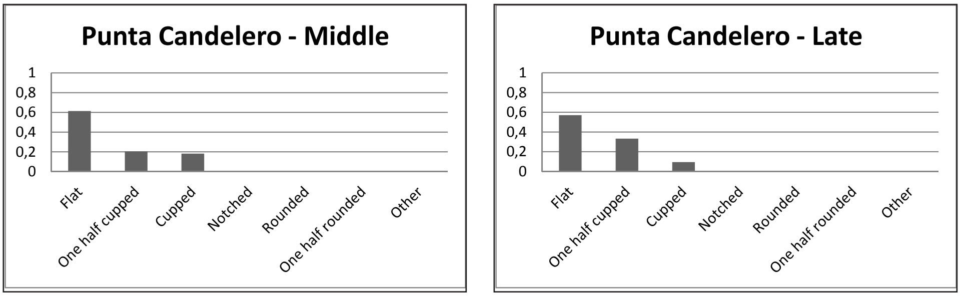


Figure 6.17 Proportions of molar occlusal surface shape Punta Candelero: Middle/Late.

Punta Candelero – As can be seen in Figure 6.17, the frequencies of occlusal surface shapes are practically the same for the middle and late phase of occupation.
Tutu – The proportion of flat wear rises slightly in the late phase of occupation

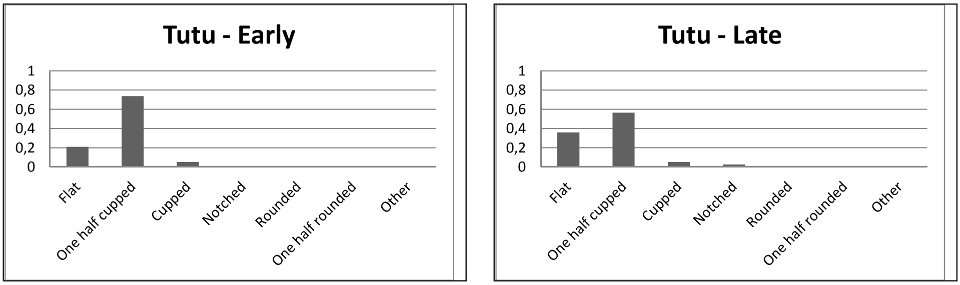


Figure 6.18 Proportions of molar occlusal surface shape Tutu: Early/Late.

(Figure 6.18), although the difference is not statistically significant ($\chi^2(1, N= 58)= 1.32, p= 0.25$).

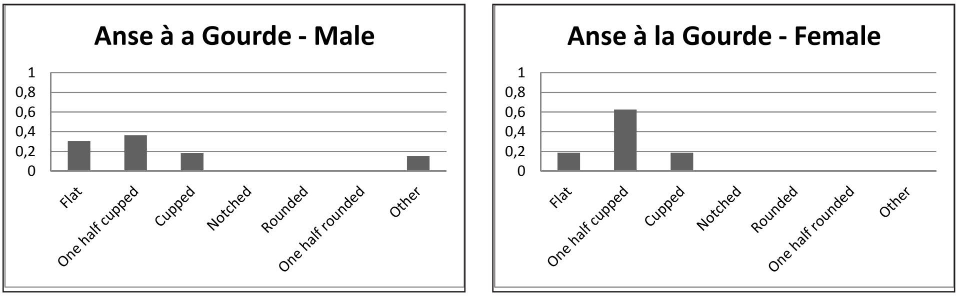


Figure 6.19 Proportions of molar occlusal surface shape Anse à a Gourde: Male/Female.

Sex-based comparisons
Anse à la Gourde – As can be seen in Figure 6.19, the proportion of cupped molar wear is somewhat higher in females than in males, however, the difference is not statistically significant ($\chi^2(1, N= 49)= 0.39, p= 0.50$).

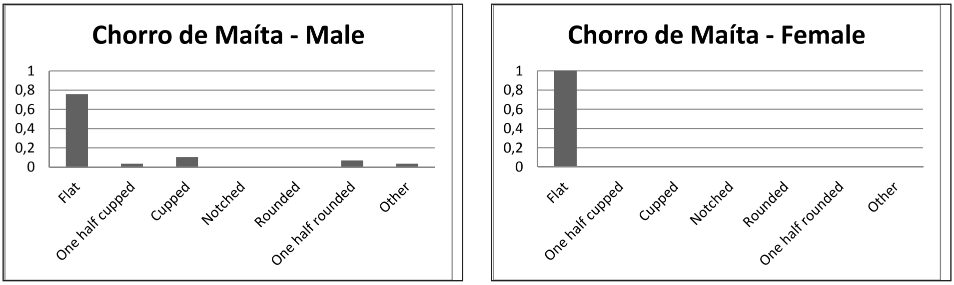


Figure 6.20 Proportions of molar occlusal surface shape Chorro de Maíta: Male/Female.

Chorro de Maíta – Figure 6.20 shows that while females have exclusively flatly worn molars, males also have a small proportion of cupped and rounded molars. The difference is most likely the result of the small number of female teeth in the sample, however, since most female teeth retain their natural shape.

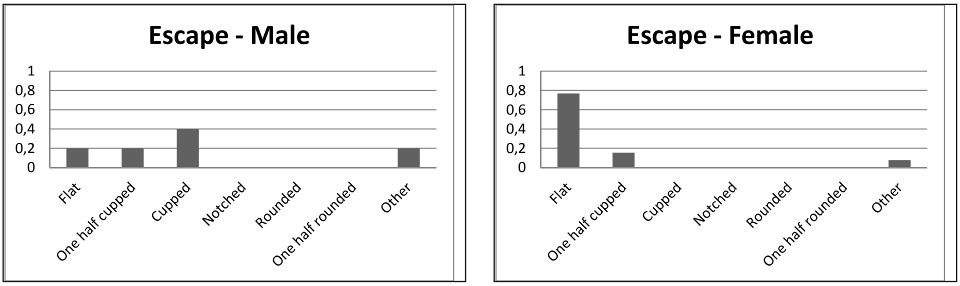


Figure 6.21 Proportions of molar occlusal surface shape Escape: Male/Female.

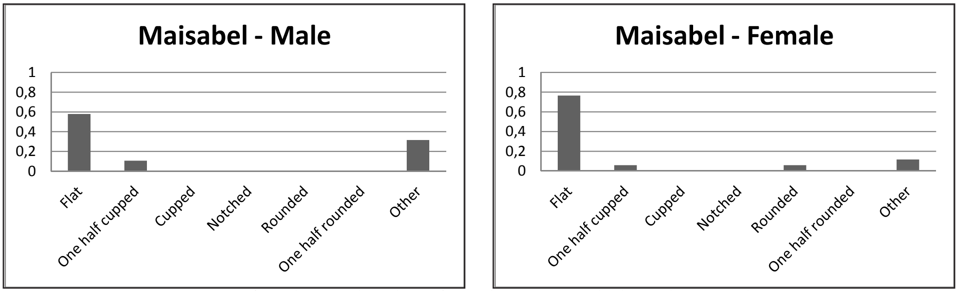


Figure 6.22 Proportions of molar occlusal surface shape Maisabel: Male/Female.

Escape – The proportion of flatly worn molars is clearly larger in females than in males. In males, cupped wear is most common (Figure 6.21). Numbers are too small to reliably test for significant differences, however (n= 18).

Lavoutte – Since most teeth have retained their natural shape, numbers are too small at Lavoutte to reliably test differences between males and females.

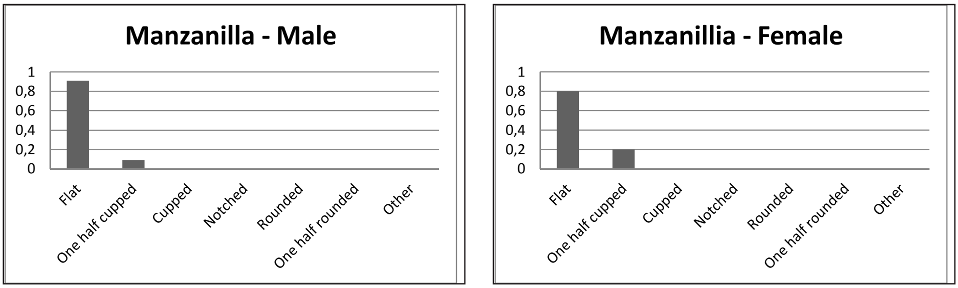


Figure 6.23 Proportions of molar occlusal surface shape Manzanilla: Male/Female.

Maisabel – The proportion between cupped and flat wear in both males and females is near enough the same (Figure 6.22). Males have a slightly larger number of teeth graded as 'other' than females, however the difference is not statistically significant ($\chi^2(1, N= 46)= 3.399, p= 0.334$).

Manzanilla – As Figure 6.23 demonstrates, the proportions of flat and cupped

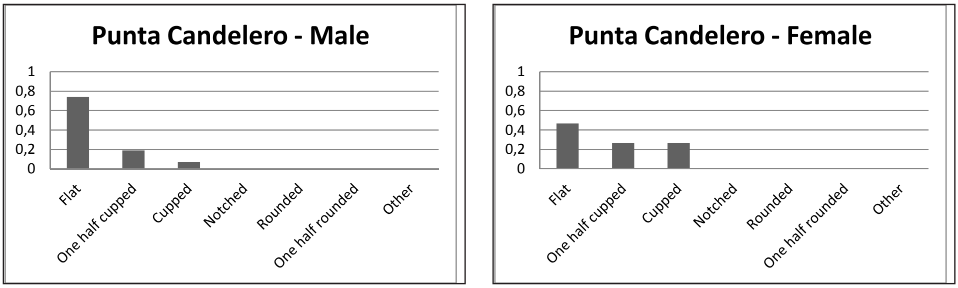


Figure 6.24 Proportions of molar occlusal surface shape Punta Candelero: Male/Female.

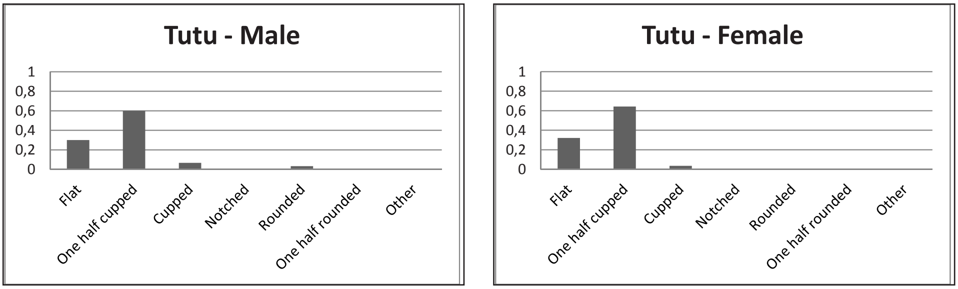


Figure 6.25 Proportions of molar occlusal surface shape Tutu: Male/Female.

wear in males and females are almost equal.

Punta Candelero – In males the flat occlusal surface shape clearly outnumbers the categories of cupped wear. In females, while flat wear in the most common surface shape, the categories of cupped wear together outnumber flat wear (Figure 6.24). The difference between males and females is statistically significant as demonstrated by a chi-square test (χ^2(1, N= 99)= 6.88, p= 0.01).

Punta Macao – Since most teeth have retained their natural shape, numbers are too small to reliably test differences between males and females.

Tutu – Both males and females are practically equally affected by flat and cupped molar surface shapes (Figure 6.25).

For the sites of Diale 1, Juan Dolio, Kelbey's Ridge 2, Malmok, Point de Caille, Santa Cruz, Savaneta, Savanne Suazey and Tocorón numbers are too small to reliably test differences between males and females. For Mamora Bay there is no information available on biological sex, meaning no comparisons could be made between males and females.

Extremely flat and horizontal wear

The combination of horizontal direction of wear and flat occlusal surface shape occurs more frequently than other combinations of wear patterns. At the sites of Chorro de Maíta and Punta Candelero extremely horizontally flattened and polished wear is frequently seen (Figure 6.26). This particular type of wear is rare or absent in the other sites.

Juvenile dental wear

The inclusion of a considerable number of juveniles (n= 69) in the dataset (although the numbers are relatively small at the individual sites), allowed for the tackling of a subject rarely dealt with in dental anthropology, or osteoarchaeology in general: juvenile dental wear, i.e., wear of the deciduous teeth (Clement and Freyne 2012). Preliminary observations of the degree of dental wear in very young (infant)

Figure 6.26 Punta Candelero 6. Oblique occlusal/lingual view of the right mandibular molars, showing very flat and horizontal wear. Note in particular, the flattened surface of the third molar. The first molar is slightly cupped, but this is to be expected considering the degree of wear and dentine exposure.

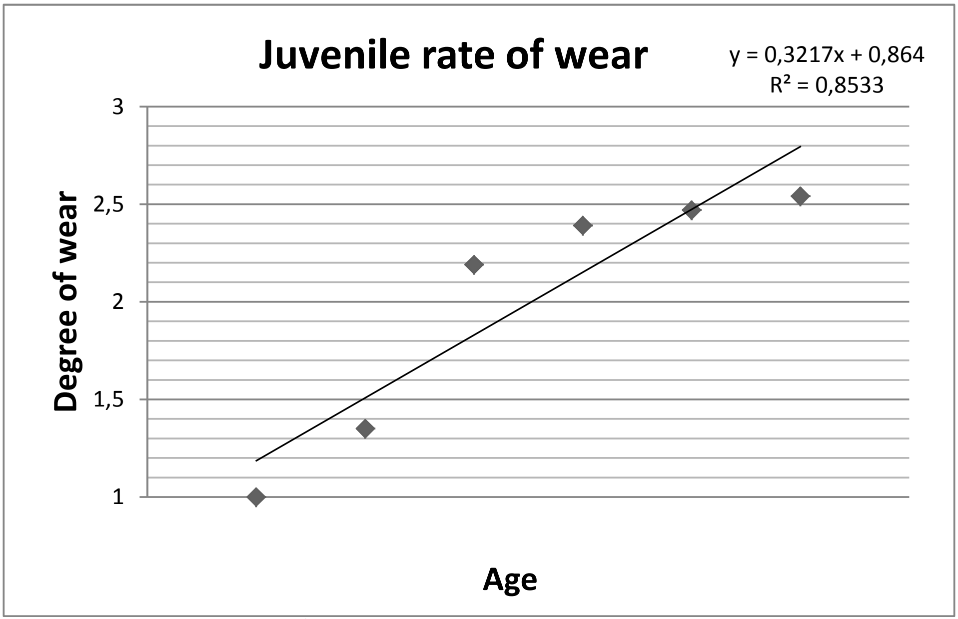


Figure 6.27 Linear regression of mean wear scores against age.

individuals led me to explore this data as a potential avenue for determining the role of juveniles in food consumption, and possible weaning age and duration. Dental wear in juveniles is caused by extrinsic abrasives (food), and tooth on tooth wear (attrition), as is the case in adults. Just as in adults, the type and degree of dental wear is partly influenced by physical aspects of the enamel. The enamel of deciduous teeth is generally less resilient than that of the permanent dentition as it is much thinner, and the deciduous dentition is generally much smaller (Hillson 1996), however, dental wear in the deciduous dentition has not been intensively studied. In part it seems this is because age estimation in juveniles uses the eruption sequence, which is much more accurate than degree of wear. Also, since the deciduous dentition is shed relatively rapidly it is generally assumed that little wear will have accumulated. The presence of even very slight deciduous dental wear in itself is highly interesting, as it indicates that the dentition was in occlusion and solid foods were being consumed – on a regular basis (Lewis 2007).

Table 6.4 and Figure 6.27 display the mean degree of dental wear of the deciduous teeth per age category and the rate of wear (regression line) for the total number of juveniles represented in the samples (n= 54). Age categories were defined by the author to represent the shortest time intervals possible with the available data on age of the individuals. Degree of dental wear is evaluated using Molnar's (1971) method, which is broadly comparable to those of Smith (1984) and Murphy (1959), on a scale of 1 to 8 in which 1 represents the category 'unworn' and 8 represents 'roots functioning in occlusion'. Figure 6.27 shows that in this group of 54 children, dental wear is present from the age of 1–2 years onward. In juveniles aged 0–1 no dental wear was observed. Degree of dental wear rises sharply at the age of

3–4, perhaps related to children being completely weaned at this age.

At 5–6 years there is only a slight rise in the mean degree of wear, probably due to the eruption of the permanent first molars and replacement of the deciduous central incisors with permanent elements around this age, which would also have taken some of the masticatory load off the rest of the dentition. Mean degree of dental wear continues to rise only very slightly at the age of 7–9 years, and 10–11, again probably due to the replacement of a number of deciduous elements by permanent teeth which take the masticatory load off the remaining deciduous teeth.

Site comparisons

Numbers of juvenile individuals per site are too small to be able to make comparisons between mean degrees of wear for the juvenile age groups.

Age	Site	Feature	Individual Age	Mean degree of wear
<1	Anse à la Gourde	1922	0.5–1	1
	Punta Macao	20	0.3–0.5	
1–2	Chorro de Maíta	17	1.5–2	1.35
	Diale 1	155	1.5–2.5	
	Maisabel	3	1–2	
	Maisabel	24	1–1.5	
	Maisabel	27	1.5–2	
3–4	Anse à la Gourde	377	2–3	2.19
	Anse à la Gourde	1413	3–4	
	Chorro de Maíta	10	2–3	
	Chorro de Maíta	84	3–5	
	Collores	162	3	
	Kelbey's Ridge 2	337	2–3	
	Maisabel	8	2–3	
	Maisabel	31	2–4	
	Punta Candelero	40	3–5	
	Punta Candelero	112	2–3	
	Punta Macao	21	2–4	
	Santa Elena	153	3–4	
	Savanne Suazey	2	2.5–3.5	
	Spring Bay 1c	1	2–4	

Age	Site	Feature	Individual Age	Mean degree of wear
5–6	Anse à la Gourde	195	4–5	2.39
	Anse à la Gourde	1944	5–7	
	Chorro de Maíta	12	5–6	
	Chorro de Maíta	13	4–5	
	Chorro de Maíta	18	5–6	
	Escape	25	6	
	Lavoutte	9	4–5	
	Lavoutte	14	4–5	
	Maisabel	16	4–5	
	Punta Candelero	113	5–7	
	Punta Candelero	114	4–5	
	Punta Macao	7	4–5	
	Punta Macao	10	4–5	
	Santa Cruz	6	4–5	
	Sistema sanitaria	2	4–5	
	Tutu	6	5.5–7	
	Tutu	22	4–5	
	Tutu	32	5	
7–9	Anse à la Gourde	291	4–9	2.47
	Chorro de Maíta	6	6–9	
	Chorro de Maíta	7	7–9	
	Chorro de Maíta	14	6–8	
	Chorro de Maíta	32	7–8	
	Chorro de Maíta	69	6–8	
	Punta Candelero	14	7–8	
	Punta Candelero	2 (B4)	6–7	
	Savaneta	Urn	7	
	Tutu	39	8	
10–11	Chorro de Maíta	64	10–12	2.54
	Chorro de Maíta	94	9–11	
	Diale 1	150	9–10	
	Tutu	20	9	

Table 6.4 The degree of dental wear per juvenile and mean degree of wear per age category for juveniles per site.

Intentional Dental Modification

A female individual (72B) aged 18–25 years from the site of Chorro de Maíta presents a clear case of intentional dental modification. The dental modification affects the upper incisors and canines, with the central incisors most prominently modified. All upper incisors and both upper canines appear to have been filed extensively, considerably reducing the crown height and leaving the occlusal surfaces extremely smooth and flattened. The central incisors have a further modification of the occlusal surfaces at both the mesial and distal margins, in the form of buccolingual grooves which extend across the entire occlusal surface. The grooves are 1.50–2.00 mm wide and 1.5 mm deep. In frontal view, the grooves appear to be semi-circular in shape, however the pits of the grooves are in actual fact almost completely flat (Figure 6.28). The other teeth in the dentition are unmodified and only very slightly worn. There is no corresponding wear on the lower anterior teeth, most likely excluding a masticatory activity as the cause. Moreover, the strik

Site	Chipping frequency (tooth count) %	Male	Female	Unknown
Monserrate	0.00	0.00	-	0.00
Tanki Flip	0.00	-	-	0.00
Savaneta	1.43	4.00	0.00	-
Point de Caille	1.52	0.00	3.00	-
Santa Cruz	3.03	0.00	0.00	5.00
Tocorón	3.13	0.00	8.00	0.00
Chorro de Maíta	5.48	7.00	3.00	2.00
Diale 1	6.00	6.00	6.00	-
Heywoods	6.06	-	5.00	6.52
Canashito	6.38	10.53	0.00	11.11
Escape	7.97	0.00	12.00	8.00
Argyle 2	9.43	11.90	-	0.00
Gordon Hill cave	10.00	0.00	-	50.00
Savanne Suazey	10.53	10.00	11.00	-
Lavoutte	10.74	13.00	8.00	5.00
Saladero	11.11	-	-	11.11
Punta Candelero	11.82	25.00	31.00	24.00
Manzanilla	14.21	16.00	18.00	0.00
Mamora Bay	15.00	-	-	15.00
St. Kitts	17.07	26.92	-	0.00
El Cabo	19.05	20.00	17.65	-
Maisabel	21.02	16.00	30.00	13.00
Punta Macao	26.98	26.00	28.00	2.00
Anse à la Gourde	28.69	37.11	22.01	25.00
Juan Dolio	30.77	33.00	29.00	-
Malmok	32.26	47.00	8.00	15.00
Canas	33.33	-	0.00	37.50
Manigat cave	34.62	25.00	-	36.36
Clarence town cave	38.46	33.33	100.00	-
Kelbey’s Ridge 2	40.00	67.00	37.00	-
Tutu	41.08	57.00	31.00	0.00
Hacienda Grande	72.22	100.00	16.67	-

Table 6.5 The frequency of chipped teeth by site and sex.

ing symmetry and precision of the grooves and flattened occlusal surfaces indicate that the modification must have been intentional as opposed to activity-induced.

Figure 6.28 Chorro de Maíta individual 72B. Intentional Dental Modification of the upper incisors and canines. Labial view.

6.3.2 Dental chipping

Chipping is prevalent throughout the entire sample, although some significant differences were found between the sites. In total 1,032 chipped teeth were recorded in the adult population, amounting to 21.01% of the teeth in which preservation and pathological condition of the tooth (e.g., the presence of large carious lesions) allowed for assessment of chipping (n= 4,912). In the total sample, 235 adult individuals with at least one chipped tooth were observed, amounting to 60.41% of the entire adult population (n= 389). Of the total population, 247 individuals with at least one chipped tooth were observed, amounting to 53.93% of the entire population (n= 458).

		High							Low												
		AAG	**JD**	**KR**	**MB**	**MK**	**PM**	**TT**	**CAN**	**CM**	**DIA**	**ESC**	**LAV**	**MMB**	**MZ**	**PdC**	**PC**	**SAV**	**SC**	**SS**	**TOC**
High	**AAG**	-	0.76	0.22	**0.01**	0.15	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	JD	0.76	-	0.47	0.07	0.22	0.19	0.22	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.05**	**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.02**	**0.00**
	KR	0.22	0.47	-	**0.02**	0.06	0.06	1.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	MB	**0.01**	0.07	**0.02**	-	0.88	0.73	**0.00**	**0.03**	**0.00**	**0.05**	**0.00**	**0.00**	0.42	0.13	**0.00**	0.10	**0.00**	**0.00**	0.14	**0.02**
	MK	0.15	0.22	0.06	0.88	-	1.00	**0.00**	**0.04**	**0.00**	0.08	**0.00**	**0.01**	0.40	0.21	**0.00**	0.25	**0.00**	**0.00**	0.16	**0.02**
	PM	**0.04**	0.19	0.06	0.73	1.00	-	**0.00**	0.18	**0.00**	**0.04**	**0.00**	**0.00**	0.29	0.12	**0.00**	0.08	**0.00**	**0.00**	0.11	**0.01**
	TT	**0.00**	0.22	1.00	**0.00**	**0.00**	**0.00**	-	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Low	**CAN**	**0.00**	**0.00**	**0.00**	**0.03**	**0.04**	0.18	**0.00**	-	0.73	1.00	1.00	0.60	0.24	0.22	0.31	0.13	0.30	0.34	0.51	0.64
	CM	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.73	-	0.33	**0.04**	**0.00**	**0.00**	**0.00**	0.37	**0.00**	0.25	0.51	0.12	1.00
	DIA	**0.00**	**0.01**	**0.00**	**0.05**	0.08	**0.04**	**0.00**	1.00	0.33	-	1.00	1.00	0.40	0.34	0.16	0.22	0.16	0.20	0.75	0.64
	ESC	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	1.00	**0.04**	1.00	-	0.45	0.08	**0.03**	0.07	**0.00**	**0.04**	0.16	0.61	0.50
	LAV	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	0.60	**0.00**	1.00	0.45	-	0.22	0.12	**0.03**	**0.01**	**0.02**	0.07	0.81	0.35
	MMB	**0.01**	**0.05**	**0.01**	0.42	0.40	0.29	**0.00**	0.24	**0.00**	0.40	0.08	0.22	-	1.00	**0.01**	1.00	**0.01**	**0.02**	0.60	0.10
	MZ	**0.00**	**0.01**	**0.00**	0.13	0.21	0.12	**0.00**	0.22	**0.00**	0.34	**0.03**	0.12	1.00	-	**0.00**	0.73	**0.00**	**0.01**	0.66	0.09
	PdC	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.31	0.37	0.16	0.07	**0.03**	**0.01**	**0.00**	-	**0.00**	1.00	1.00	**0.05**	1.00
	PC	**0.00**	**0.01**	**0.00**	0.10	0.25	0.08	**0.00**	0.13	**0.00**	0.22	**0.00**	**0.01**	1.00	0.73	**0.00**	-	**0.00**	**0.00**	0.44	**0.05**
	SAV	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.30	0.25	0.16	**0.04**	**0.02**	**0.01**	**0.00**	1.00	**0.00**	-	1.00	**0.05**	0.55
	SC	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.34	0.51	0.20	0.16	0.07	**0.02**	**0.01**	1.00	**0.00**	1.00	-	0.12	1.00
	SS	**0.00**	**0.02**	**0.00**	0.14	0.16	0.11	**0.00**	0.51	0.12	0.75	0.61	0.81	0.60	0.66	**0.05**	0.44	**0.05**	0.12	-	0.25
	TOC	**0.00**	**0.00**	**0.00**	**0.02**	**0.02**	**0.01**	**0.00**	0.64	1.00	0.64	0.50	0.35	0.10	0.09	1.00	**0.05**	0.55	1.00	0.25	-

Table 6.6 Chi-square values and p-values for the post-hoc chi-square tests of chipping frequencies per site. Only sites with four or more adult individuals are included. Statistically significant differences are marked in bold. AAG= Anse à la Gourde, JD= Juan Dolio, KR= Kelbey's Ridge 2, MB= Maisabel, MK= Malmok, PM= Punta Macao, TT= Tutu, CAN= Canashito, CM= Chorro de Maíta, DIA= Diale 1, ES= Escape, LAV= Lavoutte, MMB= Mamora Bay, MZ= Manzanilla, PdC= Point de Caille, PC= Punta Candelero, SAV= Savaneta, SC= Santa Cruz, SS= Savanne Suazey, TOC= Tocorón.

Chipping prevalence

One aim of this study is to assess differences in chipping rates between the individual sites. A preliminary investigation of chipping rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences between the sites. Only sites with at least four adult individuals were included in these analyses. The caries rates based on the tooth count method per site and by sex, can be found in Table 6.5. As can be seen in this table, there appear to be considerable differences in the rate of caries per site. The statistical significance of these differences was tested using a chi-square test. This

Site	Chipping frequency (individual count) %	Male	Female	Unknown
Monserrate	0.00	0.00	-	0.00
Tanki Flip	0.00	-	-	0.00
Tocorón	16.67	0.00	100.00	0.00
Savaneta	20.00	50.00	0.00	-
Point de Caille	25.00	0.00	50.00	-
Santa Cruz	25.00	0.00	0.00	50.00
Cañas	33.33	-	0.00	50.00
Heywoods	33.33	-	100.00	0.00
Kelbey’s Ridge 2	33.33	0.00	50.00	-
Saladero	33.33	-	-	33.33
Chorro de Maíta	40.00	46.15	30.77	66.67
Escape	40.00	0.00	66.67	37.50
Gordon Hill cave	50.00	0.00	-	100.00
Mamora Bay	50.00	-	-	50.00
St. Kitts	50.00	100.00	-	0.00
Lavoutte	51.85	80.00	40.00	28.57
Diale 1	60.00	50.00	66.67	-
Argyle 2	66.67	100.00	-	0.00
Maisabel	69.23	60.00	87.50	66.67
Manzanilla	71.43	70.00	75.00	-
Punta Macao	73.33	83.33	62.50	100.00
Punta Candelero	73.47	84.21	81.82	57.89
Canashito	75.00	100.00	0.00	100.00
Savanne Suazey	75.00	100.00	50.00	-
Anse à la Gourde	78.69	91.67	64.71	33.33
Tutu	80.95	100.00	78.57	0.00
Juan Dolio	85.71	100.00	75.00	-
Clarence town cave	100.00	100.00	100.00	0.00
El Cabo	100.00	100.00	100.00	0.00
Hacienda Grande	100.00	100.00	100.00	0.00
Malmok	100.00	100.00	100.00	100.00
Manigat cave	100.00	100.00	-	100.00

Table 6.7 The frequency of individuals affected by chipping by site and sex.

test determined a significant difference between at least two of the sites (χ^2(19, N=4912) = 420.94, p= 0.00).

Table 6.6 displays the χ^2 values and p-values of the post-hoc (chi-square) com-

Site		18–25		26–35		36–45		46+	
		Ant.	**Post.**	**Ant.**	**Post.**	**Ant.**	**Post.**	**Ant.**	**Post.**
Chorro de Maíta	**M**	13.21 (53)	0.00 (76)	6.90 (87)	9.09 (132)	7.14 (14)	8.70 (23)	6.45 (31)	4.17 (24)
	F	0.00 (77)	2.63 (114)	3.33 (30)	3.23 (31)	0.00 (13)	50.00 (14)	0.00 (8)	14.29 (7)
Escape	**M**	0.00 (8)	0.00 (19)	-	-	0.00 (8)	0.00 (12)	-	-
	F	0.00 (8)	40.00 (15)	14.29 (14)	0.00 (28)	0.00 (5)	14.29 (7)	0.00 (2)	20.00 (10)
Lavoutte	**M**	-	-	16.13 (31)	13.79 (58)	13.64 (22)	14.71 (34)	0.00 (16)	8.70 (23)
	F	0.00 (6)	5.26 (19)	0.00 (13)	0.00 (17)	0.00 (16)	13.33 (15)	30.00 (10)	26.67 (15)
Punta Candelero	**M**	0.00 (20)	22.22 (36)	8.00 (25)	50.00 (38)	23.81 (21)	29.41 (34)	17.86 (28)	58.97 (39)
	F	16.67 (12)	33.33 (15)	11.54 (26)	52.08 (48)	0.00 (11)	38.46 (13)	0.00 (8)	57.14 (14)
Manzanilla	**M**	23.08 (13)	21.74 (23)	5.26 (19)	12.12 (33)	-	50.00 (4)	0.00 (7)	42.86 (7)
	F	0.00 (8)	41.18 (17)	-	-	-	-	0.00 (9)	10.00 (10)
Maisabel	**M**	15.00 (20)	21.62 (37)	16.67 (36)	8.93 (56)	-	-	16.00 (25)	18.75 (32)
	F	-	-	-	-	39.13 (23)	32.50 (40)	24.14 (29)	15.38 (26)
Punta Macao	**M**	0.00 (2)	0.00 (8)	27.27 (11)	30.00 (10)	17.65 (17)	33.33 (12)	0.00 (1)	0.00 (2)
	F	14.29 (7)	36.36 (11)	0.00 (8)	29.41 (17)	-	-	30.77 (13)	37.50 (8)
Anse à la Gourde	**M**	44.00 (25)	18.42 (38)	27.66 (94)	35.71 (98)	57.14 (28)	38.24 (34)	46.67 (30)	55.00 (20)
	F	14.29 (63)	6.93 (101)	27.96 (93)	28.41 (88)	47.06 (34)	17.86 (28)	29.41 (17)	30.00 (10)
Tutu	**M**	-	-	-	-	42.86 (21)	52.63 (38)	38.89 (18)	73.81 (42)
	F	50.00 (18)	10.71 (28)	-	-	21.05 (19)	58.62 (29)	29.55 (44)	30.00 (60)

Table 6.8 Chipping rates for males and females per site, by age group and anterior/posterior teeth. The number of observed teeth is indicated between the brackets.

parisons of each individual site to the others in order to establish the cause of the significant difference demonstrated by the chi-square test extended to more than 2 groups. Post-hoc comparisons of each individual site with the others revealed that, as expected, the sites within the higher and ranges show significant differences with sites in the lower chipping range, and vice versa. Based on the significant differences found between the sites, two groups can be defined: one representing a low chipping range (Table 6.6). The individual count assesses the proportion of individuals in the population who have at least one chipped tooth. Of the total adult populations (n= 389), 60.41% has at least one chipped tooth (n= 235). The proportion of adult individuals affected by chipping per site and by sex is presented in Table 6.7. A chi-square test for independence of variables demonstrates that at least two sites differ significantly from each other with regards to the proportion of adults affected by chipping (χ^2(19, N=342) = 46.57, p= 0.00). Post-hoc comparisons showed that a significantly higher proportion of the adult population of Anse à la Gourde is affected by dental chipping than the adult populations of Chorro de Maíta (χ^2(1, N=116) = 14.94, p= 0.00), Escape (χ^2(1, N=85) = 7.77, p= 0.01), and Tocorón (χ^2(1, N=67) = 8.28, p= 0.01). Likewise, at Tutu a significantly higher proportion of the adult population is affected by dental chipping than the adult populations of Chorro de Maíta (χ^2(1, N=76) = 11.12, p=0.00), Escape (χ^2(1, N=45) = 7.20, p= 0.01), and Tocorón (χ^2(1, N=27) = 8.68, p= 0.01). No other significant differences were revealed.

The preliminary assessments above indicate significant differences in chipping rates between the individual sites in the sample. However, chipping like all dental wear is related to age, and is known to affect the anterior and posterior teeth in different ways. Therefore, when comparing chipping rates between groups, the effects of age, differential preservation of individual dental elements, and differential susceptibility of individual dental elements must be taken into account. The differences demonstrated above using the simple tooth count and individual count methods could (partly) result from differing age profiles and differentially preserved/affected dental elements. Table 6.8 presents the chipping rates per site by age group (18–25, 26–35, 36–45, and 46+), and by anterior and posterior teeth.

Chronological comparisons

Maisabel – A very slight increase is seen in the frequency of chipped teeth (tooth count) from the early to late period, although this is not statistically significant.

Maisabel	**Tooth count**	**Individual count**
Early	0.16	0.64
Late	0.17	0.73
	χ^2(1, N=400)= 0.13, p= 0.72	χ^2(1, N=26)= 0.28, p= 0.60

Table 6.9 Chipping frequencies (tooth count and individual count) for Maisabel per period.

The proportion of affected individuals (individual count) also rises from the early to late period. This difference is also not statistically significant (Table 6.9).

Punta Candelero – The frequency of chipped teeth (tooth count) is the same for the middle and the late period. The proportion of affected individuals (individual count) also drops from the middle to late period. This difference is also not statistically significant (Table 6.10).

Punta Candelero	**Tooth count**	**Individual count**
Middle	0.26	0.70
Late	0.26	0.60
	χ^2(1, N=336)= 0.00, p= 1.00	χ^2(1, N=25)= 0.18, p= 0.67

Table 6.10 Chipping frequencies (tooth count and individual count) for Punta Candelero per period.

Tutu – The frequency of chipped teeth (tooth count) shows a statistically significant increase from the early to late period. The proportion of affected individuals (individual count) drops somewhat from the early to late period, although the difference is not significant (Table 6.11).

Tutu	**Tooth count**	**Individual count**
Early	0.33 (42/127)	0.89 (8/9)
Late	0.47 (90/192)	0.75 (9/12)
	χ^2(1, N=319)= 6.01, p= 0.01	χ^2(1, N=21)= 0.64, p= 0.60

Table 6.11 Chipping frequencies (tooth count and individual count) for Tutu per period.

Sex-based comparisons

In the total sample 69.28% of males (n= 106) and 60.81% of females (n= 90) are affected by dental chipping. While a greater proportion of males are affected by chipping than females, a chi-square test shows that this difference is not statistically significant (χ^2(1, N= 301)= 2.38, p = 0.15). The proportion of teeth affected in males is 20.59%, while in females the proportion is 16.64%. A chi-square test shows this difference is statistically significant (χ^2(1, N= 4,572)= 11.65, p= 0.00), showing males have a greater proportion of chipped teeth overall than females.

Sex differences were investigated at the individual sites. Based on the results presented in Table 6.8, at most of the larger sites, males tend to have higher chipping rates in all age groups and in both anterior and posterior teeth than females. Below, the sites with a large enough assemblage of males and females to use in comparative statistical analyses are discussed in more detail. Frequencies of dental chipping based on the tooth count method and on the individual count method per site and by sex can be found in Table 6.5 and Table 6.7 respectively. The frequency of dental chipping (tooth count) by sex and anterior and posterior dentition for all sites with four or more adults can be found in Table 6.12.

Intra-site comparisons

Anse à la Gourde – A chi-square test demonstrates that a significantly larger proportion of males (91.67%) is affected by chipping than females (64.71%) (χ^2(1, N= 58)= 5.59, p= 0.03). Furthermore, in males (35.22%) a significantly greater proportion of the teeth is chipped than in females (19.09%) (χ^2(1, N= 935)= 30.98, p= 0.00). This difference is mainly due to the greater proportion of posterior chipping in males than in females. In males the anterior dentition is significantly more frequently affected than the posterior dentition (χ^2(1, N= 380)= 51.99, p= 0.00). In females, while the anterior dentition is more frequently affected than the posterior dentition, difference is not statistically significant (χ^2(1, N= 477)= 1.82, p= 0.19). A Mann-Whitney U test shows that males have significantly larger chips than females (*U* = 76880.50, p= 0.00).

Frequency of chipping	Male			Female			Unknown			Child		
	Ant.	Post.	Total	Ant.	Post.	Total	Ant.	Post.	Total	Ant.	Post.	Total
Anse à la Gourde	0.49	0.25	0.37	0.27	0.17	0.22	0.50	0.00	0.25	0.09	0.03	0.08
Canashito	0.00	0.17	0.11	0.00	0.00	0.00	0.20	0.00	0.11	-	-	-
Chorro de Maíta	0.09	0.06	0.07	0.01	0.05	0.03	0.02	0.03	0.02	0.01	0.00	0.00
Diale 1	0.00	0.10	0.06	0.14	0.04	0.06	-	-	-	0.00	0.50	0.50
Escape	0.00	0.00	0.00	0.07	0.14	0.12	0.01	0.12	0.08	0.00	0.00	0.00
Juan Dolio	0.14	0.41	0.33	0.14	0.33	0.29	-	-	-	-	-	-
Kelbey's Ridge	1.00	0.50	0.67	0.38	0.36	0.37	0.00	0.00	0.00	0.00	0.03	0.02
Lavoutte	0.12	0.13	0.13	0.05	0.10	0.08	0.03	0.07	0.05	0.00	0.00	0.00
Maisabel	0.16	0.16	0.16	0.31	0.29	0.30	0.09	0.17	0.13	0.00	0.00	0.00
Malmok	0.00	0.50	0.47	0.00	0.14	0.08	0.16	0.14	0.15	-	-	-
Mamora Bay	-	-	-	-	-	-	0.03	0.22	0.15	-	-	-
Manzanilla	0.12	0.19	0.16	0.00	0.30	0.18	0.00	0.00	0.00	0.00	0.14	0.18
Point de Caille	0.00	0.00	0.00	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Punta Candelero	0.11	0.34	0.25	0.11	0.43	0.31	0.14	0.29	0.24	0.00	0.18	0.10
Punta Macao	0.23	0.29	0.26	0.19	0.35	0.28	0.05	0.00	0.02	0.00	0.00	0.00
Santa Cruz	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.00	0.00	0.00
Savaneta	0.00	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Savanne Suazey	0.00	0.15	0.10	0.00	0.15	0.11	-	-	-	0.00	0.00	0.00
Tocorón	0.00	0.00	0.00	0.00	0.13	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Tutu	0.43	0.64	0.57	0.30	0.33	0.31	0.00	0.00	0.00	0.00	0.33	0.15

Table 6.12 Frequency of dental chipping anterior vs. posterior (tooth count). Only sites with more than four adults included.

Chorro de Maíta – A chi-square test shows there is no significant difference between the proportion of males (53.85%) and females (69.23%) affected by chipping (χ^2(1, N= 52)= 1.30, p= 0.39). While the proportion of chipped teeth in males (6.77%) and females (3.99%) at Chorro de Maíta does not differ significantly (χ^2(1, N= 859)= 3.19, p= 0.10), a Mann-Whitney U test shows that males have significantly larger chips than females (U = 77108.00, p= 0.05). A chi-square test confirmed there are no significant differences between the proportion of chipped male anterior (6.53%) and posterior teeth (8.11%) (χ^2(1, N= 425)= 0.50, p= 0.57). In females, the anterior teeth (1.21%) are far less frequently affected than the posterior teeth (5.16%). This difference was found to be statistically significant using a chi-square test (χ^2(1, N= 378)= 4.37, p= 0.05).

Diale 1 – Numbers are too small to compare differences in individual count between males and females. No significant differences were apparent in the proportion of chipped teeth between males (6.25%) and females (5.88%) (χ^2(1, N= 50)= 0.00, p= 1.00).

Escape – Numbers of sexed adults are too small to compare differences in individual count between males and females. The tooth count, however, demonstrated that there is a significant difference in the proportion of teeth affected by dental chipping between males (0.00%) and females (11.58%) (χ^2(1, N= 142)= 5.90, p= 0.02). Females show a significantly larger proportion of chipped teeth than males. Nonetheless, this difference is likely to be the result of poor preservation of the material and the much smaller number of males than females.

Juan Dolio – Numbers are too small to compare differences in individual count between males and females. No significant differences were apparent in the proportion of affected teeth between males (33.33%) and females (28.57%) (χ^2(1, N= 52)= 0.14, p= 0.77).

Kelbey's Ridge 2 – Numbers are too small to compare differences in individual count between males and females. No significant differences were apparent in the proportion of affected teeth between males (66.67%) and females (37.04) (χ^2(1, N= 30)= 0.99, p= 0.55).

Lavoutte – The individual count suggests that females (20.00%) are less frequently affected by dental chipping than males (100.00%); a chi-square test revealed difference is statistically significant (χ^2(1, N= 20)= 13.33, p= 0.00). The tooth count similarly suggests that females (8.45%) are slightly less frequently affected by dental chipping than males (12.50%), however this difference is not statistically significant (χ^2(1, N= 326)= 1.37, p= 0.28). Although in both sexes, the posterior dentition appears more frequently affected than the anterior dentition, no significant differences were found in the proportion of anterior (11.59%) versus posterior teeth (13.04%) affected by chipping in males (χ^2(1, N= 184)= 0.08, p= 0.82) or in the proportion of anterior (5.36%) versus posterior (10.47%) dentition in females (χ^2(1, N= 142)= 1.14, p= 0.37). A Mann-Whitney U test found no significant differences between males and females regarding chip size (U = 11479.00, p= 0.21).

Maisabel – The individual count does not show a significant difference between the proportion of males (60.00%) and females (87.50%) affected by chipping (χ^2(1, N= 23)= 1.86, p= 0.35). However, the tooth count reveals that females (29.82%) have a significantly higher proportion of chipped teeth than males (16.00%) (χ^2(1, N= 314)= 8.36, p= 0.01). Furthermore, a Mann-Whitney U test shows that females have significantly larger chips than males (*U* = 9511.50, p= 0.02). The proportions of anterior and posterior teeth affected in both males (and females are near enough the same.

Malmok – Numbers are too small to compare differences in individual count between males and females. Despite the small number of individuals (and teeth) from Malmok, a chi-square test shows a significant difference in the proportion of posterior dental chipping between males (47.37%) and females (8.33%) (χ^2(1, N= 31)= 5.13, p= 0.05). Anterior chipping is absent in both sexes.

Mamora Bay – Since there is no information available on biological sex at Mamora Bay, no comparison could be made between males and females.

Manzanilla – The individual count revealed no significant difference between the proportion of males (70.00%) and females (75.00%) affected by chipping (χ^2(1, N= 14)= 0.35, p= 1.00). The tooth count similarly showed no significant differences between the proportion of teeth affected by chipping in males (15.57%) and in females (18.18%) (χ^2(1, N= 166)= 0.16, p= 0.81). A Mann-Whitney U test found no significant differences between males and females regarding chip size (*U* = 2344.00, p= 0.74).

Point de Caille – Numbers are too small to compare differences in individual count between males and females. For the tooth count, a chi-square test revealed there are no significant differences in the proportion of chipped teeth between males (0.00%) and females (3.23%) (χ^2(1, N= 66)= 1.15, p= 0.47).

Punta Candelero – A chi-square test revealed there are no significant differences between the proportion of males (84.21%) and females (81.82%) affected by chipping (χ^2(1, N= 30)= 0.03, p= 1.00). Furthermore, no significant differences were found in the proportion of chipped teeth between males (24.64%) and females (30.06%) at Punta Candelero (χ^2(1, N= 518)= 1.74, p= 0.21). In both males (χ^2(1, N= 335)= 21.15, p= 0.00) and females (χ^2(1, N= 164)= 18.25, p= 0.00) the posterior (male: 33.81%, female: 43.14%) dentition is significantly more frequently chipped than the anterior dentition (male 11.20%, female: 11.29%). Although females appear to be affected by larger chips overall, a Mann-Whitney U test found no significant differences between males and females regarding chip size (*U* = 24327.50, p= 0.13).

Punta Macao – A chi-square test found no significant difference between the proportion of males (62.50%) and females (83.33%) affected by chipping (χ^2(1, N= 14)= 0.73, p= 0.58). No significant difference was apparent in the proportion of affected teeth between males (19.77%) and females (26.56%) (χ^2(1, N= 150)= 0.97, p= 0.33). In both males (χ^2(1, N= 66)= 0.33, p= 0.59) and females (χ^2(1, N= 60)= 1.87, p= 0.25), no significant differences were found between the proportions of the anterior (male: 22.86%, female: 19.23%) and posterior (male: 29.03%, female:

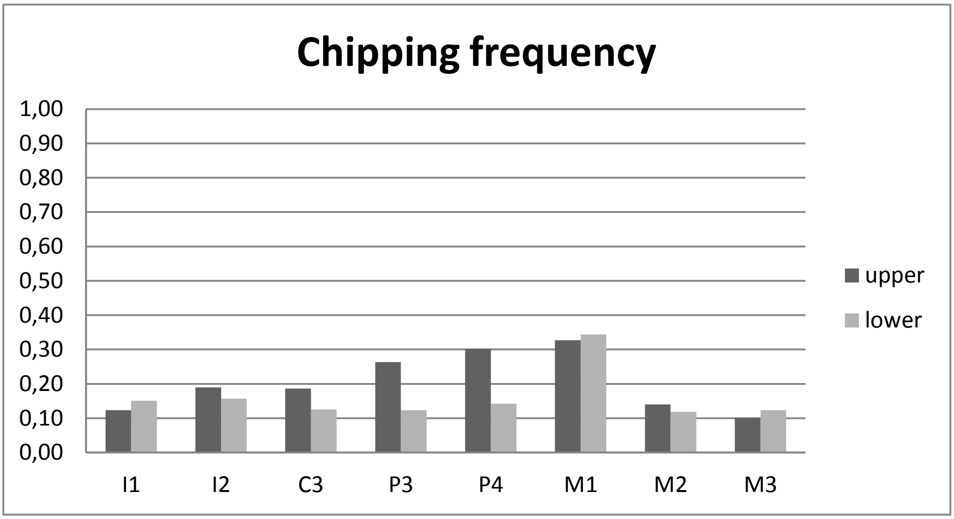


Figure 6.29 The frequency of chipping per dental element.

35.29%) dentitions affected by chipping. A Mann-Whitney U test found no significant difference in chip size between males and females (*U* = 2141.50, p= 0.37).
Santa Cruz – None of the individuals of known sex have dental chipping.
Savanne Suazey – Numbers are too small to compare differences in individual count between males and females. No significant differences were apparent in proportion of affected teeth between males (9.52%) and females (11.11%) (χ^2(1, N= 57)= 0.04, p= 1.00).
Savaneta – Numbers are too small to compare differences in individual count between males and females. No significant differences were apparent in proportion of affected teeth between males (3.70%) and females (0.00%) (χ^2(1, N= 70)= 1.62, p= 0.39).

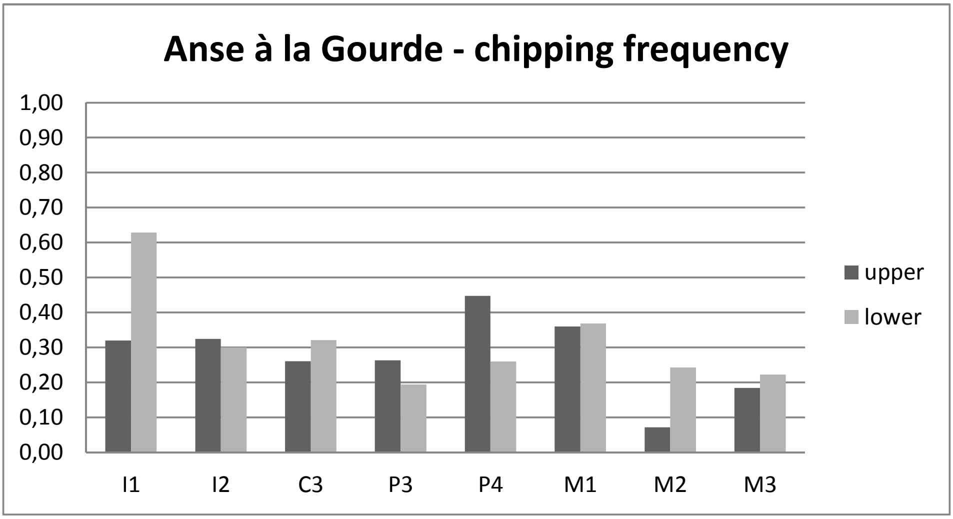


Figure 6.30 The frequency of chipping per dental element for Anse à la Gourde.

Tocorón – Numbers are too small to compare differences in individual count between males and females. No significant differences were apparent in proportion of affected teeth between males (0.00%) and females (8.33%) (χ^2(1, N= 32)= 1.72, p= 0.38).
Tutu – In both males and females, the posterior dentition (male: 55.00%, female: 41.91%) is more frequently affected than the anterior dentition (male: 43.24%, female: 20.69%). In females, however, the difference is more pronounced than in males. This difference is statistically significant in females (χ^2(1, N= 197)= 15.21, p= 0.00), but not in males (χ^2(1, N= 117)= 1.40, p= 0.32). A chi-square test demonstrates that the proportion of teeth affected by chipping is significantly greater in males (42.74%) than in females (19.29%) (χ^2(1, N= 314)= 22.23, p= 0.00). However, the proportion of male individuals (100.00%) and female individuals (78.57%) affected by chipping does not differ significantly (χ^2(1, N= 20)= 1.51, p= 0.52). A Mann-Whitney U test shows that males have significantly larger chips than females (*U* = 8077.50, p= 0.00).

Chipping location

Dental arch
For all sites combined, we see that the frequency of chipping is higher in the maxillary teeth than in the mandibular teeth. This difference is mainly due to the much higher number of chipped upper canines and premolars (see Figure 6.29). Furthermore, the lower central incisors are slightly more frequently affected than the upper central incisors. No correlations were found between the location of the chip on the tooth crown and the location of chip in the dental arch. The most frequently chipped teeth for both the upper and lower dentition are the first mo-

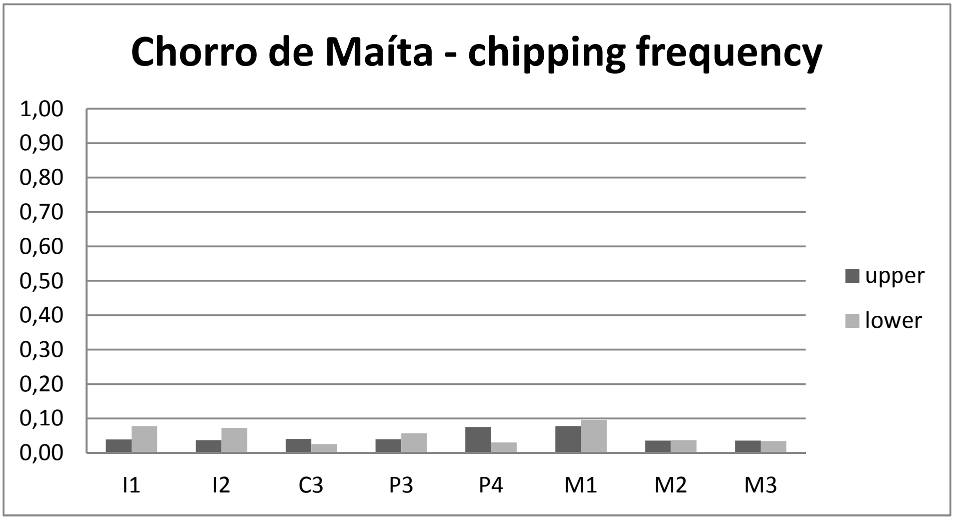


Figure 6.31 The frequency of chipping per dental element for Chorro de Maíta.

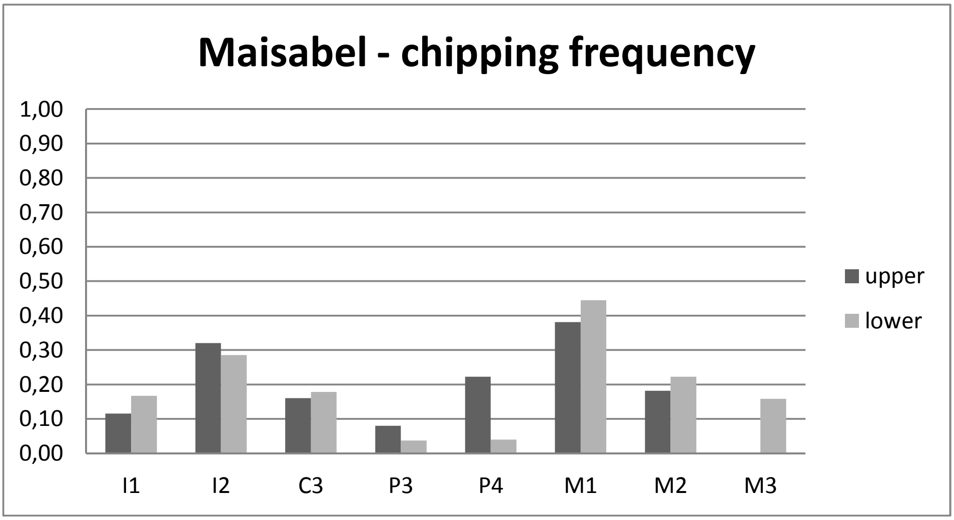


Figure 6.32 The frequency of chipping per dental element for Maisabel.

lars, most likely because of the long period they spend in functional occlusion (eruption at around 6 years of age), and their important role in the mastication of tougher foodstuffs. The individual sites mirror the distribution of chips throughout the dental arch seen in Figure 6.29, except Anse à la Gourde, Chorro de Maíta, and Maisabel (see Figures 6.30, 6.31, and 6.32). At Anse à la Gourde, particularly the lower central incisors are more frequently affected by chipping. At Chorro de Maíta the lower central and lateral incisors are very frequently affected. At Maisabel chipping is particularly frequent in the lateral incisors (upper and lower).

In the total sample, the frequency of chipping is higher in the posterior dentition than in the anterior dentition. A chi-square test shows that the posterior dentition is significantly more frequently affected by chipping than the anterior dentition

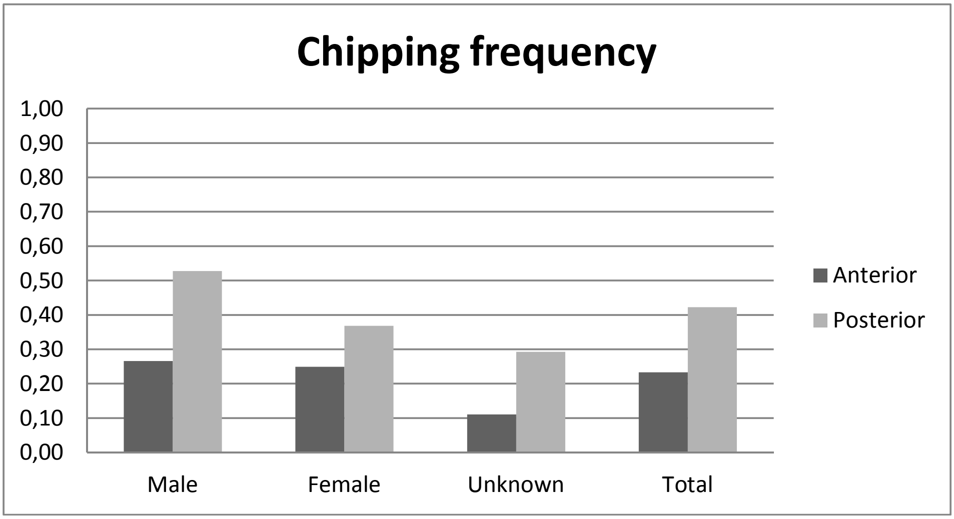


Figure 6.33 The frequency of chipping by anterior/posterior dentition.

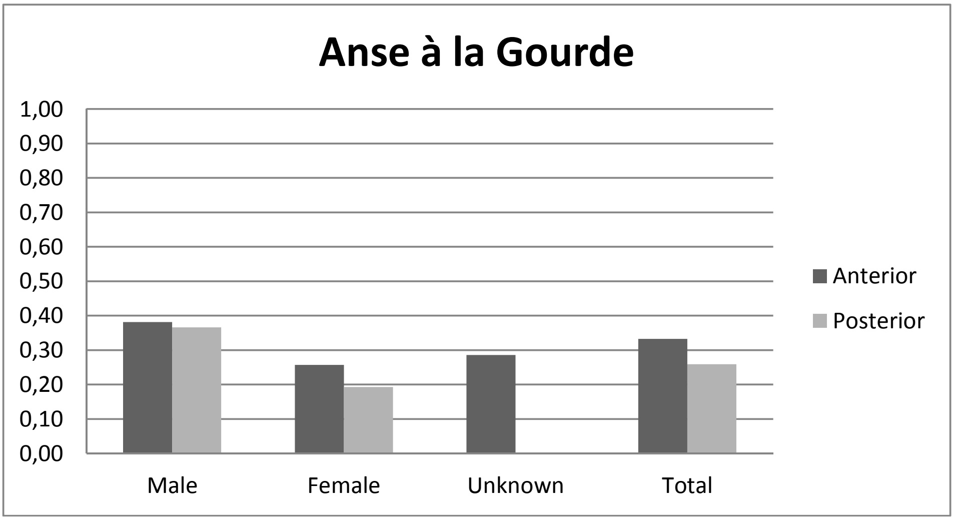


Figure 6.34 The frequency of chipping by anterior/posterior dentition for Anse à la Gourde.

(χ^2(1, N= 5191)= 197.25, p= 0.00).
Most sites in the sample show a similar difference between anterior and posterior chipping to that seen in Figure 6.33, except Chorro de Maíta and Maisabel (see Figures 6.35 and 6.36). At Anse à la Gourde anterior chipping frequency is greater in both males and females than posterior chipping frequency (Figure 6.34). At Chorro de Maíta anterior chipping is greater in males, but not in females. At Maisabel, the frequency of anterior and posterior chipping is the same (see also section 6.3.2 Dental Chipping – Sex-based comparisons).

Tooth crown
Next to the location of chipping throughout the dental arch, discussed in the sections above, the location of the chip(s) on the tooth crown was also recorded, potentially giving insight into different non-alimentary uses of the teeth or different dietary factors contributing to dental chipping. Comparison of the different sites, however, shows a consistent tendency for chips to be located along the buccal edge of the occlusal surface. This tendency was observed in both the anterior and posterior dentitions, and is present regardless of other differences in the proportion of the anterior and posterior dentitions affected by chipping, or difference between the sexes. The second most frequently affected location on the tooth is the interproximal edges of the occlusal surface, either mesial or distal. This type of dental chipping is slightly more frequently found in the posterior dentition, although the anterior dentition is certainly not unaffected by it, and at Punta Macao is even more frequently affected than the posterior dentition. Figure 6.37 shows the frequencies in which the nine different chipping locations were observed for the larger sites in the sample.

Degree of chipping

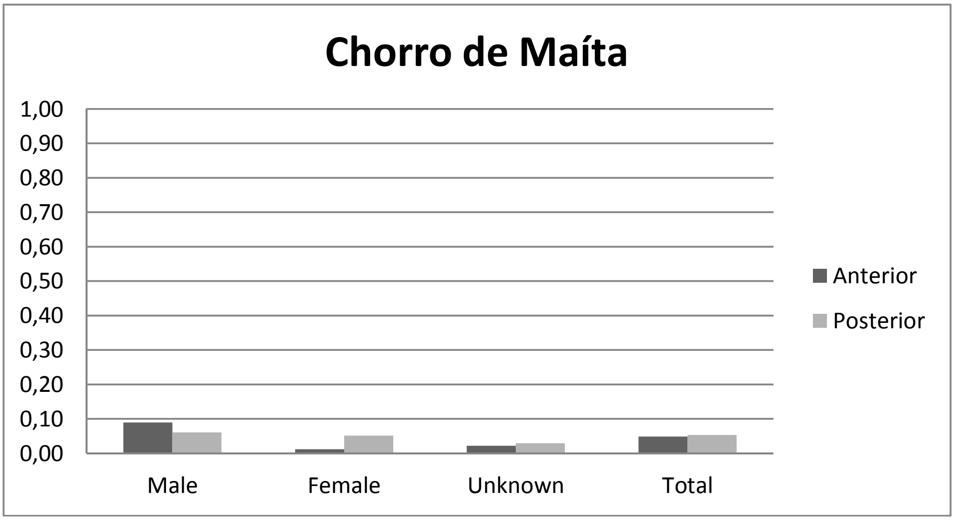


Figure 6.35 The frequency of chipping by anterior/posterior dentition for Chorro de Maíta.

The degree of chipping was measured according to an ordinal scale (0= none, 1= slight [0.5 mm or larger but superficial], 2= medium [1 mm with the enamel more deeply involved], 3= large [>1 mm involving enamel and dentine]) (Bonfiglioli et al. 2004).

For all sites combined, we see that the mean degree of chipping is higher in the maxillary teeth ($\overline{X} = 0.39$) than in the mandibular teeth ($\overline{X} = 0.31$). The difference can mainly be attributed to the much higher mean degree of chipping in the upper canines and premolars (Figure 6.38). Furthermore, the lower second and third molars are more severely affected than their upper counterparts. The lower central incisors are similarly more severely affected than the upper central incisors.

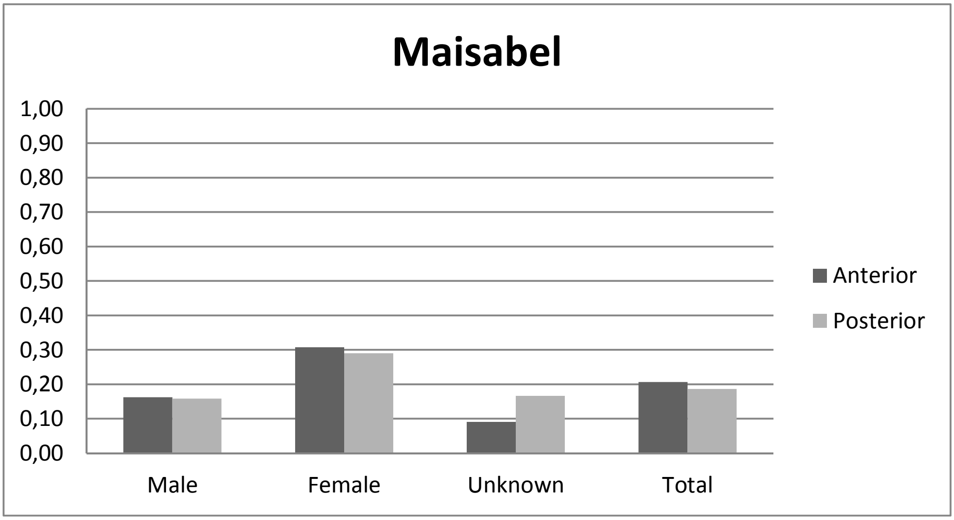


Figure 6.36 The frequency of chipping by anterior/posterior dentition for Maisabel.

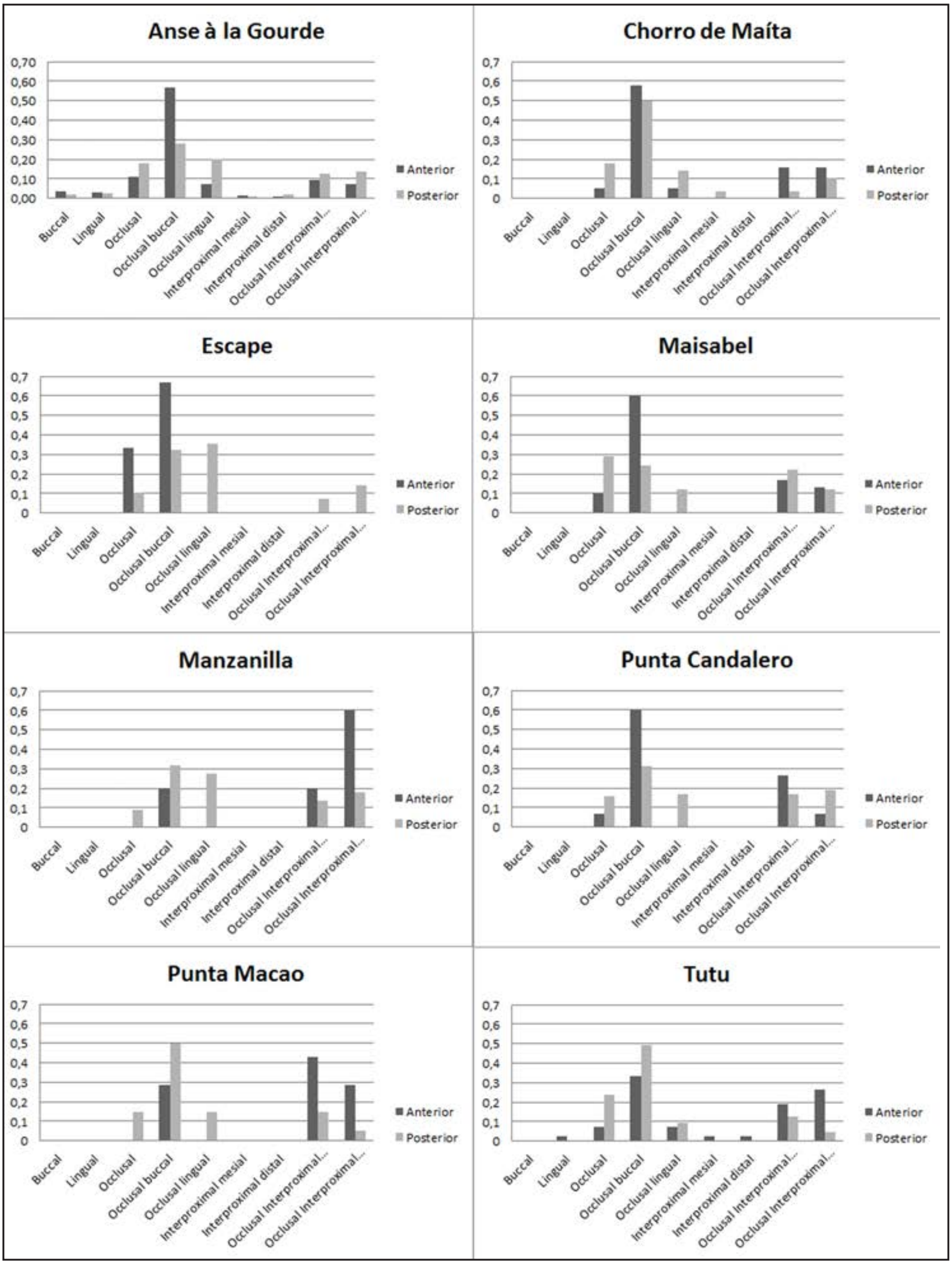


Figure 6.37 Bar charts depicting the frequencies of chipping locations (tooth crown) per site.

Even so, no differences were apparent in the location of the chipping on the tooth crown between upper and lower dentitions. The most severely chipped teeth for both the upper and lower dentition are the first molars, most likely because of their early eruption (at around 6 years of age), and important role in the mastication of tougher foodstuffs.

For all sites combined, we see that the mean degree of chipping is lower in the anterior teeth ($\overline{X}$= 0.23) than in the posterior teeth ($\overline{X}$= 0.43). Similar differences between the anterior and posterior dentition are seen in both males and females (Figure 6.39 and Table 6.13), and at all individual sites except Anse à la Gourde, Diale 1, and Kelbey's Ridge 2, where in females the anterior teeth have a very slightly higher mean degree of chipping than the posterior teeth.

The results of a Kruskal-Wallis test show there is a statistically significant difference between the degree of chipping recorded in the different sites (*H*(18)= 365.06, p= 0.00). Post-hoc testing of the individual sites two by two produced the results presented in Table 6.14, which displays the significance (p) values for each individual site compared with each other individual site. Based on shared significant differences, and the degree of chipping, two groups could be distinguished: one represents sites with a high degree of chipping ($\overline{X}$= 0.45–0.86), and the other represents sites with a (relatively) low degree of chipping ($\overline{X}$= 0.01–0.29).

Mean degree of chipping	**Male**			**Female**			**Unknown**		
	Ant.	**Post.**	**Total**	**Ant.**	**Post.**	**Total**	**Ant.**	**Post.**	**Total**
Anse à la Gourde	0.57	0.90	0.73	0.43	0.37	0.40	1.50	0.00	0.75
Canashito	0.00	0.33	0.21	0.00	0.00	0.00	0.20	0.00	0.11
Chorro de Maíta	0.11	0.13	0.12	0.02	0.15	0.09	0.08	0.16	0.13
Diale 1	0.00	0.13	0.09	0.14	0.04	0.06	-	-	-
Escape	0.00	0.00	0.00	0.07	0.23	0.18	0.01	0.24	0.16
Juan Dolio	0.14	0.86	0.57	0.14	0.48	0.39	-	-	-
Kelbey's Ridge 2	2.00	3.00	2.50	0.38	0.36	0.37	-	-	-
Lavoutte	0.14	0.31	0.24	0.07	0.24	0.17	0.03	0.08	0.05
Maisabel	0.20	0.27	0.24	0.34	0.39	0.37	0.14	0.25	0.20
Malmok	0.00	0.78	0.74	0.00	0.14	0.08	0.16	0.14	0.15
Mamora Bay	-	-	-	-	-	-	0.07	0.46	0.30
Manzanilla	0.16	0.28	0.24	0.00	0.59	0.36	0.00	0.00	0.00
Point de Caille	0.00	0.00	0.00	0.00	0.06	0.03	-	-	-
Punta Candelero	0.15	0.68	0.48	0.22	0.78	0.59	0.16	0.52	0.41
Punta Macao	0.28	0.53	0.46	0.32	0.82	0.60	0.09	0.00	0.04
Santa Cruz	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.11
Savaneta	0.00	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Savanne Suazey	0.00	0.25	0.20	0.00	0.23	0.17	-	-	-
Tocorón	0.00	0.00	0.00	0.00	0.38	0.25	0.00	0.00	0.00
Tutu	0.81	1.55	1.32	0.52	0.67	0.61	0.00	0.00	0.00

Table 6.13 The mean degree of chipping by site, sex, and anterior/posterior dentition.

Gross localized chipping

Eight dentitions showed a particular pattern of very severe dental chipping confined to the buccal surfaces of a small number of teeth (Figures 6.40 and 6.41;

Table 6.15). The chipping is graded 3 according to Bonfiglioli et al. (2004), but its severity is remarkable, with large parts of the tooth crown having been lost. Often there is considerable rounding and smoothing of the chipped area showing the teeth were in functional occlusion long after the damage occurred. Considerable localized force would have been necessary to cause such damage, and since in all cases the damaged areas are located on the buccal edge of the tooth crown, the use of the teeth in some sort of non-alimentary activity is the most likely cause. Trauma is thought to be an unlikely explanation for this pattern of wear, since a forceful blow to this area of the face would more likely result in complete loss of the elements.

Figure 6.41 Punta Candelero 1 (B4). Gross localized chipping of the third and fourth lower left premolars. Note the considerable rounding and smoothing of the break surface due to continued use after damage.

		High						Low												
		AAG	**JD**	**KR**	**PC**	**PM**	**TT**	**CAN**	**CM**	**DIA**	**LAV**	**MB**	**MMB**	**MK**	**MZ**	**PdC**	**SAV**	**SC**	**SS**	**TOC**
High	**AAG**	-	1.00	1.00	1.00	1.00	**0.00**	1.00	**0.00**	**0.00**	**0.00**	**0.00**	0.81	0.22	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.05**
	JD	1.00	-	1.00	1.00	1.00	0.29	1.00	0.37	0.15	0.94	1.00	1.00	1.00	1.00	**0.03**	**0.02**	0.08	0.99	0.96
	KR	1.00	1.00	-	1.00	1.00	1.00	1.00	0.35	0.21	0.63	0.95	0.99	0.98	0.96	0.11	0.11	0.16	0.68	0.51
	PC	1.00	1.00	1.00	-	1.00	**0.00**	1.00	**0.00**	**0.00**	**0.00**	**0.00**	1.00	0.89	0.17	**0.00**	**0.00**	**0.00**	**0.02**	0.20
	PM	1.00	1.00	1.00	1.00	-	**0.01**	1.00	**0.00**	**0.00**	0.19	1.00	1.00	1.00	1.00	**0.00**	**0.00**	**0.00**	0.71	0.79
	TT	**0.00**	0.29	1.00	**0.00**	**0.01**	-	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Low	**CAN**	1.00	1.00	0.10	1.00	1.00	**0.01**	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CM	**0.00**	0.37	0.35	**0.00**	**0.00**	**0.00**	1.00	-	1.00	1.00	**0.00**	1.00	1.00	0.64	**0.01**	**0.00**	1.00	1.00	1.00
	DIA	**0.00**	0.15	0.21	**0.00**	**0.00**	**0.00**	1.00	1.00	-	0.94	**0.01**	0.98	0.86	0.23	1.00	1.00	1.00	1.00	1.00
	LAV	**0.00**	0.94	0.63	**0.00**	0.19	**0.00**	1.00	1.00	0.94	-	1.00	1.00	1.00	1.00	**0.00**	**0.00**	0.53	1.00	1.00
	MB	**0.00**	1.00	0.95	**0.00**	1.00	**0.00**	1.00	**0.00**	**0.01**	1.00	-	1.00	1.00	1.00	**0.00**	**0.00**	**0.00**	1.00	1.00
	MMB	0.81	1.00	0.99	1.00	1.00	**0.00**	1.00	1.00	0.98	1.00	1.00	-	1.00	1.00	0.42	0.41	0.84	1.00	1.00
	MK	0.22	1.00	0.98	0.89	1.00	**0.00**	1.00	1.00	0.86	1.00	1.00	1.00	-	1.00	0.13	0.12	0.56	1.00	1.00
	MZ	**0.00**	1.00	0.96	0.17	1.00	**0.00**	1.00	0.64	0.23	1.00	1.00	1.00	1.00	-	**0.00**	**0.00**	0.07	1.00	1.00
	PdC	**0.00**	**0.03**	0.11	**0.00**	**0.00**	**0.00**	1.00	**0.01**	1.00	**0.00**	**0.00**	0.42	0.13	**0.00**	-	1.00	1.00	0.98	1.00
	SAV	**0.00**	**0.02**	0.11	**0.00**	**0.00**	**0.00**	1.00	**0.00**	1.00	**0.00**	**0.00**	0.41	0.12	**0.00**	1.00	-	1.00	0.98	1.00
	SC	**0.00**	0.08	0.16	**0.00**	**0.00**	**0.00**	1.00	1.00	1.00	0.53	**0.00**	0.84	0.56	0.07	1.00	1.00	-	1.00	1.00
	SS	**0.00**	0.99	0.68	**0.02**	0.71	**0.00**	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.98	1.00	-	1.00
	TOC	**0.05**	0.96	0.51	0.11	0.79	**0.00**	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-

Table 6.14 Significance (p) values for comparisons of degree of chipping per site based on the post-hoc testing of sites two by two after a Kruskal-Wallis test revealed significant differences were present ($H(18) = 365.06$, p= 0.00). Note that Escape is excluded from the calculations due to poor preservation. AAG= Anse à la Gourde, JD= Juan Dolio, KR= Kelbey's Ridge 2, PC= Punta Candelero, PM= Punta Macao, TT= Tutu, CAN= Canashito, CM= Chorro de Maíta, DIA= Diale 1, LAV= Lavoutte, MB= Maisabel, MMB= Mamora Bay, MK= Malmok, MZ= Manzanilla, PdC= Point de Caille, SAV= Savaneta, SC= Santa Cruz, SS= Savanne Suazey, TOC= Tocorón.

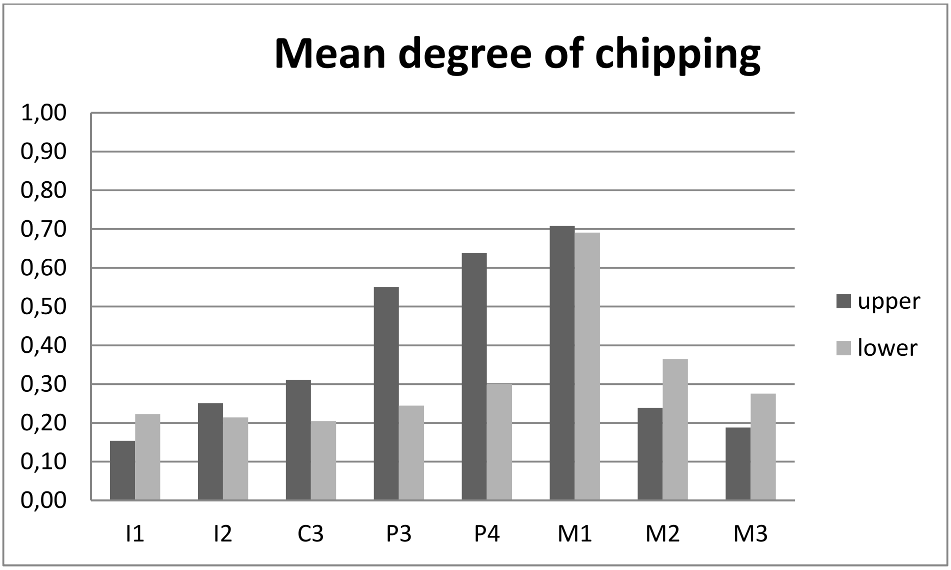


Figure 6.38 The mean degree of chipping per dental element.

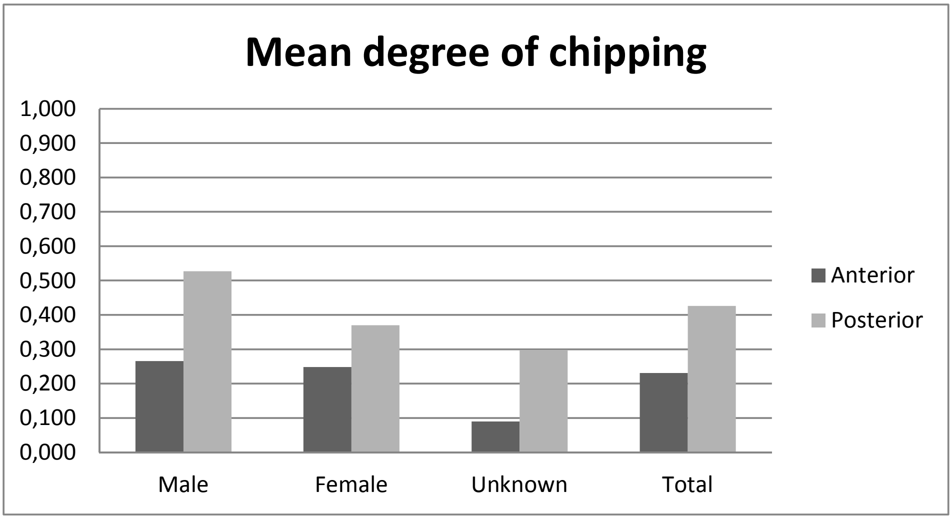


Figure 6.39 The mean degree of chipping by anterior/posterior dentition.

Site	Individual	Affected teeth
La Caleta	190	2.3, 2.4, 2.5
Punta Candelero	1 (B4)	3.4, 3.5, 3.6
Punta Candelero	1 (Y)	1.4
Punta Candelero	3 (B3)	1.4, 1.5, 2.4
Punta Candelero	13 (Huecoid)	1.3, 1.4, 1.6, 1.7
Punta Candelero	59 (B5)	1.3, 1.4, 1.5
Punta Macao	25	1.4, 2.4, 2.5
Savanne Suazey	5	1.4

Table 6.15 Individuals affected by gross localized chipping.

6.3.3 LSAMAT

Figure 6.40 Punta Macao 25. Gross localized chipping of the third and fourth upper left premolars.

As described in Chapter 4, the presence of LSAMAT (lingual surface attrition of the maxillary anterior teeth) was documented according to guidelines established by Turner and Machado (1983). They describe LSAMAT as "the occurrence of progressive wearing with age of upper anterior lingual tooth surfaces without corresponding lingual or labial surface wear on any lower teeth. It is not the result of any manner of occlusal overbite, overjet, malocclusion, or other normal or abnormal anatomical consideration" (Turner and Machado 1983:126). They also note a correlation between LSAMAT and a high rate of caries. According to a number of previous studies, lingual surface enamel of teeth affected by LSAMAT is worn away, often leaving the dentine exposed, and the remaining structure tends to have a polished appearance (Irish and Turner 1997; Robb et al. 1991; Turner and Machado 1983; Turner et al. 1991).

Figure 6.42 Type 1 LSAMAT (Chorro de Maíta 45).

While adhering closely to the described appearance of LSAMAT for its diagnosis in this study, I noticed a degree of variation in the appearance of LSAMAT in the sample. This variation is partly the result of different stages of LSAMAT wear. Especially the early stages of LSAMAT may be hard to distinguish. Mostly, these are characterized by lingual polishing and slight loss of enamel but no dentine exposure. Apart from differences due to the stage of the wear, however, there appear to be two different types of LSAMAT present in the material used in this study, both of which fit the original description of LSAMAT as set out by Turner and Machado (1983).

Figure 6.43 Type 1 LSAMAT (Higuey).

Type 1

The lingual surfaces of the central incisors are unevenly affected by wear, especially in the early stages. The most severe wear is located on the central incisors, on the projecting area of the cingulum, close to the cement-enamel junction. Here, the enamel is generally worn away, exposing a considerable portion of the dentine. The lateral incisors and canines ap-

Figure 6.44 Type 1 LSAMAT. Left: Punta Candelero 1 (B4); Right: Chorro de Maíta 34.

pear to be worn more evenly across the lingual surfaces, although the cingulum and the area closest to the cement-enamel junctions are also most severely affected. In the early stages, the wear facets are circular in shape, and tend to be very slightly cupped. The remainder of the lingual surfaces appears not to be worn, but in some cases has a polished appearance. Later, the central incisors in particular may become severely worn across the entire lingual surface (but mostly around the cingulum), with considerable loss of crown height. Type 1 LSAMAT is also characterized by lingual wear of the premolars, and in a few cases even the first molar. Lingual wear of the premolars tends to be relatively severe, exposing a moderately sized, highly cupped dentine patch.

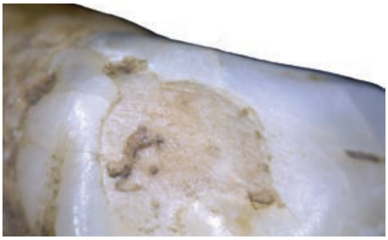


Figure 6.45 Manzanilla 267B (oblique view).

The photo example of an individual affected by LSAMAT given by Irish and Turner (1997) closely fits the appearance of Type 1 LSAMAT. Figures 6.42, 6.43, and 6.44 show examples of Type 1 LSAMAT from this study.

Type 2

The lingual wear of the incisors tends to affect the entire surface, and is generally flattened and angled in an oblique (downward-labial) direction (Figures 6.45 and 6.46). In early stages of wear, this type closely resembles Type 1 LSAMAT, as due to its naturally raised relief, the cingulum is worn first. However, early Type 2 can be distinguished from Type 1 by wear and / or polishing of other parts of the lingual surface, especially the part closest to the incisal edge. Furthermore, the lingual surface is always worn flat and often displays macroscopically observable labio-lingual striations. The central incisors are often the most severely affected, followed by the lateral incisors and then the canines. These teeth are similarly affected by flattened wear which extends across the entire lingual surface. Premolars are not involved.


Figure 6.46 Type 2 LSAMAT. El Cabo 85-34-06.

Surface striations

The lingual surfaces of teeth affected by both Type 1 and Type 2 LSAMAT were assessed macroscopically and microscopically. Microscopic examination revealed that both types of LSAMAT are associated with lingual striations. In both types of LSAMAT, these striations are most prevalent on the central incisors, followed by the lateral incisors and the canines (i.e., the teeth most severely affected by LSAMAT). In both types, the striations are predominantly oriented in linguo-labial direction. Type 1 LSAMAT, however, tends to have finer striations overall, and a more diffuse pattern of direction. This type is more strongly associated with lingual polishing. Type 2 LSAMAT presents with larger and coarser striations with a clearer directionality.

The lingual surface wear of a small number of teeth with LSAMAT was assessed with a Scanning Electron Microscope. The results hereof are discussed in detail in section 6.3.5.

LSAMAT frequency

Of the total sample, 42.14% is affected by LSAMAT (n= 193). Of the total group of males, 48.37% (n= 74) is affected by LSAMAT. Of the females, 49.32% (n= 73) is affected by LSAMAT. The proportion of males and females affected by LSAMAT is more or less equal. Table 6.16 displays the percentages of individuals affected by LSAMAT per site and by sex. At the individual sites, some slight differences are apparent between the sexes. Most are not statistically significant however, except at Chorro de Maíta, where males are significantly more frequently affected by LSAMAT than females (χ^2(1, N= 52)= 6.32, p= 0.03).

% individuals affected							
Site	**Male**	**Female**	**Unknown**	**Juvenile**	**Adults**	**Total**	**Sex-based difference**
Anse à la Gourde	54.17	47.06	40.00	12.50	49.18	44.93	No
Canashito	0.00	0.00	100.00	-	25.00	25.00	No
Chorro de Maíta	73.08	38.46	40.00	18.75	54.39	46.58	Yes: male > female (χ^2(1, N= 52)= 6.32, p= 0.03)
Diale 1	50.00	33.33	-	0.00	40.00	28.57	No
Escape	50.00	50.00	25.00	0.00	33.33	32.00	No
Juan Dolio	33.33	25.00	-	-	28.57	28.57	No
Kelbey’s Ridge 2	100.00	50.00	-	0.00	66.67	33.33	No
Lavoutte	50.00	60.00	42.86	0.00	51.85	46.67	No
Maisabel	33.33	25.00	33.33	0.00	30.78	25.00	No
Malmok	100.00	100.00	100.00	-	100.00	100.00	No
Mamora Bay	-	-	75.00	-	75.00	75.00	n.a.
Manzanilla	22.22	50.00	0.00	0.00	28.57	23.53	No
Point de Caille	50.00	50.00	-	-	50.00	50.00	No
Punta Candelero	47.36	63.64	47.39	16.67	52.00	48.21	No
Punta Macao	33.33	50.00	33.33	0.00	40.00	31.58	No
Santa Cruz	100.00	100.00	50.00	0.00	75.00	50.00	No
Savaneta	0.00	0.00	-	0.00	0.00	0.00	No
Savanne Suazey	0.00	50.00	-	0.00	25.00	20.00	No
Tocorón	0.00	0.00	0.00	-	0.00	0.00	No
Tutu	83.33	85.71	100.00	40.00	85.71	76.92	No

Table 6.16 Frequency of individuals affected by LSAMAT by site and sex/age. Statistically significant differences between the proportions of affected males and females are given.

Next to those incorporated into Table 6.16, a number of sites with less than four individuals also showed LSAMAT wear: Argyle 2, Buccament West, Canas, Ceru Noka, El Cabo, Esperanza, Heywoods, Hacienda Grande, Higuey, La Mina, Manigat cave, Saladero, Spring Bay 1c, St. Kitts (unknown site).

Frequency per type

Of the total adult population (N= 389), 6.94% (n= 27) is affected by Type 1 LSAMAT, and 40.10% (n= 156) is affected by Type 2 LSAMAT. This clear difference in proportions is statistically significant as demonstrated by a chi-square test (χ2(1, N= 389)= 118.90, p= 0.00).

Table 6.17 displays the numbers of individuals and the corresponding percentages affected by the two different types of LSAMAT (by sex and age), of the total group of individuals with LSAMAT wear. As already shown, Type 1 LSAMAT occurs much less frequently than Type 2 LSAMAT. A binomial test for goodness of fit shows that there is a significant difference between the expected ratio (0.5) and the sample ratio (0.85, 0.15; p= 0.000). Similarly, the difference is statistically significant for males (0.81, 0.19; p= 0.00), females (0.86, 0.14; p= 0.00), individuals of unknown sex (0.92, 0.08; p= 0.00) and juveniles (0.90, 0.10; p= 0.02). Overall, no association is apparent between the type of LSAMAT and age or sex.

	Male %	N	Female %	N	Unknown %	N	Child %	N	Total %	N
Type 1	18.92	14	13.70	10	8.33	3	10.00	1	14.51	28
Type 2	81.08	60	86.30	63	91.67	33	90.00	9	85.49	165
Total	100.00	74	100.00	73	100.00	36	100.00	10	100.00	193

Table 6.17 The frequency of LSAMAT types.

Table 6.18 shows the numbers of individuals per site (by sex and age) affected by the two types of LSAMAT. This table does not include sites with less than 4 individuals. Smaller assemblages in which both types of LSAMAT are found are: El Cabo and Heywoods. The single individual representing an unknown site close to the modern day city of Higuey was found to have Type 1 LSAMAT. Of all sites, none appear to show any association between sex and LSAMAT type, except for Chorro de Maíta. Here it seems that Type 1 LSAMAT is more strongly associated with males than with females. A chi-square tests shows that the difference is statistically significant (χ^2(2, N= 52)= 8.20, p= 0.02).

LSAMAT	Individuals affected (N)						
	Type	Male	Female	Unknown	Juvenile	Adults	Total
Anse à la Gourde	1	0	1	0	0	1	1
	2	13	16	0	1	29	30
Chorro de Maíta	1	9	2	0	0	11	11
	2	10	8	1	4	19	23

LSAMAT	**Individuals affected (N)**						
	Type	**Male**	**Female**	**Unknown**	**Juvenile**	**Adults**	**Total**
Lavoutte	1	1	0	0	0	1	1
	2	4	6	3	0	13	13
Manzanilla	1	0	2	0	0	2	2
	2	3	1	0	0	0	4
Punta Candelero	1	2	2	2	1	6	7
	2	5	8	7	0	20	20
Punta Macao	1	0	1	0	0	1	1
	2	2	2	1	0	5	5
Tutu	1	1	0	0	0	1	1
	2	4	12	1	2	17	19

Table 6.18 The number of LSAMAT types per site and sex/age. Only sites with both types of LSAMAT are displayed.

LSAMAT and caries rate

The total caries rate in the group of individuals affected by LSAMAT is 13.77%. The overall population of adults without any type of LSAMAT shows a caries rate of 10.48%. The difference is statistically significant according to the results of a chi-square test (χ^2(1, N= 5580)= 13.70, p= 0.00). The group affected by LSAMAT also shows a significantly higher mean number of caries per individual (2.37) than the group not affected by LSAMAT (1.26) (*t*(383)= 5.12, p= 0.00). Therefore, there appears to be an association between caries rate and LSAMAT: adult individuals with LSAMAT have a higher rate of caries overall than those without LSAMAT. There is some evidence, however, that this association may be influenced by the age distributions of both groups: the non-LSAMAT group is generally younger than the LSAMAT group (Appendix B). Since both dental wear (including non-masticatory wear) and caries are age-related the greater caries rate in the LSAMAT groups could be (partially) related to age.

The adult individuals affected by Type 1 LSAMAT show a caries rate of 12.75%. The adult individuals affected by Type 2 LSAMAT show a caries rate of 13.96%. No significant difference was found between the caries rates of both groups (χ^2(1, N= 3138)= 0.51, p= 0.52). The Type 1 LSAMAT group (χ^2(1, N= 2936)= 2.19, p= 0.15) does not show a significantly high caries rate than the non-LSAMAT group. The Type 2 LSAMAT group (χ^2(1, N= 5086)= 14.21, p= 0.00) does show a significantly higher caries rate than the non-LSAMAT group.

Site	Total sample (N)	Affected (N)	Male	Female	Unknown	Juvenile	Affected %
Anse à la Gourde	69	14	4	9	0	1	20.29
Argyle 2	3	1	1	0	0	0	33.33
Chorro de Maíta	73	7	5	2	0	0	9.59
Coto	1	1	0	0	1	0	100.00
El Cabo	2	1	1	0	0	0	50.00
Escape	25	3	1	2	0	0	12.00
Esperanza	2	1	0	0	0	1	50.00
Higuey	1	1	1	0	0	0	100.00
Indian Creek	1	1	0	0	1	0	100.00
Juan Dolio	7	2	2	0	0	0	28.57
Kelbey’s Ridge 2	6	2	1	1	0	0	33.33
La Caleta	1	1	1	0	0	0	100.00
Lavoutte	31	1	1	0	0	0	3.23
Maisabel	35	4	2	2	0	0	11.43
Manigat Cave	3	1	0	0	1	0	33.33
Manzanilla	18	1	1	0	0	0	5.55
Punta Candelero	56	13	6	3	3	1	23.21
Punta Macao	19	4	3	1	0	0	21.05
Savanne Suazey	5	1	1	0	0	0	20.00
St. Croix	1	1	1	0	0	0	100
St. Kitts	1	1	0	0	1	0	100
Tutu	26	4	3	1	0	0	15.38

Table 6.19 The number and proportion of individuals affected by non-alimentary dental wear per site by sex/age.

Chronological comparisons

Maisabel – in the early phase of occupation 30.77% of the population is affected by LSAMAT. In the late period this drops to 21.05%. A chi-square test shows the difference is not significant ($\chi^2(1, N= 32)= 0.39, p= 0.68$).

Punta Candelero – in the middle phase of occupation 47.62 % of the population is affected by LSAMAT. In the late period this rises to 80.00%. The difference is not statistically significant ($\chi^2(1, N= 26)= 1.70, p= 0.33$).

Tutu – in the early phase of occupation 100.00 % of the population is affected by LSAMAT. In the late period this drops to 68.75%. The difference is not statistically significant ($\chi^2(1, N= 25)= 3.52, p= 0.12$).

Sex-based comparisons

As can be seen in Table 6.16, males at Chorro de Maíta are significantly more frequently affected than females. None of the other sites show significant differences in the proportions of males and females affected by LSAMAT.

6.3.4 Non-alimentary tooth use: *teeth as tools*

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 (Table 6.19).

Sex-based comparisons

The number of males (n= 153) and females (n= 148) across the entire sample is more or less equal. The distribution of individuals in the group displaying non-alimentary wear appears different, however (Table 6.20).

	Non-alimentary wear %	N	Population %	N
Male	53.03	35	33.41	153
Female	31.82	21	32.31	148
Unknown	10.61	7	19.21	88
Child	4.55	3	15.07	69
Total	100.00	66	100.00	458

Table 6.20 The proportions of males and females in the entire sample, and the proportions of males and females in the non-alimentary wear group.

An exact binomial test for goodness of fit shows that in the non-alimentary wear group the proportion of males and females using their teeth as tools differs sig-

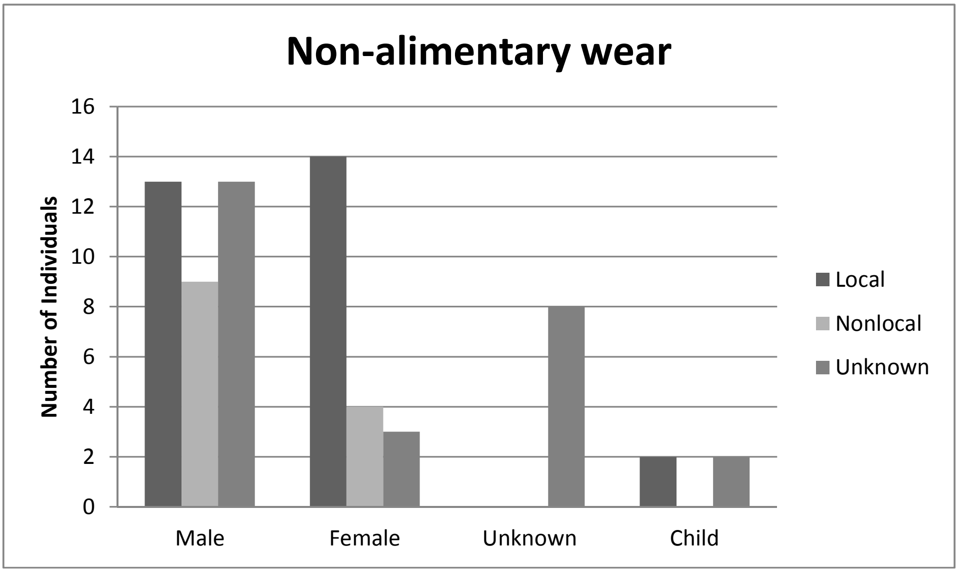


Figure 6.47 The number of nonlocals, locals, and individuals for which provenience is unknown by sex/age.

	Site	Individual	Sex	Age	C14	Origin
Type 1	Anse à la Gourde	139	Male	46+	?	Local
	Anse à la Gourde	207	Female	36–45	?	Local
	Anse à la Gourde	1948	Male	46+	?	Nonlocal
	Kelbey’s Ridge 2	68	Male	36–45		Local
	Maisabel	28	Male	46+	Hacienda Grande	Local
	Manigat Cave	264654	Unknown	Adult	?	?
	Punta Candelero	7 (B6)	Male	46+	cal. A.D. 598–871	?
Type 2	Anse à la Gourde	304	Female	26–35	?	Local
	Argyle 2	1	Male	36–45	?	?
	Chorro de Maíta	25	Male	26–35		Local
	Chorro de Maíta	92	Male	36–45	Contact period	Nonlocal
	El Cabo	F85-34-06	Male	26–35	?	?
	Juan Dolio	8	Male	26–35	?	?
	Kelbey’s Ridge 2	132	Female	46+		Local
	Lavoutte	68-04	Male	26–35	cal. A.D. 1304–1422	Local
	Maisabel	7	Male	46+	cal. A.D. 932–1162	Nonlocal
	Manzanilla	119	Male	46+	Late Palo Seco	Local
	Punta Candelero	1A (D1)	Female	46+	cal. A.D. 680–942	?
	Punta Candelero	3 (B3)	Unknown	Adult	?	?
	Punta Candelero	4 (B3)	Female	26–35	?	?
	Punta Candelero	9 (B3)	Female	36–45	cal. A.D. 468–663	?
	Punta Macao	1	Female	36–45	Late?	Local
	Punta Macao	11	Male	26–35	Late?	Local
	Punta Macao	13	Male	36–45	Late?	Local
2a	Anse à la Gourde	706	Male	26–35	?	Local
	Anse à la Gourde	2212	Female	46+	cal. A.D. 1218–1388	Local
	La Caleta	190	Male	36–45	?	?
2b	Anse à la Gourde	452	Female	26–35	?	Local
	Anse à la Gourde	1948	Male	46+	?	Nonlocal
	Chorro de Maíta	65	Male	18–25		Local
	Higuey	Dario Yune	Male	26–35	?	?
	Punta Candelero	ass. w. 1 (C3)	Unknown	Adult	?	?
Type 3	Anse à la Gourde	50	Female	Adult	?	Local
	Anse à la Gourde	159	Female	18–25	?	Local
	Anse à la Gourde	238B	Female	26–35	?	Local
	Anse à la Gourde	450	Male	26–35	cal. A.D. 1264–1317	Nonlocal
	Anse à la Gourde	452	Female	26–35	?	Local
	Anse à la Gourde	2213	Female	46+	cal. A.D. 1273–1382	Nonlocal
	Argyle 2	1	Male	36–45	?	?
	Chorro de Maíta	65	Male	18–25		Local
	Coto	266173	Unknown	Adult	?	?
	El Cabo	F85-34-06	Male	26–35	?	?
	Higuey	Dario Yune	Male	26–35	?	?

	Site	Individual	Sex	Age	C14	Origin
Type 3	Maisabel	10	Female	46+	cal. A.D. 606–785	Local
	Maisabel	23	Female	46+	cal. A.D. 1057–1277	Nonlocal
	Punta Candelero	A3	Unknown	Adult	cal. A.D. 622–773	?
	Punta Candelero	1 (B6)	Male	46+	?	?
	Punta Candelero	1 (F4)	Unknown	Adult	?	?
	Punta Candelero	1A (D1)	Female	46+	cal. A.D. 680–942	?
	Punta Candelero	40	Child	3–5	?	?
	Punta Candelero	59 (B5)	Male	Adult	?	?
	Punta Macao	12	Male	36–45	Late?	Local
	Tutu	30	Male	36–45	Late	Local
	Tutu	31	Female	36–45	Late	Nonlocal
Type 4	Anse à la Gourde	1945	Female	26–35	?	Local
	Chorro de Maíta	47	Male	26–35		Nonlocal
	Chorro de Maíta	68	Female	18–25		Local
	Chorro de Maíta	87A	Female	26–35		Nonlocal
	Chorro de Maíta	89	Male	46+		Nonlocal
	Esperanza	2	Child	4–5	?	?
	Indian Creek	254343	Unknown	Adult	?	?
	Juan Dolio	69	Male	Adult	?	?
	Punta Candelero	29 (A3)	Male	26–35	cal. A.D. 591–769	?
	Punta Macao	1	Female	46+	Late?	Local
	Savanne Suazey	5	Male	Adult		?
	Tutu	33	Male	36–45	Late	Local
	Tutu	38	Male	46+	Late	Nonlocal
	Tutu	39	Child	8	Late	Local
Type 5	Anse à la Gourde	219	Child	9–11	?	Local
	Anse à la Gourde	1945	Female	26–35	?	Local
	Escape	2	Female	36–45	?	Local
	Escape	24	Female	26–35	?	Local
	Escape	36	Male	36–45	?	Nonlocal
	Punta Candelero	1 (B4)	Male	46+	cal. A.D. 553–666	?
	St. Croix	496	Male	26–35	?	?
	St. Kitts	511	Unknown	Adult	?	?
	Tutu	38	Male	46+	cal. A.D. 1170–1400	Nonlocal

Table 6.21 Individuals affected by the different types of non-alimentary wear by sex/age, dating, and provenience (Laffoon and de Vos 2011; Laffoon 2012; Hoogland personal communication 2012; Pestle 2011; Siegel 1992, 1996, 1999).

nificantly from the expected ratio (0.5) and the sample ratio (0.62, 0.38; p= 0.048). Males are more frequently affected by non-alimentary wear than females. A chi-square test confirms that males are significantly more frequently affected by non-alimentary dental wear than females ($\chi^2(1, N= 301)= 3.75$, p= 0.05).

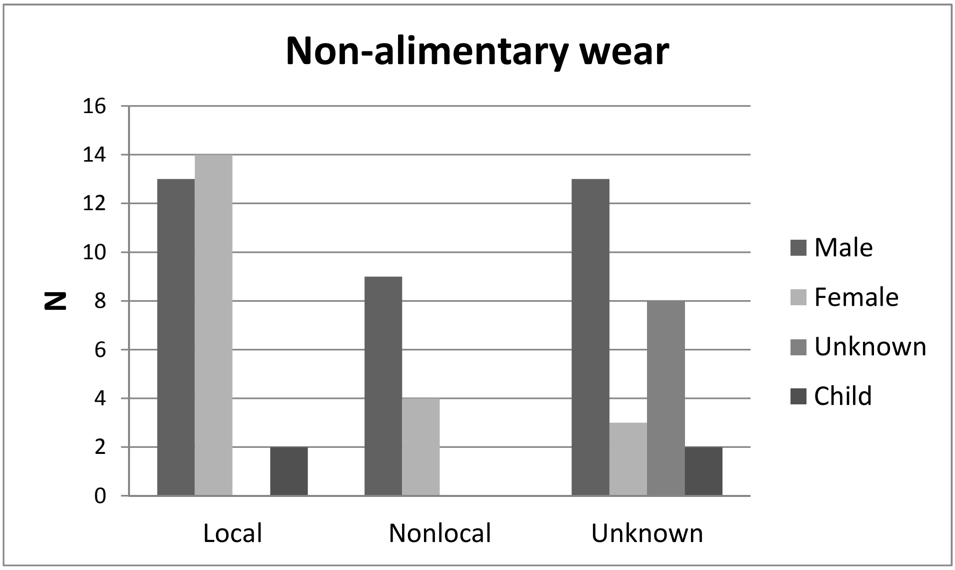


Figure 6.48 The number of males, females, individuals of unknown sex, and juveniles by provenience.

Chronological comparisons

The earliest dated individual showing signs of the use of the teeth as tools is radiocarbon dated to cal. A.D. 553–666, the latest to cal. A.D. 1304–1422 (Table 6.21). Individuals 47, 65, 89, and 92 from Chorro de Maíta probably fall outside of this range, as based on extended (Christian) burial position, and European faunal remains and metals found in the grave sediments, these individuals postdate contact. Individuals 25, 68, and 87 may pertain to the pre-Columbian phase of occupation as there are no indications of contact and they are buried in a typically Amerindian manner. Caution must be applied here, however, since these burial practices may have been in use well into the contact period, and it is possible that Chorro de Maíta was an entire Contact period site (Valcárcel Rojas 2012).

Provenience and non-alimentary wear

A study of human mobility and migration throughout the Caribbean region through Strontium isotope analysis was undertaken simultaneously to the research presented here (Laffoon 2012; Laffoon, Davies, et al. 2012), as a part of the NWO Vici programme ‘Communicating Communities’ led by Prof. Dr. C.L. Hofman (project no. 277-62-001). Many of the samples used in the isotope study and in this study are derived from the same sites and skeletal individuals. Since the geographical origins of an individual found buried at a particular location are likely to have influenced their social and cultural identity, it is interesting to see whether another aspect of their identity (craft activities, the use of the teeth as tools) is associated in some way with origin.

Figures 6.47 and 6.48 both display the numbers of locals and nonlocals within the non-alimentary tooth use group by sex and age. Both diagrams show that the number of nonlocal females is considerably smaller than the number of local females using their teeth as tools. It is also clear that the number of nonlocal males is much larger than the number of nonlocal females. A chi-square test reveals that although a larger proportion of females using their teeth as tools appear to be of local origin than the proportion of males of local origin there is no statistically significant difference between the sexes (χ^2= 1.58, p= 0.21).

Types of non-alimentary wear

The 66 individuals in the total sample that showed evidence of the use of their teeth as tools are not only of both sexes and varying ages; there is also considerable variation in the type of non-masticatory wear observed in the group. Some patterns of wear are unique to an individual, while in other cases the same (or a very similar) pattern of wear is observed in numerous individuals. Based on the degree of wear, the size and shape of the affected area(s), the location of the wear on the individual dental elements, and its distribution throughout the dentition, a number of types of non-alimentary wear could be identified.

Type 1: lingual wear of the lower incisors

This pattern is characterized by the loss of enamel on the lingual surfaces of the lower anterior teeth, specifically the incisors. Central incisors are generally more severely affected than lateral incisors. Root surfaces are also affected in cases of alveolar bone resorption. This pattern is not associated with malocclusion, or any corresponding wear on the upper anterior teeth.

Figure 6.49 Type 1 non-alimentary wear. Punta Candalero 7 (B6).

Type 2: Disproportionate wear between anterior and posterior teeth

This pattern is characterized predominantly by disproportionate wear between the anterior and posterior teeth. The anterior teeth are more severely worn than the posterior teeth (Figure 6.50). Often, the entire crowns of the anterior teeth are lost, and the surfaces of these elements are worn rounded or flat. In some cases the severe wear of the anterior teeth has resulted in an open bite. In other cases, only the upper or lower teeth are disproportionately worn, with no corresponding wear on the opposite teeth.

Figure 6.50 Type 2 non-alimentary wear. Punta Macao 13.

Type 3: Notching / grooving of the anterior teeth

Notches or grooves on the occlusal surfaces tend to be located in the anterior dentition, as they are generally the result of the use of the teeth as tools, as opposed to for example tooth picking (in which case they are located on the interproximal surfaces). In most individual cases documented here only one or two elements are affected. In one case opposing teeth are notched /grooved, showing they were used to clamp (and possibly pull) a thin strip of material or another object. In many other cases opposing teeth are not preserved. The affected dental element, and size and direction of the notch/groove varies. The surface of the notch/groove tends to be polished and display small striations parallel to the notch/groove, indicating the direction of the movement of the material across the tooth.

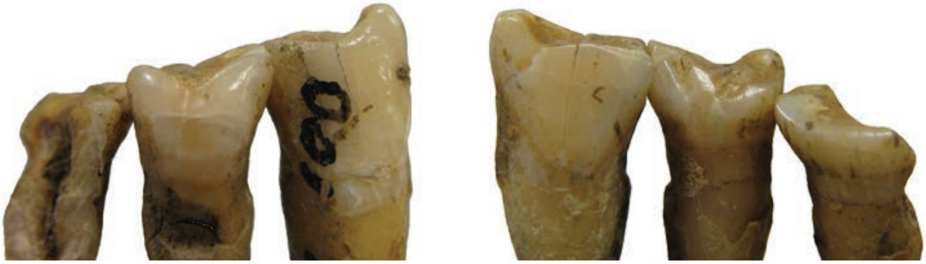


Figure 6.51 Type 3 non-alimentary wear. Coto 266173. Labial/lingual.

Six individuals from the sites of Anse à la Gourde, Punta Candelero, and Tutu, display highly similar notches, with regards to size, shape, depth, and orientation of the notches, and with regards to the elements of the dentition that are affected. Five of these individuals are female, perhaps indicating some form of gender-based task differentiation. In all six cases the anterior teeth are affected by notches of approximately 1.5 mm in width, with striations and/or pitting microscopically visible in the groove. The size of the notches, combined with microscopically observed striations and sometimes slight pressure pitting in the grooves, corresponds to those observed in individuals who clamp thin strips of material such as (cotton) thread or plant stems or leaves, perhaps indicating sewing, cordage manufacture, or basketry. Some notches display polishing along the walls and pit of the groove (Figure 6.51), which is consistent with a fine fibrous material, such as cotton thread, being pulled across the surface.

Figure 6.52 Type 4 non-alimentary wear.

Type 4: Buccal wear

This pattern of wear is characterized by the loss of enamel on the buccal/labial surfaces of the teeth. Usually this type of wear affects the anterior teeth, or alternatively the premolars. In a number of cases only the upper central incisors were found to be affected. Wear facets tend to be flat. When the lower incisors or canines are affected the wear is generally flat or slightly curved (rounded), and angled in lingual-labial direction (Figure 6.52). In these cases lingual-labial striations can sometimes be distinguished macroscopically. When the upper (central) incisors are affected, the wear tends to be flat and not angled.

Type 5: Singular cases
Nine individuals displayed patterns of unique non-masticatory wear, perhaps resulting from individual habits or very rare uses of the teeth as tools. These individual cases are described here.

Anse à la Gourde 219
This juvenile aged between 9–11 years shows wear of the upper incisors and premolars that is typical for both Type 1 and Type 2 LSAMAT. The upper incisors are worn flat on the lingual surface, and there is slight dentine exposure. The upper third premolars are also worn flat on the lingual surface, although only the enamel is affected. The lower left premolars and first molar show slight wear on the buccal-occlusal edge, reminiscent of that seen in cases of lingual tilting of the molars, although these teeth have not tilted any more than the normal human helicoidal plane upon eruption of the permanent dentition (Figure 6.53) (Molnar 2011; Reinhardt 1983; Smith 1986). The wear is not severe, however, as is the case in lingual tilting, and no dentine is exposed. No striations were observed on the wear facets either macroscopically of microscopically, although SEM may (in future) reveal patterns of microwear.The wear facets observed in the upper and lower left teeth correspond well, suggesting that they could have been caused by the drawing of an object or material outward and downward between the occluded teeth.


Figure 6.53 Type 5 non-alimentary wear. Anse à la Gourde 219.

Anse à la Gourde 1945
This female aged between 26–35 years shows a unique pattern of wear of the upper incisors and the lower left premolars (Figure 6.54). The wear on the upper incisors is highly symmetrical and very smooth, reminiscent of intentional dental modification. The upper cen-


Figure 6.54 Type 5 non-alimentary wear. Anse à la Gourde 1945.

Figure 6.55 Type 5 non-alimentary wear. Escape 2.

tral incisors are worn on both the lingual and labial surfaces. The lingual wear appears to be Type 2 LSAMAT with dentine exposure. The labial wear is quite severe, with much exposed dentine, and affects the labial-incisal surface of the central incisors. Together in labial view, the upper central incisors form a crescent shape. The lateral incisors, which are much less severely worn, are both notched in occlusal-traversal direction close to the mesial margin of the crown. The remaining lower incisors (left central and lateral) are less severely worn than the upper incisors, but do show signs of incipient occlusal-traversal notching.

The lower left premolars are both very severely worn on the buccal surface, exposing the dentine. The wear facets are very flat and smooth. It seems that these wear facets may have been polished, however, the teeth are poorly preserved, and the wear facets are too damaged to be sure.

The almost perfect symmetry, smoothness, and differential wear between the opposing teeth would suggest this may be a case of intentional dental modification. However, this individual also shows clear signs of the use of the teeth as tools: LSAMAT and the buccal wear of the lower premolars. This, combined with the incipient notching of the lower left incisors, which may indicate some task activity involving the occluding pairs of incisors, suggests that this is more likely a striking case of non-alimentary tooth wear, perhaps associated with cordage manufacture.

Escape 2

This female aged between 36–45 years displays severe irregular wear of the lower left second molar is (Figure 6.55). The mesio-buccal quadrant of the crown is worn away entirely in very oblique lingual-buccal direction. Wear facet is somewhat concave and elongated, resembling a large smooth groove. Some pressure must have been put on the tooth as it is slightly lingually tilted, with the roots becoming detached on the buccal side.

Figure 6.56 Type 5 non-alimentary wear. Escape 24.

Escape 24

This female aged between 26–35 years has extreme wear on the lower right first molar (Figure 6.56). The rest of the dentition is moderately worn, with the other molars assigned no more than 3 or 4 on the degree of wear scale. The lower right first molar is worn to a degree of at least seven on this scale. The surface is very flat, and very slightly angled in lingual-buccal direction. The enamel and crown have

entirely worn away. Sadly, the upper right first molar was not present (it is unclear whether it was lost ante or post mortem), so any corresponding excessive wear of this element could not be assessed.
It seems a highly specific task activity or personal habit was the cause of this pattern of wear, since this is the only case of its kind in the entire sample. It is likely that an object or material was regularly clamped between the upper and lower right first incisors and perhaps moved along the occlusal surfaces. This object or material could be no larger than 1 cm in width, since the adjacent teeth are not affected.

Escape 36
This male individual aged between 36–45 years has a somewhat similar pattern of wear to that of Anse à la Gourde 219, although there are differences. This individual shows clear Type 2 LSAMAT, combined with wear on the buccal-occlusal edges of the lower right premolars. This wear across the surface is slightly rounded, and angled in lingual-buccal direction. Buccal (rounded) wear was also found on the severely worn lower left central incisor (which is merely a root tip functioning in occlusion). The upper right premolars are worn in buccal-lingual direction. It seems this individual manipulated some sort of flexible material (hence the rounded wear) between the occluding upper and lower right teeth, likely in an outward and downward direction.

Punta Candelero 1 (B4)
This male aged 46+ years, discussed above under section 6.3.2 "Gross localized chipping", shows very severe chipping on the buccal surfaces of the mandibular left premolars and first molar. The latter is unique among the individuals affected by gross localized chipping, since in all other cases the maxillary dentition is affected. The chipping is very severe, with large part of the tooth crowns broken off. The chipped area is highly rounded and smooth, showing the teeth were in functional occlusion long after the tooth was damaged. Considerable localized force would have been necessary to cause such damage, probably clamping and pulling a tough or hard material across the buccal-occlusal edges of the lower left premolars and first molar (Figure 6.40).

St. Croix (unknown site) 496
This male aged 26–35 years has what appears to be a pipe notch between the upper left lateral incisor and canine, and the lower left canine (Figure 6.57). The also appears to be a second developing pipe notch between the upper left canine and the third premolar. The shape and size of the notch, the angle toward the frontal exterior, the extreme symmetry and smooth regularity, and the polished surface of

Figure 6.57 Type 5 non-alimentary wear. St. Croix 496.

the notched area are typical characteristics for pipe notches. Also the presence of a second, developing notch is typical for pipe smokers (Van Dijk et al. in press). Naturally, the presence of a true pipe notch would indicate that this individual does not date to the pre-Columbian period, as pipe smoking was not practiced in the Caribbean at that time.

St. Kitts (unknown site) 511

Similar to St. Croix 496, this adult of unknown age and sex displays what in other circumstances may be identified as a pipe notch (Figure 6.58). According to the Peabody Museum of Natural History catalogue, however, the teeth of this individual were found in a Saladoid jar, obviously predating the contact period by hundreds of years. The notch is located on the occluding left canines. The upper canine has a large polished notch along the lingual surface, the bottom of which is concave and very regular. The lower left canine has a crescent-shaped notch on the incisal edge. The possible cause of this pattern of wear is unknown.

Figure 6.58 Type 5 non-alimentary wear. St. Kitts 511. Lingual view.

Tutu 38

This male aged 46+ years shows lingual tilting of a single tooth (the lower right molar). Lingual tilting is characterized by the lingual orientation of the (molar) teeth, exposure of the roots as they come loose of the alveolar bone, and buccal wear which can extend to the exposed roots. This type of wear is usually associated with severe attrition syndrome, but when it occurs in a single tooth (especially without wear of the opposing tooth) is more likely to be the result of the use of the teeth as tools. In this case, some sort of flexible material would have been pulled across the buccal-occlusal surface of the mandibular right molar.

6.3.5 Microwear

To obtain further insight into the precise cause(s) of some non-alimentary wear patterns, a small number of teeth were submitted for study with a scanning electron microscope. Microwear analysis of this kind is usually used to infer dietary practices, in which case molars are the preferred elements for analysis. Microwear

Figure 6.59 Punta Macao 1, upper right central incisor.

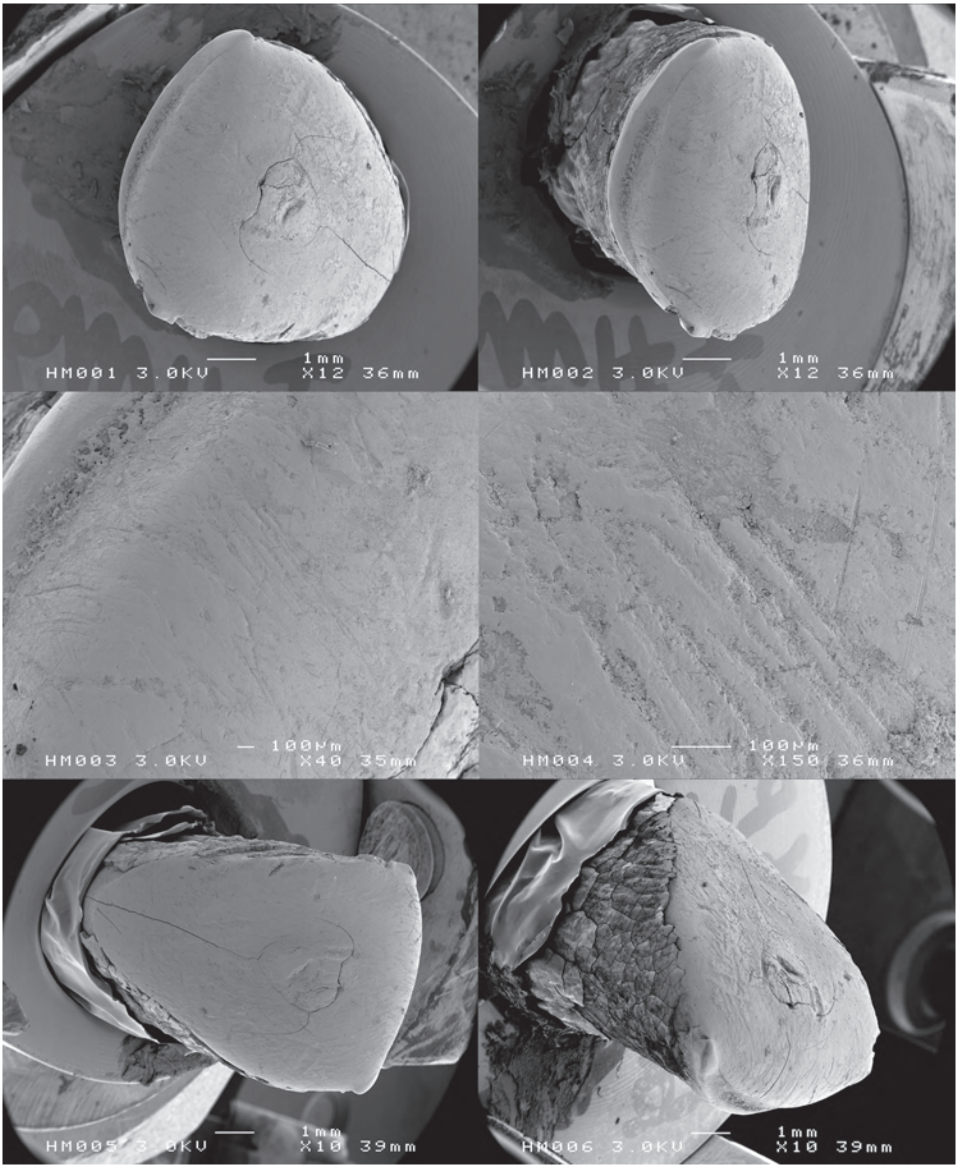


Figure 6.60 Punta Macao 1, upper right central incisor.

studies have infrequently dealt with non-alimentary uses of the teeth, and when they do, they tend to focus on the labial enamel surfaces of the incisors (Krueger and Ungar 2010; Lukacs and Pastor 1988; Ungar and Spencer 1999). Here, the surfaces of anterior teeth which were macroscopically observed to show signs of non-alimentary wear (often the lingual surfaces) are the subject of study. As we will see, the degree of abrasion on these surfaces often means that there is no longer any enamel present. Since dentine and enamel differ in hardness (dentine is softer), we must take into account both materials may be somewhat differently affected by

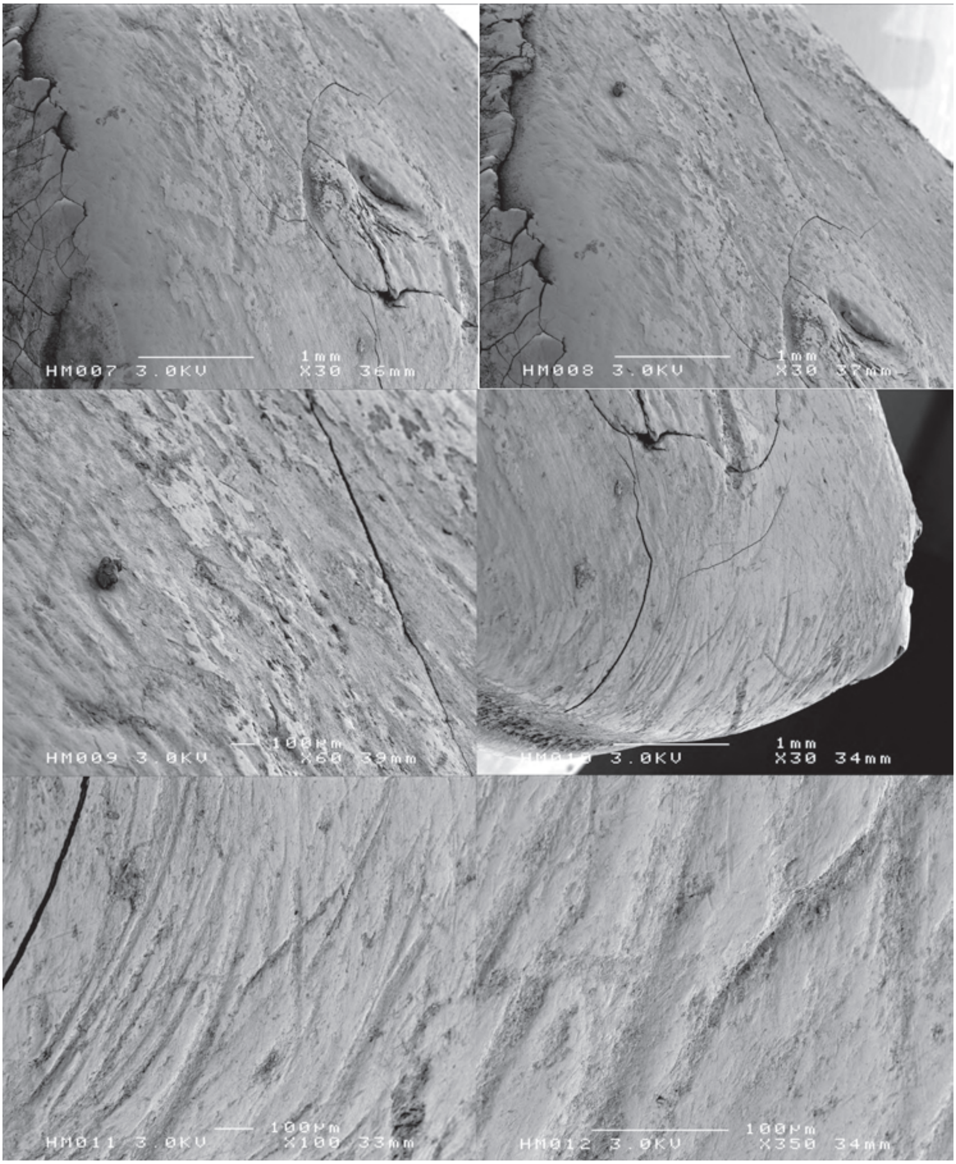


Figure 6.61 Punta Macao 1, upper right central incisor.

pitting, striations and scratches than enamel (Fiorillo 2006, 2008). Furthermore, since this does not concern an analysis of dietary practices, quantification and statistical analyses are not used. Orientation, length, width, starting point, and to a certain extent density, are used to infer potential causes of the wear patterns (Puech 1979; Ryan 1979).

Table 5.4 presents an overview of the samples included in this analysis. The samples were selected based on specific patterns of wear, including Type 2 and Type 4 non-alimentary wear and LSAMAT.

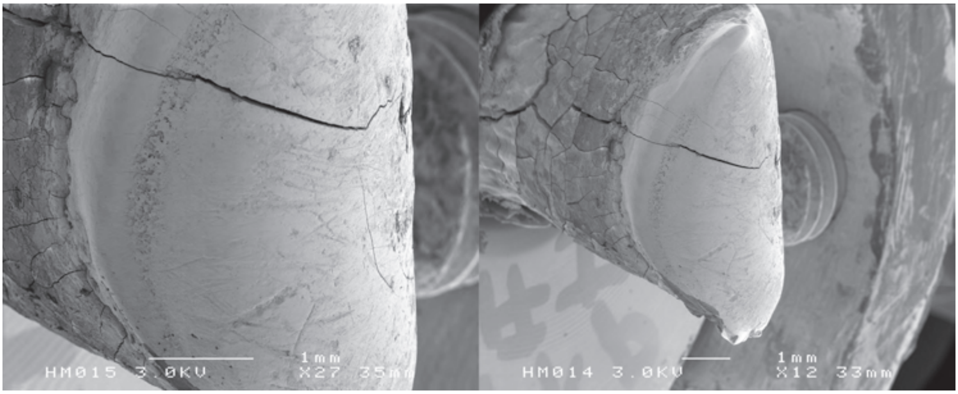


Figure 6.62 Punta Macao 1, upper right central incisor.

Non-alimentary wear

Punta Macao 1

Individual 1 from the site of Punta Macao (female, 46+ years) was selected to represent Type 2 and Type 4 non-alimentary wear. The dental elements 3.1 and 4.2 were chosen for their labial wear (Type 4), and elements 1.1 and 2.2 for their high degree of lingual, and incisal edge abrasion (Type 2).

Since this individual displays lingual abrasion of the upper incisors, and labial abrasion of the lower incisors, the hypothesis is tested that this pattern of wear was caused by the drawing of some kind of thin strip of material in a downwards motion between the upper and lower front teeth (where there is a slight natural overbite). If this was indeed the case, we would expect to find striations of a similar direction, size, and shape on the lingual surfaces of the upper teeth and the labial surfaces of the lower teeth.

Figure 6.63 Punta Macao 1, upper left lateral incisor.

Element 1.1

The upper right central incisor (Figures 6.59–6.62) is worn to the extent that all but

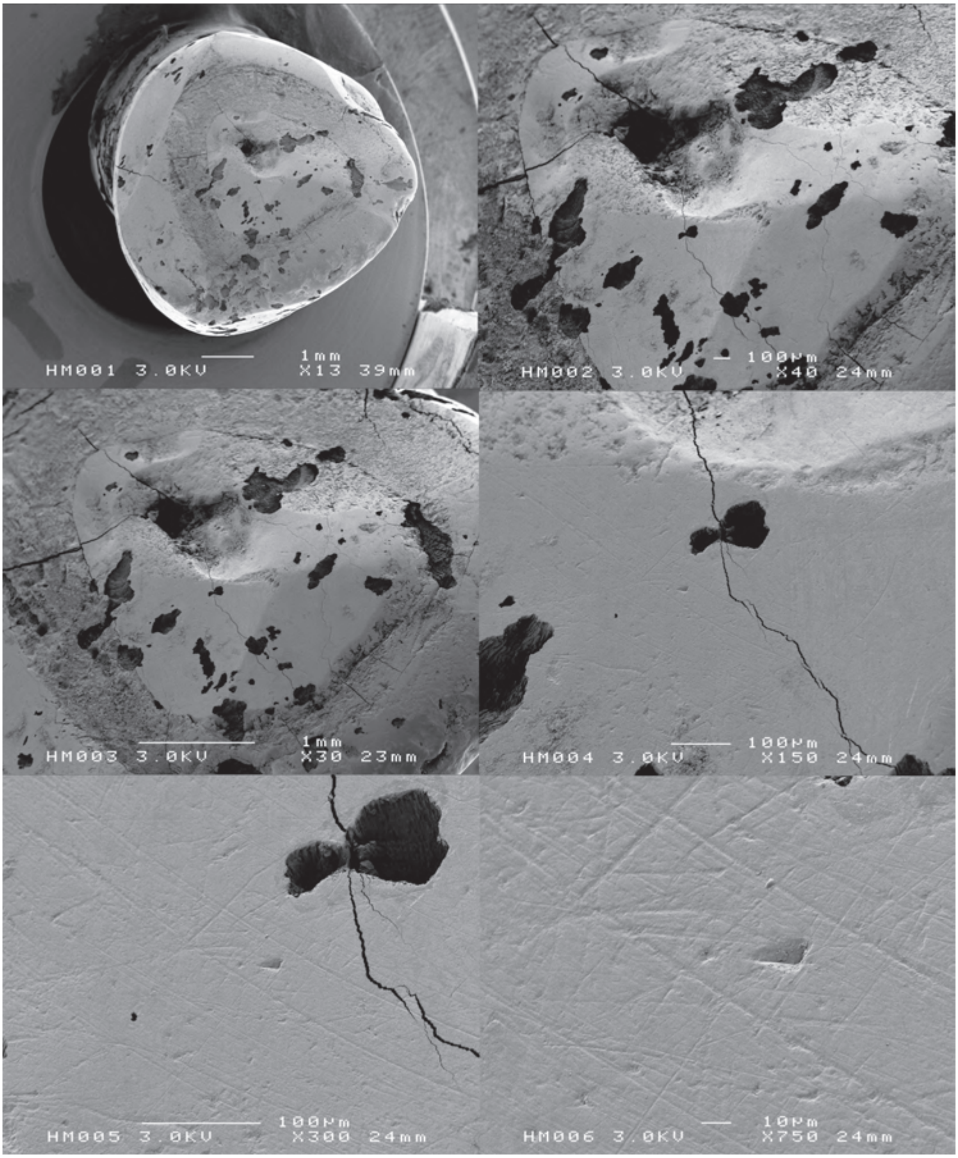


Figure 6.64 Punta Macao 1, upper left lateral incisor.

a tiny strip of enamel is still present on the labial surface. Scratches of various sizes were found in the exposed dentine on the lingual surface and the incisal edge. The highest density of scratches is found along the linguo-incisal edge. The scratches are predominantly oriented in labio-lingual direction, with the starting point labial and the ending point lingual. The latter indicates that the motion of drawing the material across the surface was upward or 'front-to-back' as opposed to the downward motion that is often suggested for similar extreme lingual wear of the upper incisors. Scratches are mostly between 0.50–1.00 mm in length; width varies between 5–50 µm. The pits of the scratches are highly irregular, appearing pitted in some cases and damaged by post-depositional processes in others. The central area of the lingual surface, and the area closer to the cement-enamel junction appear to be damaged by deterioration of the material over time, post-depositional processes, or perhaps acid erosion in life.

Element 2.2
The upper left lateral incisor is much less severely worn than the upper right central incisor (Figures 6.63–6.65). The exposed dentine on the lingual surface is highly

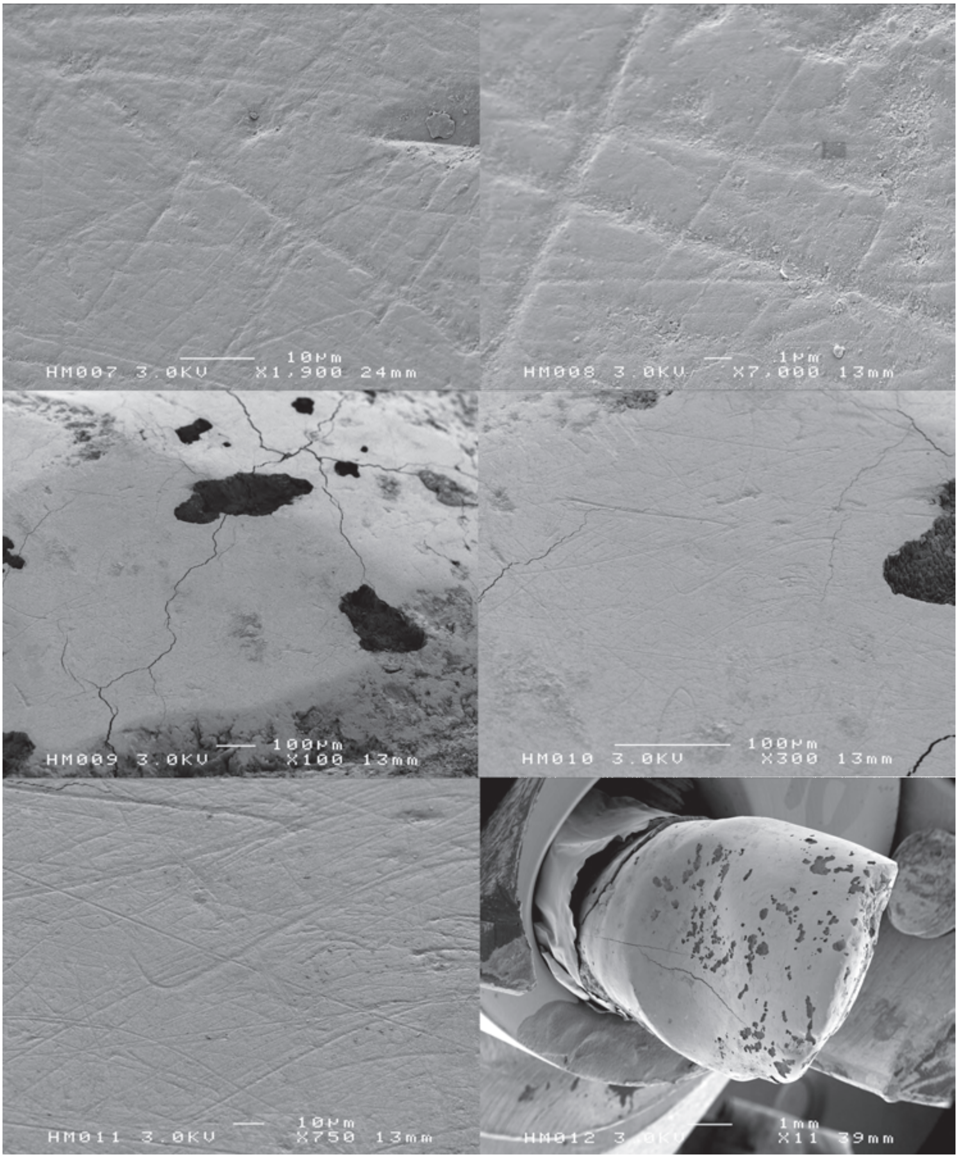


Figure 6.65 Punta Macao 1, upper left lateral incisor.

pitted, appearing damaged by post-depositional processes or perhaps acid erosion in life. Both the enamel and the dentine are damaged by relatively large (up to 0.8 mm) ‘pits’ or ‘holes’ (clearly visible as darker patches on the SEM images) on the entire tooth crown, but in particular on the labial enamel surface. It is thought that this is modern damage is due to changing air humidity, which often results in cracking and flaking of


Figure 6.66 Punta Macao 1, lower left central incisor.

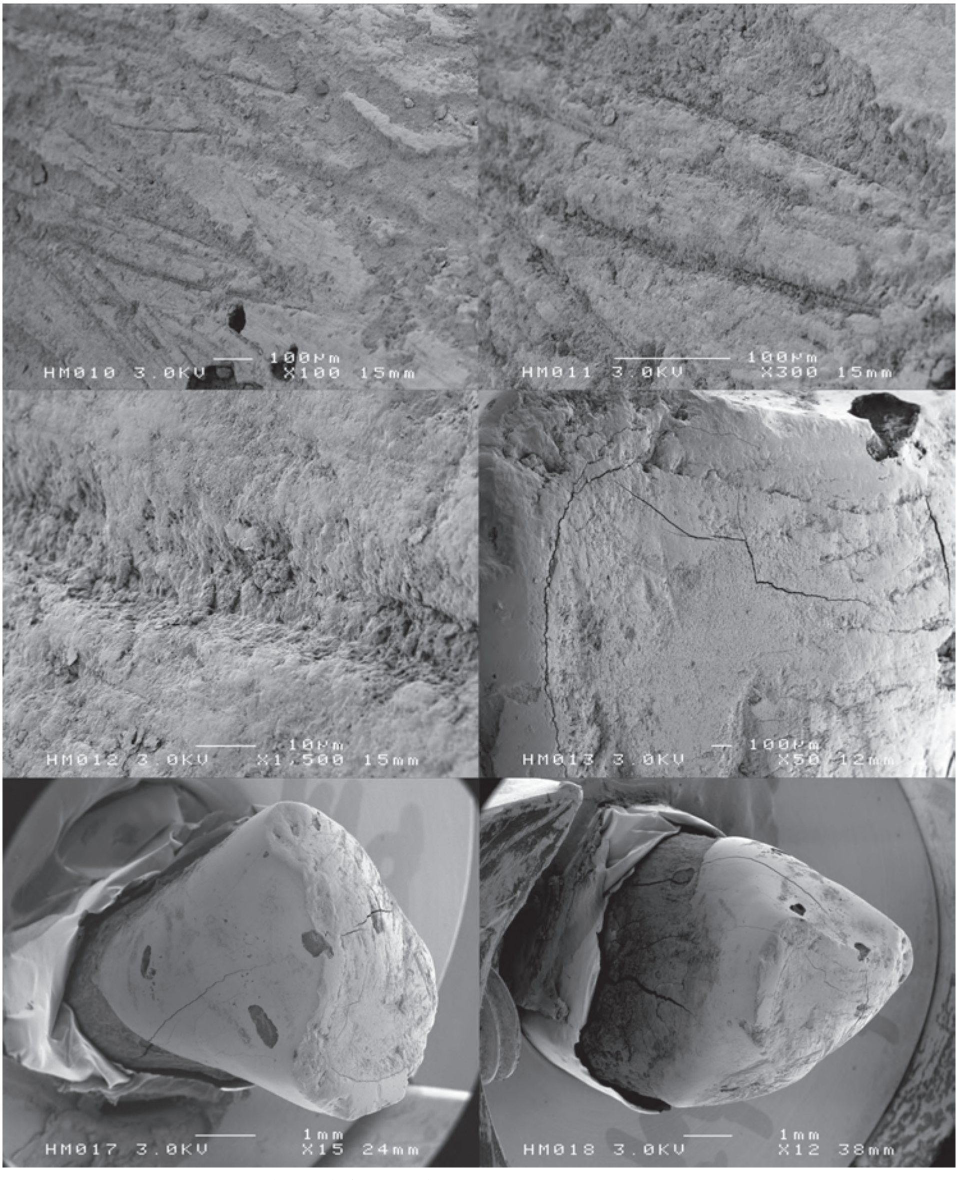


Figure 6.67 Punta Macao 1, lower left central incisor.

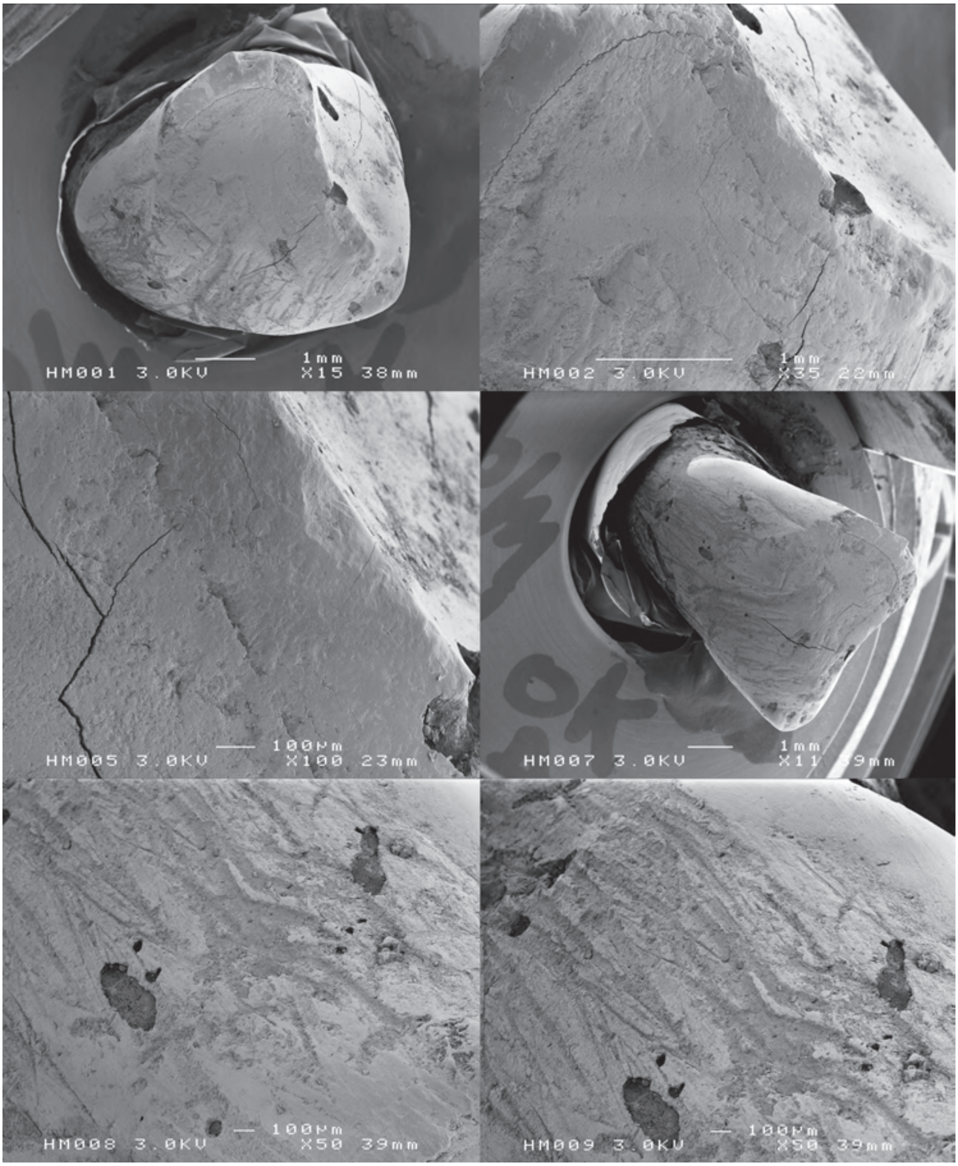


Figure 6.68 Punta Macao 1, lower left central incisor.

particularly the enamel of teeth. The lingual enamel surface was observed macroscopically to be worn in numerous facets, which together form a ‘pyramid-shaped’ relief. The enamel appears highly polished. Scratches on the lingual enamel range up to around 0.7 mm in length, and between 0.50–1.00 µm in width. Orientation is mostly labio-lingual on the most distally positioned wear facet, although there is considerable cross-hatching. On the facet closest to the linguo-incisal edge, there is no clearly predominant orientation, and scratches are dense, and curved. Many scratches are shorter (up to 200 µm), and mesio-distally oriented scratches are also present. These scratches are also generally between 0.50–1.00 μm wide. The pits of the scratches are highly irregular, appearing pitted in some cases and damaged by post-depositional processes in others.

The linguo-incisal enamel edge is affected by a series of very small chips which have rounded surface from subsequent wear. The distal portion of this edge is most severely affected.

The labial surface of this tooth was observed macroscopically to have a large obliquely oriented groove, which is highly polished. Since very few striations were found on this surface, and those present were very small and lacked clear orientation, the cause of this groove is still uncertain.

Element 3.1

The lower left central incisor is highly worn, particularly on the labial surface (Figures 6.66–6.68). This surface was observed macroscopically to have large striations on the remaining enamel and on the exposed dentine. Many of these striations are over 1 mm in length, and are up to 100 μm in width. Finer striations surround these larger scratches, and are similarly oriented in labio-lingual direction, with the starting point labial and the end point lingual. The pits of the scratches are highly irregular, appearing pitted in some cases and damaged by post-depositional processes in others.

The incisal edge is worn to a flat surface, with exposed dentine. This surface shows no evidence of scratches, but is densely pitted. The appearance of these pits suggests the surface has been damaged by post-depositional processes or by acid erosion in life. The lingual surface of the tooth did not reveal any significant wear.

The mesial cement-enamel junction revealed a series of highly uniform and parallel striations, covering an area of approximately 1 mm^2 (Figure 6.68). These striations are approximately 10 μm wide, and the pits of the striations are highly irregular, again appearing damaged (weathered) post mortem.

Element 4.2

The lower right lateral incisor was observed macroscopically to be worn on the labial surface, displaying a number of large scratches surrounded by finer striations (Figures 6.69–6.72). The scratches are up to 3 mm in length and up to 50 μm in width. These larger scratches are relatively deep, and the pit of the scratches, although ‘weathered’ in appearance, is generally V-shaped. The smaller scratches and striations surrounding these are shorter and finer, and are not V-shaped in cross section. Orientation is labio-lingual, with the start labial and the end lingual.

The distal corner of the incisal edge of this tooth is worn rounded in mesio-distal direction, and displays corresponding striations, approximately 30 μm wide. The length and starting point of these striations could not be determined due

Figure 6.69 Punta Macao 1, lower right lateral incisor.

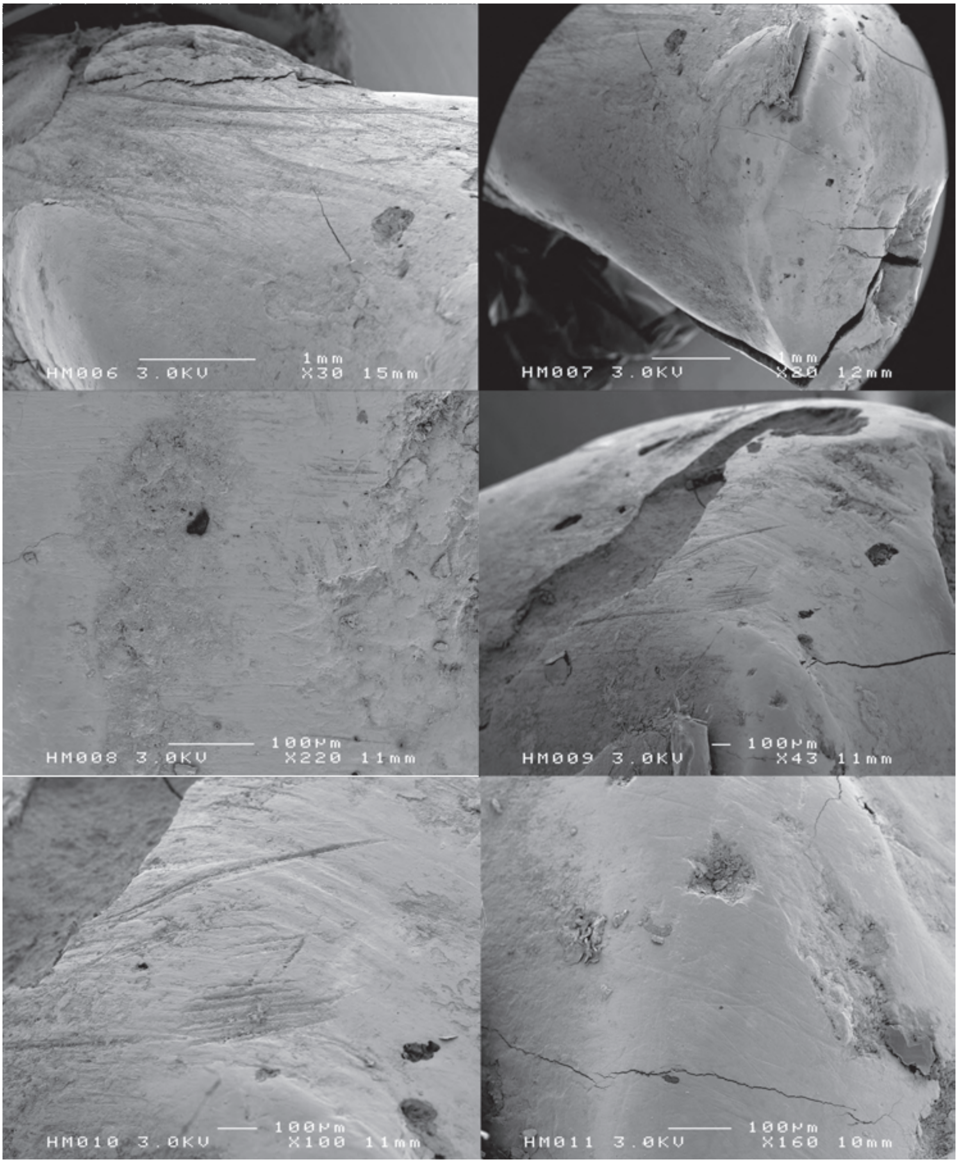


Figure 6.70 Punta Macao 1, lower right lateral incisor.

to modern damage to the enamel, most likely caused by changing humidity or the surroundings of the tooth. On the same portion of the tooth a small patch of highly uniform, dense and parallel striations was observed (Figure 6.71; lower left). Almost 400 µm long and approximately 10 µm wide, these striations are generally mesio-distally oriented, although the starting point is not clear.

The labio-incisal edge has a polished wear facet, which shows very fine and uniformly oriented striations in labio-lingual direction. They are no longer than 80 µm, and around 1 µm in width.

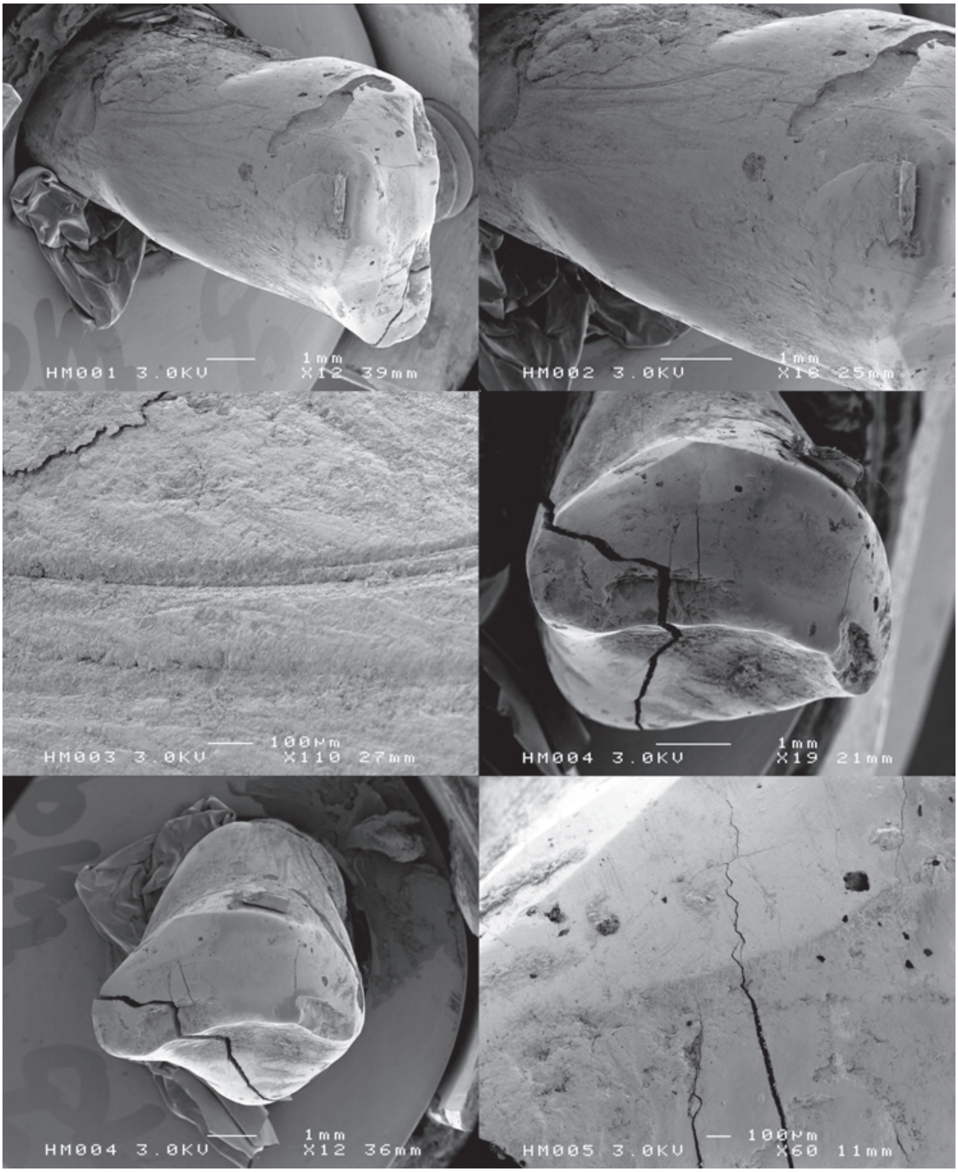


Figure 6.71 Punta Macao 1, lower right lateral incisor.

Punta Macao 11

Individual 11 from the site of Punta Macao (male, 26–35 years) was selected to represent Type 2 non-alimentary wear (disproportionate wear of the anterior teeth). The dental elements 1.1 and 1.2 were used. Element 1.1 displays severe rounded wear of the incisal surface in linguo-labial direction. Element 1.2 is also severely worn, and displays a groove on the labio-incisal edge.

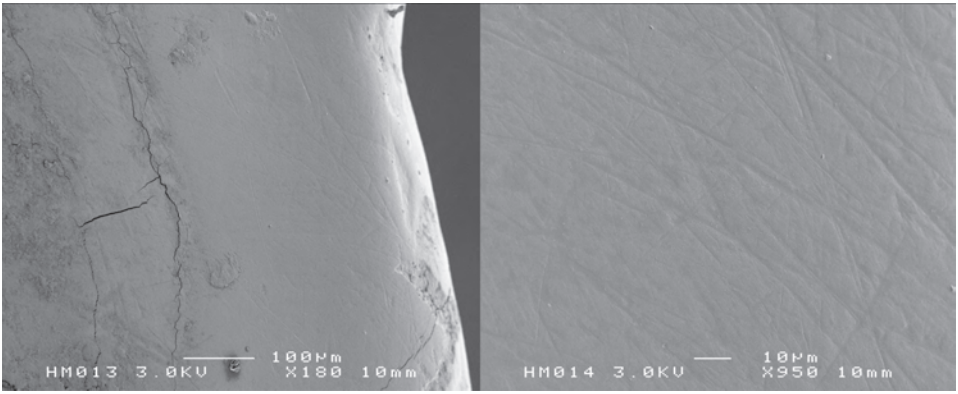


Figure 6.72 Punta Macao 1, lower right lateral incisor.

Element 1.1
The upper right central incisor is severely worn, with all enamel lost (Figures 6.73–6.75). This tooth was observed macroscopically to be worn into a labio-lingually rounded, smooth stump, with striations across the occlusal surface. The densest concentration of scratches is located on the labial portion of the occlusal surface, and here most scratches are oriented in labio-lingual direction (with the starting point labial). Toward the central portion of the occlusal surface, striations are found in both labio-lingual and linguo-labial direction. The scratches are relatively short, considering those seen in Punta Macao individual 1, generally measuring less than 1 mm in length. Width ranges up to approximately 40 µm, and most scratches are V-shaped in cross section. The pits of the scratches are highly irregular, appearing pitted in some cases and damaged by post-depositional processes in others.

Figure 6.73 Punta Macao 11, upper right central and lateral incisor.

The most central portion of the exposed incisal dentine surface shows some pitting and appears haphazardly scratched and damaged, perhaps indicating pressure damage and lifting of fractured areas.

Element 1.2
The upper right lateral incisor is much less severely worn than its mesial neighbour, as the entire crown is still surrounded by enamel (Figures 6.73 and 6.76–6.77). This tooth was observed macroscopically to be worn flat lingually, and with

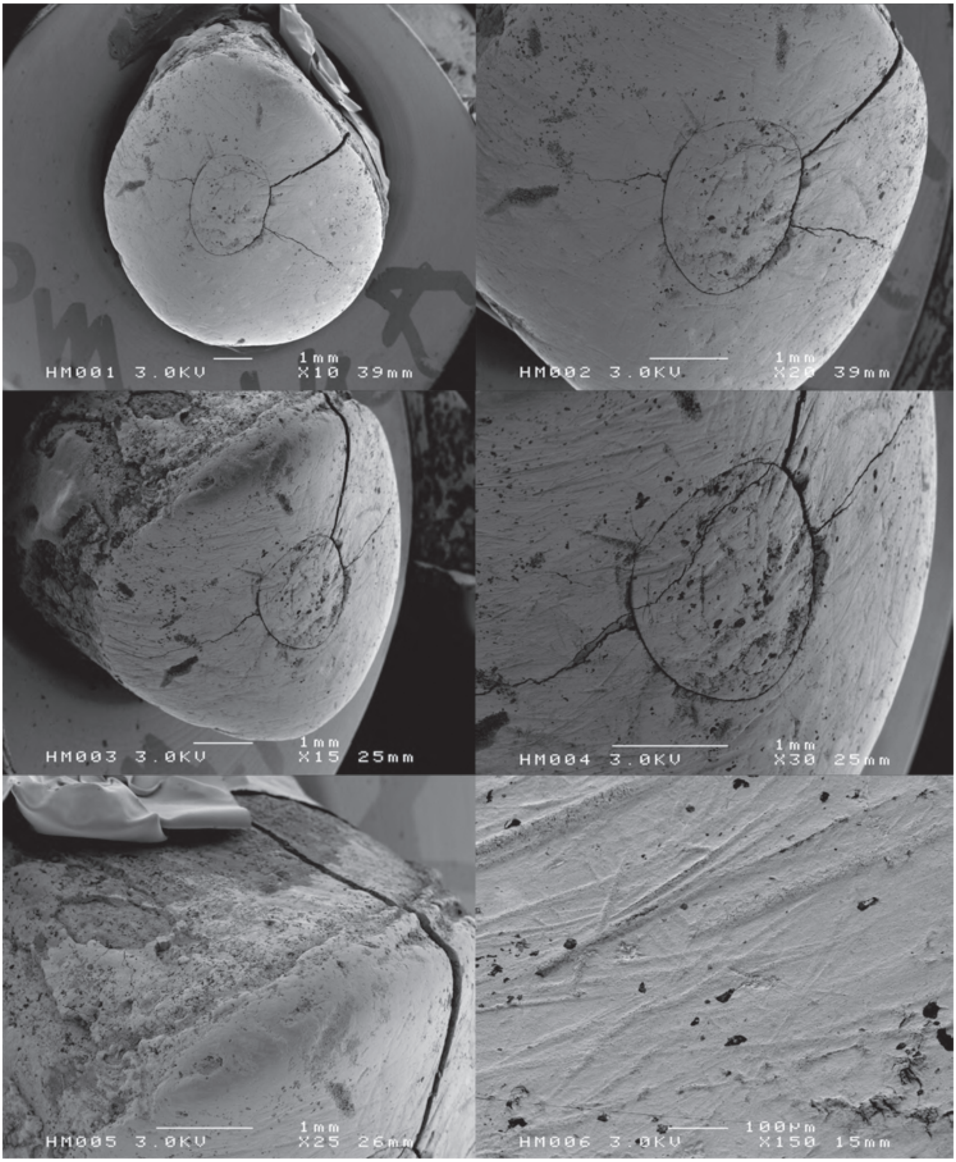


Figure 6.74 Punta Macao 11, upper right central incisor.

considerable loss of crown height, reducing the incisal edge to a flat surface. The mesio-labial edge is particularly worn, resembling an occlusal traversal notch in labial view. However, since the wear does not extend in lingual direction across the entire occlusal surface, this wear was not classed as a notch.

The flat area of the lingual surface, which is highly polished, does not show many striations, and those present are very fine and show no clear orientation. The notch-like area on the mesial corner of the labio-incisal edge also shows relatively few striations. These range up to 0.6 mm in length and 20 µm in width, and are

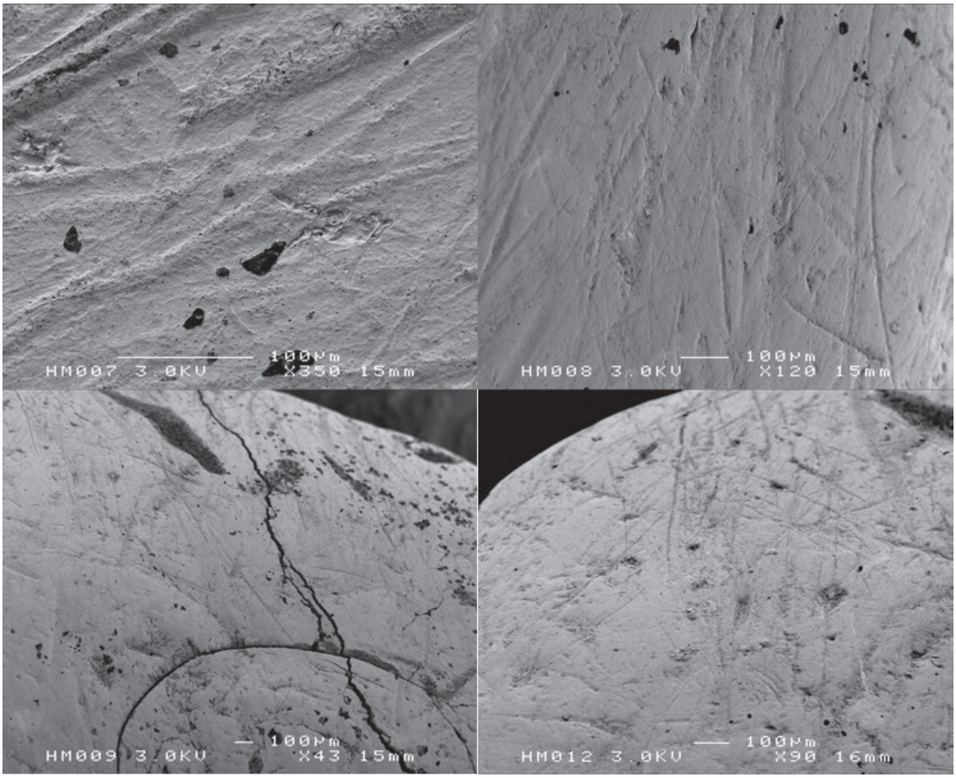


Figure 6.75 Punta Macao 11, upper right central incisor.

oriented in linguo-labial direction, although the starting point is unclear. The exposed incisal dentine surface shows a number of large pits and damaged areas which could be related to the exertion of pressure on the surface and resulting fracturing and lifting of dentine fragments.

Remarkably, the particular wear pattern of both upper right incisors is practically identical to that found in another adult male at Punta Macao (individual 13).

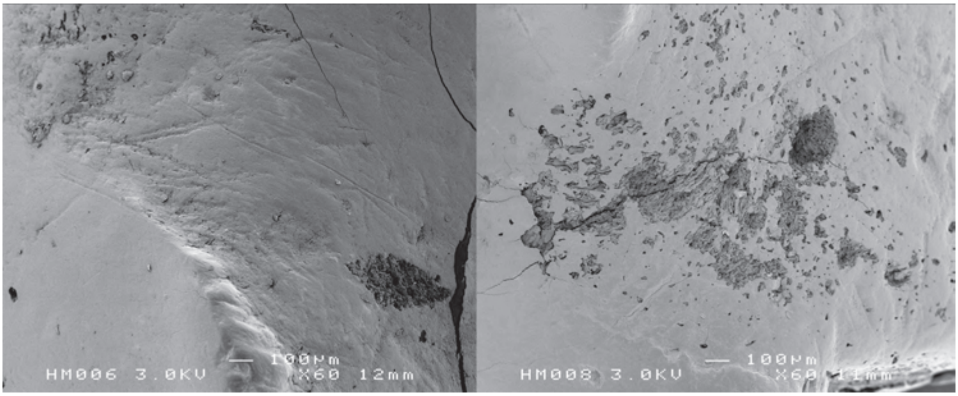


Figure 6.76 Punta Macao 11, upper right lateral incisor.

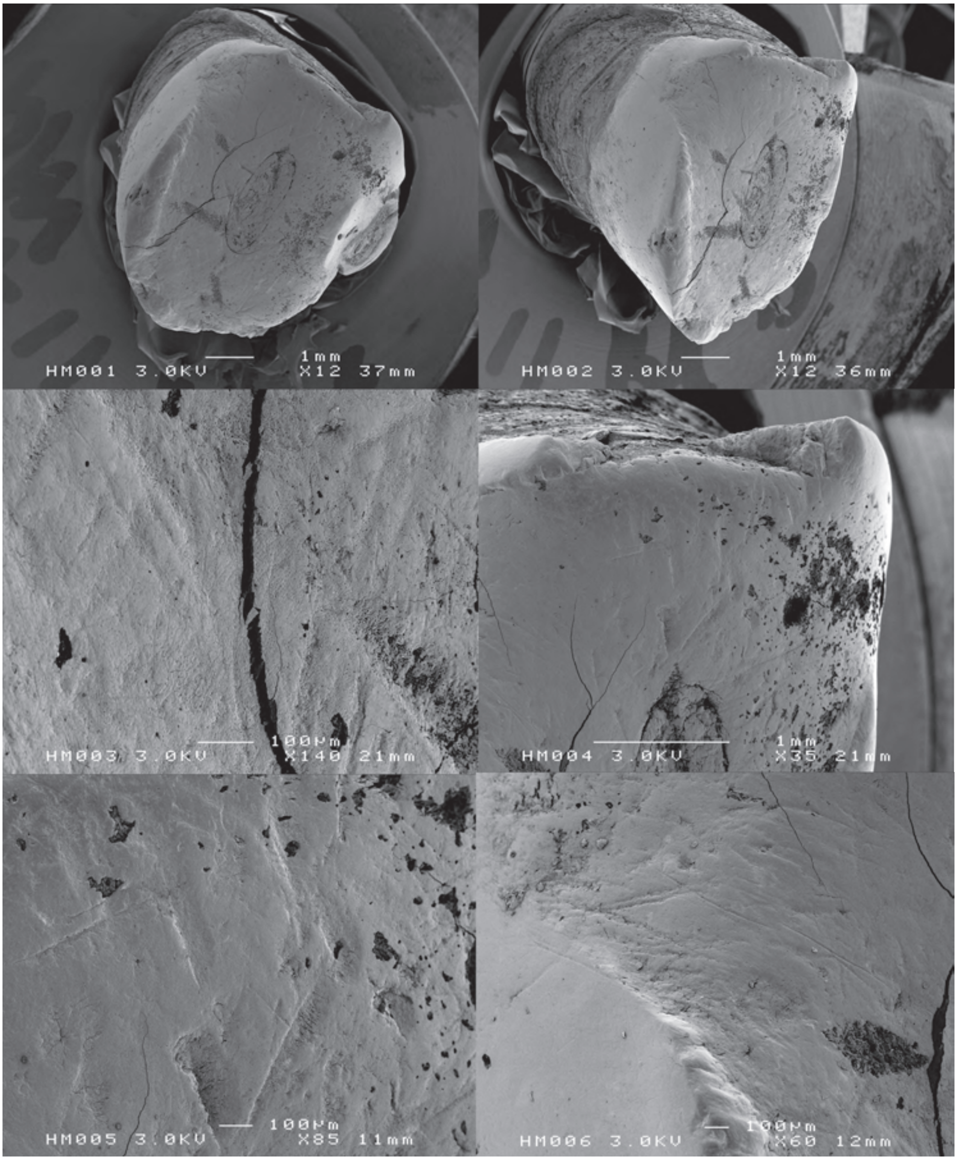


Figure 6.77 Punta Macao 11, upper right lateral incisor.

LSAMAT

Anse à la Gourde 430

The dental elements 1.1 and 1.2 from individual 430 from the site of Anse à la Gourde (female, 26–35 years) were selected to represent Type 1 LSAMAT. Element 1.1 displays dentine exposure on the lingual surface of the tooth, particularly along the raised mesial and distal ridges of the shovel-shaped crown. The most severe wear is located on and around the cingulum, close to the cement-enamel junction. Element 1.2 is less severely worn, with the raised ridges of the shovel shaped surface worn flat, and some dentine exposed. No striations were observed macroscopically on the lingual surface of this tooth.

Figure 6.78 Anse à la Gourde 430, upper central incisor (lingual view).

Element 1.1

The upper right central incisor is worn to the extent that the dentine is exposed on the incisal edge and the lingual surface, particularly on and around the cingulum (Figure 6.78). The exposed dentine and worn enamel show no macroscopically observable striations. Scanning electron microscopy revealed very few striations, and those that are present show no clear directionality, and are exclusively located on the enamel surface. The exposed dentine appears weathered, with an irregular surface relief. The lack of observable microwear patterns is most likely the result of acid erosion of the enamel and dentine surfaces of the tooth. The slightly worn enamel along the lingual side of the incisal edge shows characteristic signs of acid erosion in the form of a uniform honeycomb pattern of enamel prisms (Figures

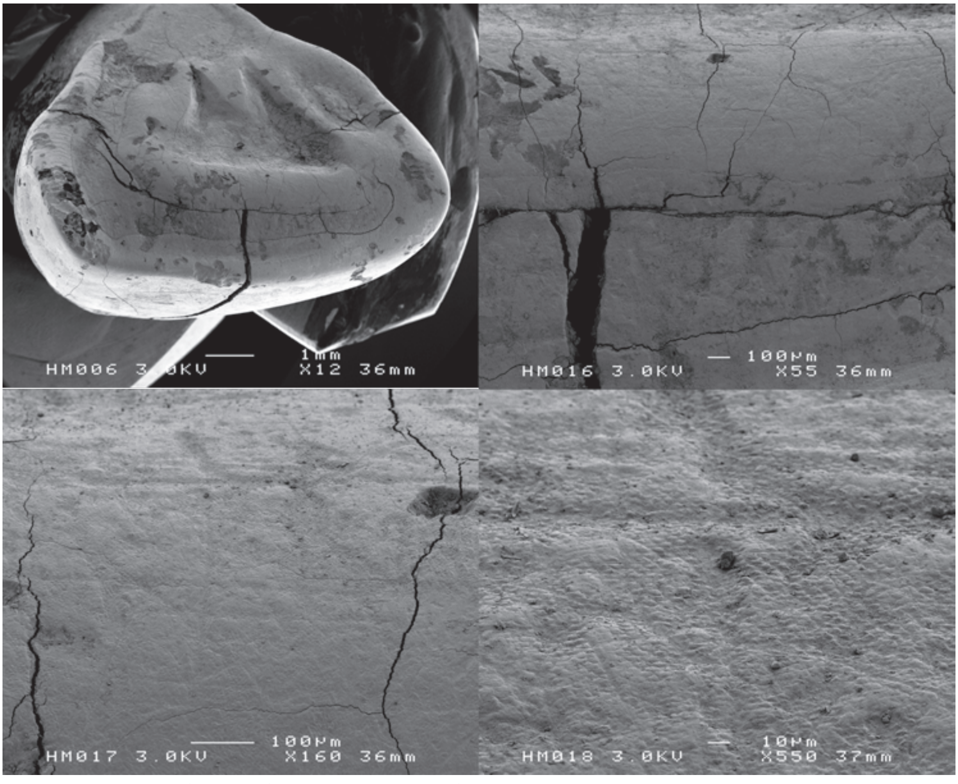


Figure 6.79 Anse à la Gourde 430, upper central incisor.

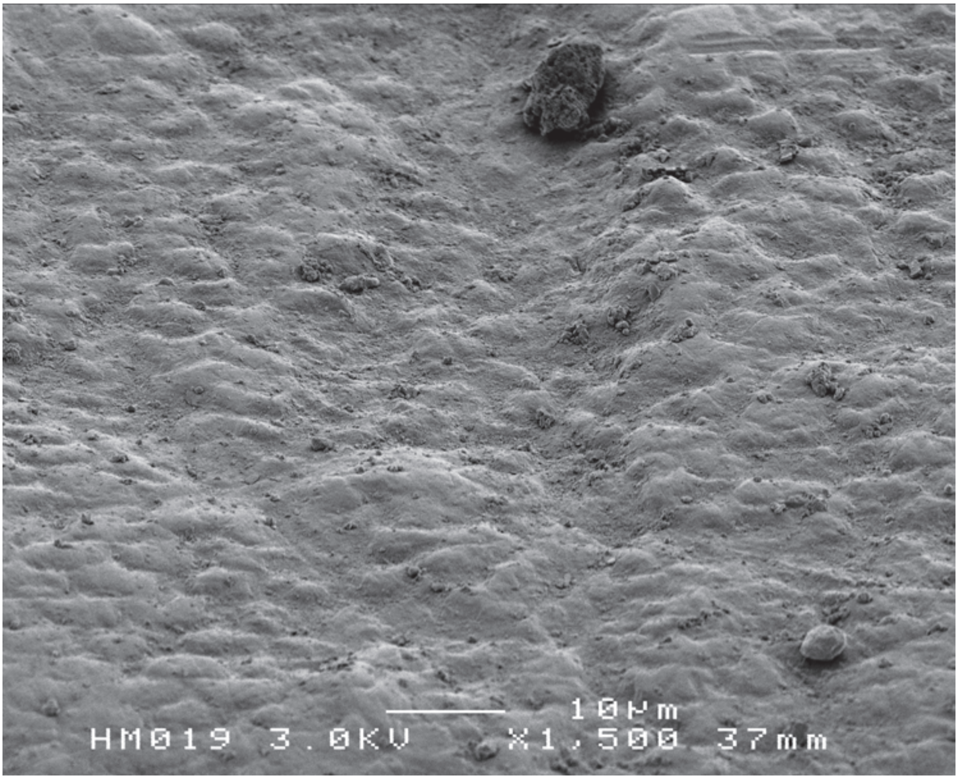


Figure 6.80 Anse à la Gourde, upper central incisor; enamel prisms.

6.79 and 6.80). The distal raised portion of the shovel-shaped crown also displays characteristic signs of acid erosion of the enamel (Figure 6.81). Similarly, the worn area on and around the cingulum shows some enamel prisms and 'weathered', irregular dentine surface (Figure 6.82) (King et al. 1999).

Element 1.2

The upper right lateral incisor is slightly worn, with small patches of enamel lost on the lingual surface (Figure 6.83). No striations were observed macroscopically on the lingual surface. The worn patches are slightly cupped, with some dentine exposure. Scanning electron microscopy revealed very fine labio-lingual striations in the enamel around one of these patches, all measuring less than 0.5 mm in length, with most striations around 40 µm in length. Width ranges between 1–5 µm. The striations are relatively well defined, and the troughs of the scratches show no pitting (Figure 6.84). There is also evidence of acid erosion in this area as shown by the presence of a uniform honeycomb pattern of enamel prisms (Figure 6.85) (King et al. 1999). The central portions of the worn patches show some pitting and damage. It is not clear whether this damage is post-depositional in nature, or whether it is the result of pressure or acid erosion.

The very fine nature of the striations, and the absence of pitting suggests that relatively little pressure was involved in their formation. The length and width of the striations indicates that course, fibrous plant material with adhering grit is highly unlikely to have been the cause.

Anse à la Gourde 2215
The upper left central incisor of individual 2215 from the site of Anse à la Gourde (female, 26–35 years) was selected to represent Type 2 LSAMAT. The tooth is very severely worn, with the lingual surface of the tooth comprising entirely of exposed dentine. Some striations were observed macroscopically on the lingual surface. The incisal edge displays chipping which has become rounded from subsequent wear.

Element 2.1
The area of the lingual surface around the cingulum displays a number of scratches of variable size and generally labio-lingual directionality in the exposed dentine. Some of the larger scratches range up to 2 mm in length and 100 µm in width. The pits of these larger scratches are generally irregular in shape. A series of smaller scratches are also present around the area of the cingulum. These smaller scratches are more sharply defined, and tend to have V-shaped pits. They are of varying

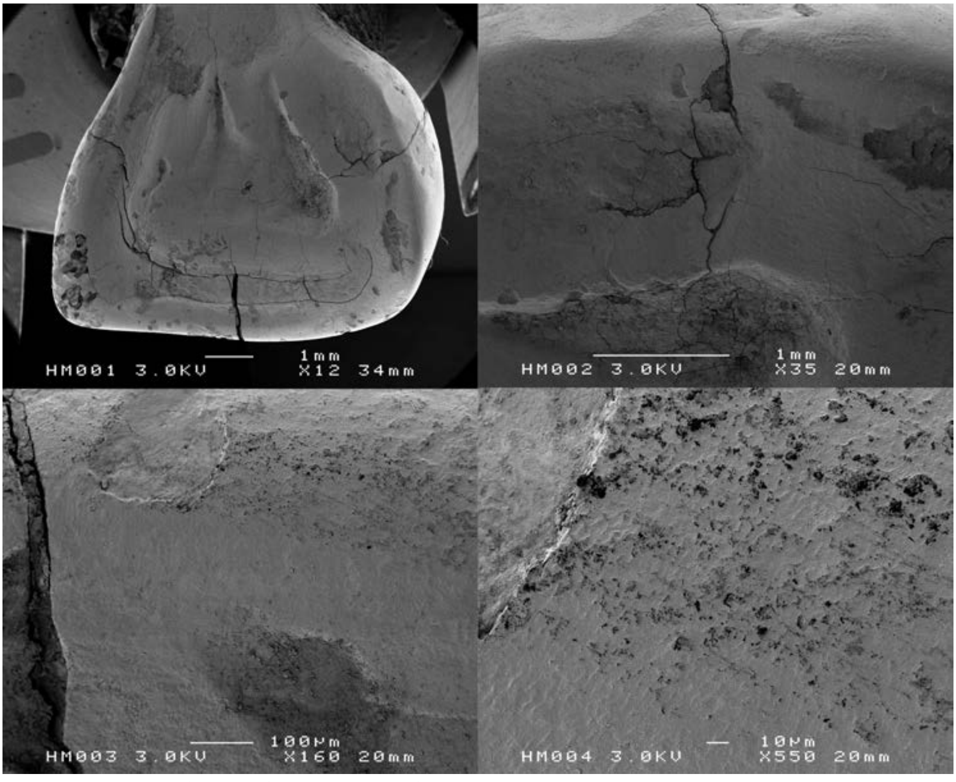


Figure 6.81 Anse à la Gourde, upper central incisor.

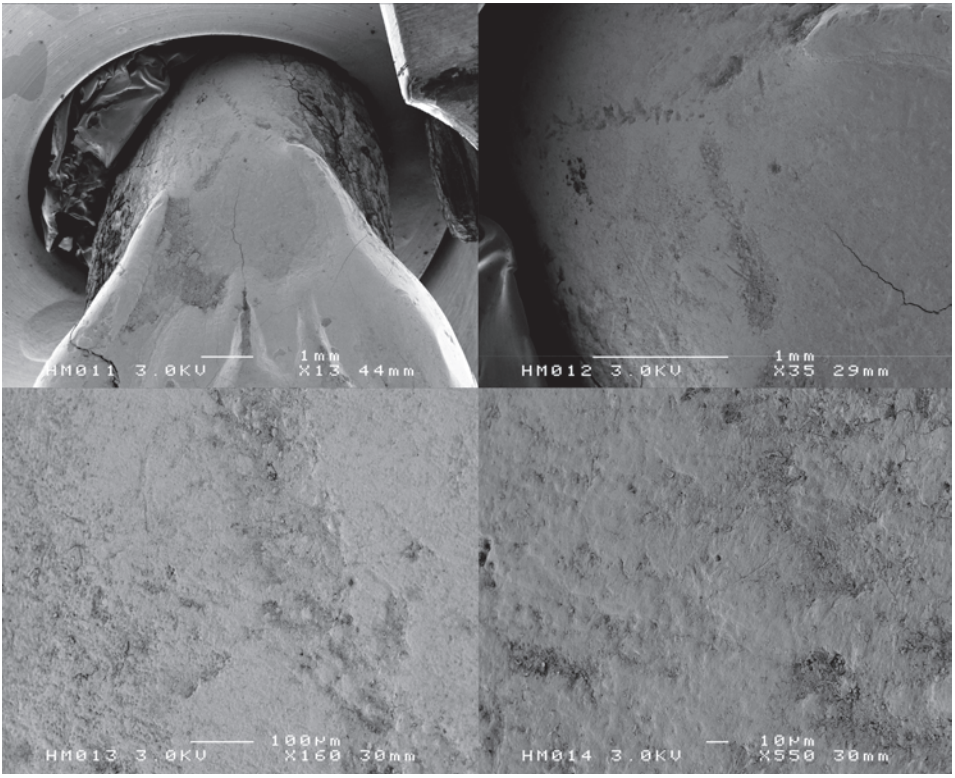


Figure 6.82 Anse à la Gourde, upper central incisor.

length and generally around 10 µm or less in width. The lingual surface shows evidence of pitting and perhaps pressure damage. Due to this damage and taphonomical damage, the starting pints of the scratches were hard to define (Figure 6.86).

Spring Bay 1c individual 1

The upper right deciduous central incisor of individual 1 from the site of Spring Bay 1c (child, 2–4 years) was selected. This tooth shows severe wear with dentine exposure on the incisal edge and across the lingual surface. The projecting area of the cingulum is particularly affected by wear. No striations were observed macroscopically, however the enamel edge surrounding the lingual dentine patch appears chipped and pitted

Figure 6.83 Anse à la Gourde 430, upper right lateral incisor.

Element 5.1

The area of the lingual surface around the cingulum displays an exposed dentine patch with fine linguo-labially oriented scratches. The enamel surrounding this area also shows a series of fine scratches, oriented in labio-lingual direction. The scratches are sharply defined, and tend to

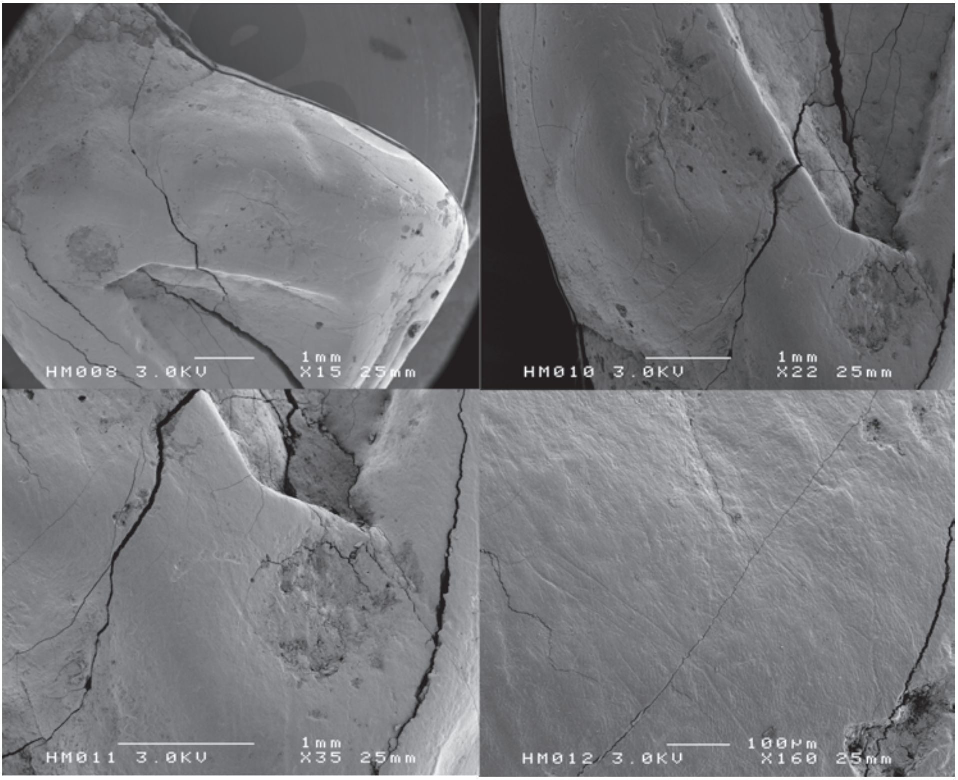


Figure 6.84 Anse à la Gourde, upper right lateral incisor.

have V-shaped pits. They are of varying length and generally around 1–2 μm or less in width. The troughs of the scratches show no pitting. The lingual surface shows

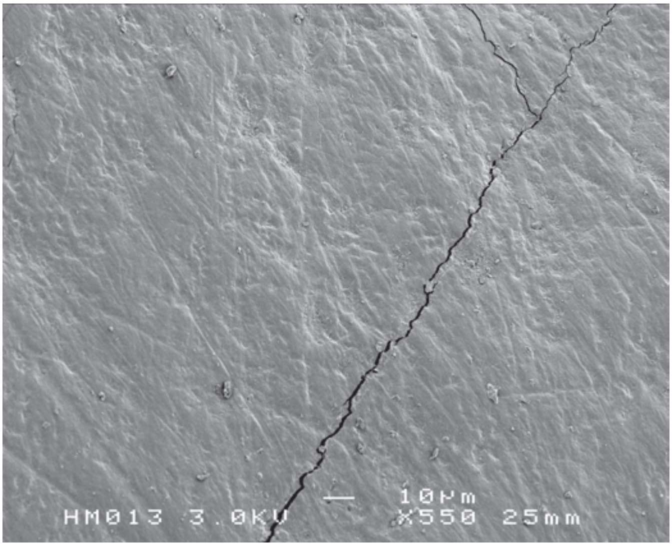


Figure 6.85 Anse à la Gourde, upper right lateral incisor.

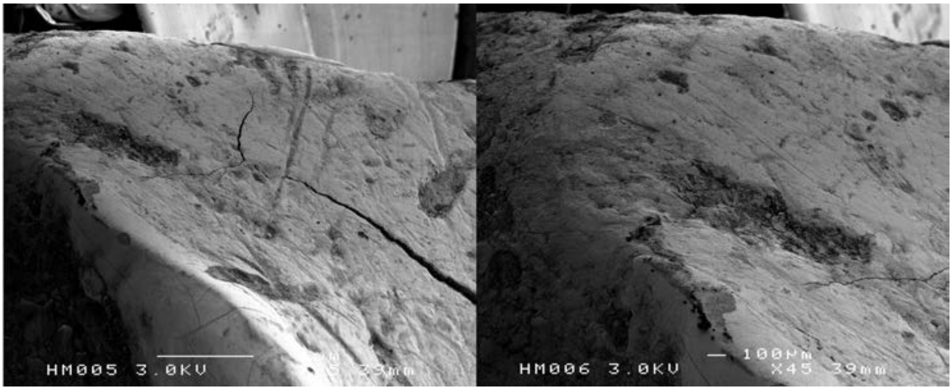


Figure 6.86 Anse à la Gourde 2215, upper left central incisor.

no evidence of pitting or pressure damage. The very fine nature of the striations, and the absence of pitting suggests that relatively little pressure was involved in their formation. The length and width of the striations indicates that tough, fibrous plant material (with adhering grit) is unlikely to have been the cause (Figure 6.87).

6.4 Dental pathology

6.4.1 Caries

Of the 8,144 observable teeth and sockets, 767 teeth (9.42%) were lost ante mortem, and 660 teeth were lost post mortem (8.10%). Anomalous eruption was observed in 5 teeth (third molars only). Complete failure to erupt (due to young age, impaction or agenesis) was recorded in 232 tooth positions (of which 43 third molars). Of the 6,480 fully erupted teeth, 48 were excluded from the present study due to severe postmortem damage that prevented evaluation. Therefore, it has been possible to study caries in 6,432 teeth. Caries are prevalent throughout the entire sample, although significant differences were found between the sites. In total, 687 carious lesions were recorded in the adult population, amounting to 12.29% of the total number of observed teeth (n= 5,592). Of all adults 232 adult individuals with at least one carious lesion were observed, amounting to 59.64% of the entire adult population (n= 389). The mean number of carious lesions per individual for all adults is 1.78.

Caries prevalence

One aim of this study is to assess differences in caries rates between the individual sites, to investigate potential differences in foodways. A preliminary investigation of caries rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences between the sites. Only sites with at least four adult individuals were included in these analyses. The caries rates based on the tooth count method per site can be found in Table 6.22.

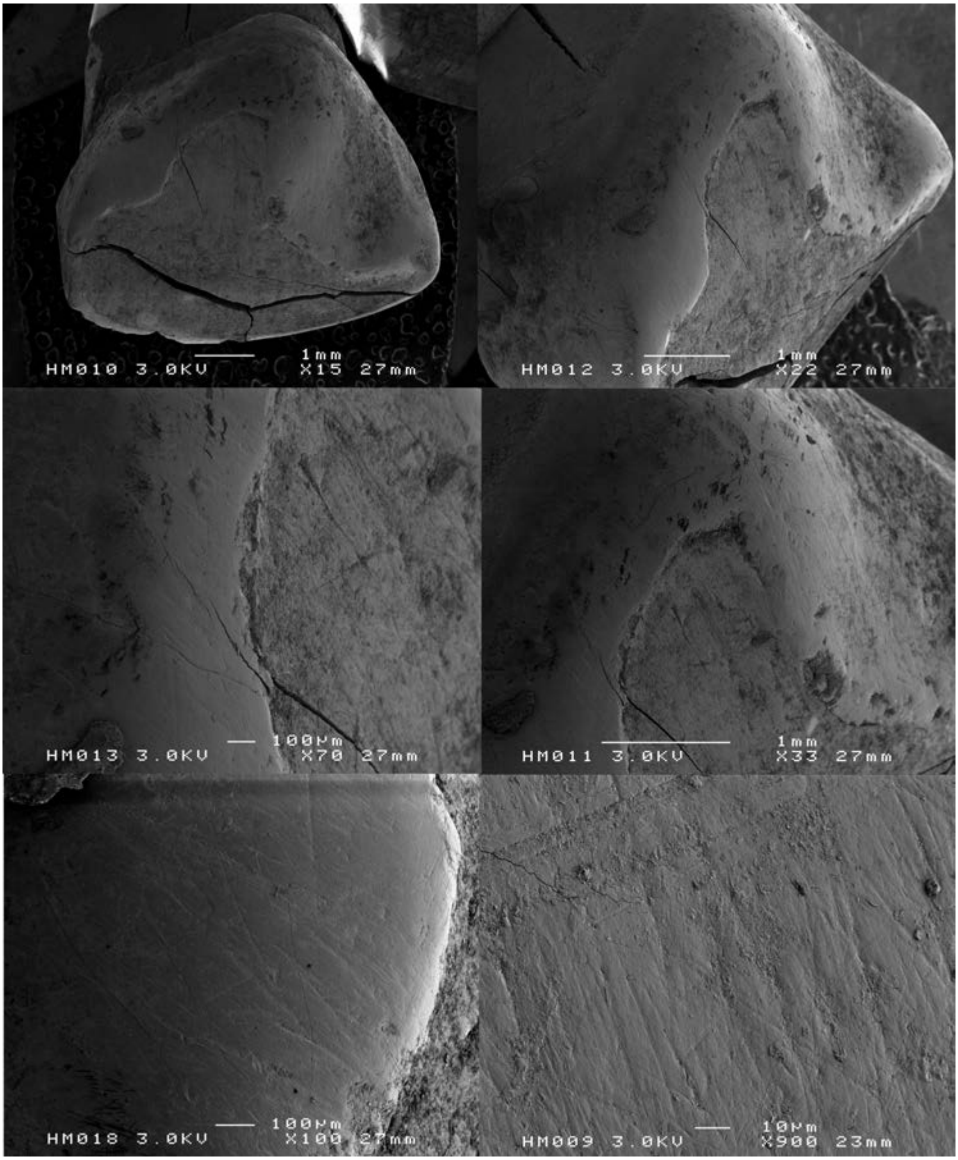


Figure 6.87 Spring Bay 1c individual 1, upper right deciduous central incisor.

As can be seen in this table, there appear to be considerable differences in the rate of caries per site. The statistical significance of these differences was tested using a chi-square test. This test determined a significant difference between at least two of the sites ($\chi^2(19, N= 5039)= 175.01, p= 0.00$).

Post-hoc comparisons of the sites to each other site using chi-square testing revealed that Anse à la Gourde has a significantly greater caries rate than all sites excepting Kelbey's Ridge 2, Punta Macao, Santa Cruz, Savanne Suazey, and Tocorón. Canashito has a significantly lower caries rate than all sites, excepting Diale 1, Escape, Juan Dolio, Malmok, Point de Caille, and Savaneta. Chorro de Maíta has a significantly higher rate of caries than Canashito, Diale 1, Escape, Juan Dolio, Malmok, Point de Caille, Punta Candelero, Savaneta, and a significantly lower rate of caries than Anse à la Gourde, Kelbey's Ridge 2, Santa Cruz, Savanne Suazey, and Tocorón. Diale 1 has a significantly lower caries rate than all sites, excepting Escape, Juan Dolio, Malmok, Point de Caille, and Savaneta. Escape has a significantly lower caries rate than Anse à la Gourde, Chorro de Maíta, Kelbey's Ridge 2, Lavoutte, Maisabel, Mamora Bay, Manzanilla, Punta Candelero, Punta Macao, Santa Cruz, Tocorón, and Tutu. Juan Dolio has a significantly lower caries rate than all sites, excepting Canashito, Diale 1, Malmok, Point de Caille, and Savaneta. Kelbey's Ridge 2 has a higher caries rate than all sites, excepting Anse à la Gourde, Santa Cruz, Savanne Suazey, and Tocorón. Lavoutte has a significantly higher caries rate than Canashito, Escape, Malmok, and Savaneta, and a significantly lower caries rate than Anse à la Gourde, Kelbey's Ridge 2, Santa Cruz, Savanne Suazey, and Tocorón. Maisabel has a significantly higher caries rate than Escape, Juan Dolio, Malmok, and Savaneta, and a significantly lower caries rate than Anse à la Gourde, Kelbey's Ridge 2, Santa Cruz, Savanne Suazey, and Tocorón. Malmok has a significantly lower caries rate than all sites, excepting Diale 1, Escape, Juan Dolio,

Site	**N**	**Frequency (tooth count)**
Canashito	47	0.00
Juan Dolio	51	0.00
Malmok	61	0.00
Savaneta	75	1.33
Escape	388	2.32
Diale 1	54	3.70
Point de Caille	66	4.55
Mamora Bay	75	9.33
Maisabel	400	9.50
Punta Candelero	733	9.82
Lavoutte	397	11.84
Manzanilla	166	12.05
Tutu	319	12.54
Chorro de Maíta	922	13.23
Punta Macao	176	14.77
Anse à la Gourde	940	19.89
Santa Cruz	58	24.14
Savanne Suazey	57	24.56
Kelbey's Ridge 2	39	30.77
Tocorón	34	35.29

Table 6.22 The caries frequency (tooth count) per site.

Point de Caille, and Savaneta. Mamora Bay has a significantly higher caries rate than Escape, Juan Dolio, Malmok, and Savaneta, and a significantly lower caries rate than Anse à la Gourde, Kelbey's Ridge 2, Santa Cruz, Savanne Suazey, and Tocorón. Manzanilla has a significantly higher caries rate than Canashito, Escape, Juan Dolio, Malmok, and Savaneta, and a significantly lower caries rate than Kelbey's Ridge 2, Santa Cruz, Savanne Suazey, and Tocorón. Point de Caille has a significantly lower caries rate than Anse à la Gourde, Chorro de Maíta, Kelbey's Ridge 2, Punta Macao, Santa Cruz, Savanne Suazey, and Tocorón. Punta Candelero has a significantly higher caries rate than Escape, Juan Dolio, Malmok, and Savaneta, and a significantly lower caries rate than Anse à la Gourde, Chorro de Maíta, Kelbey's Ridge 2, Santa Cruz, Savanne Suazey, Tocorón, and Tutu. Punta Macao has a significantly higher caries rate than Canashito, Diale 1, Escape, Juan Dolio Malmok, Point de Caille, and Savaneta, and a significantly lower caries rate than Kelbey's Ridge 2, Tocorón. Santa Cruz has a significantly higher caries rate than all sites, excepting Anse à la Gourde, Kelbey's Ridge 2, Punta Macao, Santa Cruz, Savanne Suazey, and Tocorón. Savaneta has a significantly lower caries rate than all sites, excepting Canashito, Diale 1, Escape, Juan Dolio, Malmok, and Point de Caille. Savanne Suazey has a significantly higher caries rate than all sites, excepting Anse à la Gourde, Kelbey's Ridge 2, Punta Macao, Santa Cruz, Savanne Suazey,

		High					Medium								Low						
		AAG	KR	SS	SC	TOC	CM	LAV	MB	MMB	MZ	PC	PM	TT	CAN	DIA	ES	JD	MK	PdC	SAV
High	AAG	-	0.11	0.39	0.40	0.05	0.00	0.00	0.00	0.02	0.02	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	KR	0.11	-	0.64	0.64	0.80	0.01	0.00	0.00	0.02	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SS	0.39	0.64	-	1.00	0.34	0.02	0.01	0.00	0.03	0.03	0.00	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SC	0.40	0.64	1.00	-	0.34	0.03	0.01	0.00	0.03	0.03	0.00	0.11	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	TOC	0.05	0.80	0.34	0.34	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medium	CM	0.00	0.01	0.02	0.03	0.00	-	0.53	0.07	0.47	0.80	0.04	0.63	0.85	0.03	0.04	0.00	0.00	0.00	0.04	0.00
	LAV	0.00	0.00	0.01	0.01	0.00	0.53	-	0.30	0.69	1.00	0.31	0.34	0.82	0.05	0.10	0.00	0.01	0.00	0.09	0.00
	MB	0.00	0.00	0.00	0.00	0.00	0.07	0.30	-	1.00	0.36	0.92	0.08	0.23	0.10	0.21	0.00	0.01	0.01	0.24	0.02
	MMB	0.02	0.01	0.03	0.03	0.00	0.47	0.69	1.00	-	0.66	1.00	0.31	0.55	0.19	0.30	0.01	0.04	0.02	0.34	0.05
	MZ	0.02	0.01	0.03	0.03	0.00	0.80	1.00	0.36	0.66	-	0.40	0.53	1.00	0.05	0.11	0.00	0.01	0.00	0.09	0.01
	PC	0.00	0.00	0.00	0.00	0.00	0.04	0.31	0.92	1.00	0.40	-	0.08	0.19	0.10	0.22	0.00	0.01	0.00	0.19	0.01
	PM	0.12	0.03	0.10	0.11	0.01	0.63	0.34	0.08	0.31	0.53	0.08	-	0.49	0.02	0.03	0.00	0.00	0.00	0.03	0.00
	TT	0.00	0.01	0.02	0.02	0.02	0.85	0.82	0.23	0.55	1.00	0.19	0.49	-	0.04	0.05	0.00	0.00	0.00	0.08	0.00
Low	CAN	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.10	0.19	0.05	0.10	0.02	0.04	-	0.53	1.00	1.00	1.00	0.55	1.00
	DIA	0.00	0.00	0.00	0.00	0.00	0.04	0.10	0.21	0.30	0.11	0.22	0.03	0.05	0.53	-	0.63	0.50	0.22	1.00	0.57
	ES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	1.00	0.63	-	0.61	0.62	0.40	1.00
	JD	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.01	0.01	0.00	0.00	1.00	0.50	0.61	-	1.00	0.26	1.00
	MK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	1.00	0.22	0.62	1.00	-	0.25	1.00
	PdC	0.00	0.00	0.00	0.00	0.00	0.04	0.09	0.24	0.34	0.09	0.19	0.03	0.08	0.55	1.00	0.40	0.26	0.25	-	0.34
	SAV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.01	0.01	0.00	0.00	1.00	0.57	1.00	1.00	1.00	0.34	-

Table 6.23 Significance (p) values for comparisons of adult caries frequency per site using chi-square testing. Statistically significant values are shown in bold. AAG= Anse à la Gourde, KR= Kelbey's Ridge 2, SS= Savanne Suazey, SC= Santa Cruz, TOC= Tocorón, CM= Chorro de Maíta, LAV= Lavoutte, MB= Maisabel, MMB= Mamora Bay, MZ= Manzanilla, PC= Punta Candelero, PM= Punta Macao, TT= Tutu, CAN= Canashito, DIA= Diale 1, ES= Escape, JD= Juan Dolio, MK= Malmok, PdC= Point de Caille, SAV= Savaneta.

and Tocorón. Tocorón has a significantly higher caries rate than all sites, excepting Kelbey's Ridge 2, Santa Cruz, and Savanne Suazey. Tutu has a significantly higher caries rate than Canashito, Diale 1, Escape, Juan Dolio, and Malmok, and a significantly lower caries rate than Anse à la Gourde, Kelbey's Ridge 2, Santa Cruz, Savanne Suazey, and Tocorón.

Table 6.23 presents the significance (p) values of the chi-square test comparing each site with each other site. Grouping of the sites based on shared significant differences with other sites, reveals that there are three distinct groups in the assemblage, representing low, medium, and high caries rates respectively. The low caries rate group represents sites with caries rates between 0.00–4.55%. The medium caries rate group represents sites with caries rates between 9.33–14.77%. The high caries rate group represents sites with caries rates between 19.89–35.29%.

Site	N	Frequency (individual count)
Canashito	4	0.00
Juan Dolio	7	0.00
Malmok	4	0.00
Diale 1	5	20.00
Savaneta	5	20.00
Escape	24	33.33
Maisabel	26	34.62
Manzanilla	14	42.86
Mamora Bay	4	50.00
Point de Caille	4	50.00
Punta Candelero	49	59.18
Punta Macao	15	60.00
Tocorón	6	66.67
Lavoutte	27	70.37
Tutu	21	71.43
Santa Cruz	4	75.00
Savanne Suazey	4	75.00
Chorro de Maíta	55	76.36
Anse à la Gourde	61	80.33
Kelbey's Ridge 2	3	100.00

Table 6.24 The caries frequency (individual count) per site.

These distinct differences in caries rates per group, suggest that foodways, specifically carbohydrate consumption and food preparation techniques, differed per group. Sites in the highest caries rate range represent communities in which soft, sticky, refined carbohydrates would have comprised a large portion of the daily diet, whereas the sites in the lowest caries rate range represent communities in which carbohydrate consumption would have been less important, and foods were likely less soft, sticky, and refined. The sites in the medium caries rate range are intermediate between the two cases.

Table 6.24 shows the caries rates per site based on the individual count method, which assesses the frequency of individuals with at least one carious lesion in each site assemblage. Only sites with at least four adult individuals were included in these analyses. As can be seen in this table, there appear to be considerable differences in the prevalence of caries per site. These differences were tested using a chi-square test. This test determined a significant difference between at least two of the sites ($\chi^2(19, N= 342)= 67.11$, $p= 0.00$). Post-hoc comparisons of the sites to each other site revealed that Anse à la Gourde and Chorro de Maíta have a signifi-

Site	18–25			26–35			36–45			46+		
	I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M
Canashito	-	-	-	0.00 (6)	0.00 (6)	0.00 (7)	0.00 (5)	0.00 (3)	0.00 (2)	-	-	-
Juan Dolio	0.00 (8)	0.00 (8)	0.00 (11)	0.00 (1)	0.00 (2)	0.00 (3)	-	-	-	-	-	-
Malmok	-	-	-	0.00 (8)	0.00 (9)	0.00 (19)	0.00 (17)	0.00 (9)	0.00 (16)	-	-	-
Savaneta	0.00 (9)	0.00 (9)	0.00 (6)	0.00 (20)	9.09 (11)	0.00 (13)	-	-	-	-	-	-
Escape	0.00 (34)	0.00 (34)	4.17 (48)	0.00 (45)	0.00 (30)	0.00 (47)	10.00 (20)	12.50 (16)	0.00 (14)	10.0 (10)	0.00 (12)	5.88 (17)
Diale 1	0.00 (1)	0.00 (5)	0.00 (12)	-	-	-	-	-	-	-	-	-
Point de Caille	0.00 (16)	0.00 (10)	0.00 (8)	-	-	-	-	-	-	11.1 (9)	16.67 (6)	0.00 (12)
Mamora Bay	-	-	-	-	-	-	-	-	-	-	-	-
Maisabel	0.00 (25)	0.00 (17)	2.94 (34)	0.00 (36)	0.00 (26)	0.00 (30)	0.00 (22)	0.00 (14)	0.00 (26)	3.03 (66)	20.00 (30)	48.39 (31)
Punta Candelero	0.00 (51)	0.00 (42)	13.46 (52)	9.09 (44)	2.63 (38)	17.39 (46)	0.00 (32)	0.00 (22)	24.00 (25)	2.78 (36)	3.85 (26)	28.00 (25)
Lavoutte	0.00 (6)	0.00 (7)	25.00 (12)	0.00 (44)	12.9 (31)	20.54 (44)	6.12 (49)	16.67 (30)	18.52 (27)	0.00 (26)	5.88 (17)	30.00 (20)
Manza-nilla	0.00 (21)	11.76 (17)	0.00 (23)	10.53 (19)	15.4 (13)	10.00 (20)	-	0.00 (1)	0.00 (3)	0.00 (15)	22.22 (9)	37.50 (8)
Tutu	0.00 (18)	23.08 (13)	6.67 (15)	-	-	-	10.53 (38)	26.83 (41)	32.00 (25)	0.00 (64)	7.02 (57)	20.51 (39)
Chorro de Maíta	1.55 (129)	0.00 (81)	18.95 (95)	4.27 (117)	7.14 (70)	20.48 (83)	0.00 (24)	25.00 (20)	6.25 (16)	19.4 (36)	45.45 (11)	50.00 (12)
Punta Macao	0.00 (20)	0.00 (11)	9.52 (21)	0.00 (19)	4.17 (12)	5.83 (12)	11.76 (17)	28.57 (7)	33.33 (3)	8.33 (12)	0.00 (5)	0.00 (3)
Anse à la Gourde	2.33 (86)	11.76 (51)	31.76 (85)	2.76 (181)	25.3 (83)	36.05 (86)	11.29 (62)	15.15 (33)	10.34 (29)	0.00 (47)	0.00 (11)	33.33 (15)
Santa Cruz	0.00 (4)	50.00 (4)	6.25 (16)	0.00 (8)	50.0 (4)	25.00 (4)	0.00 (3)	0.00 (3)	50.00 (4)	-	-	-
Savanne Suazey	0.00 (3)	0.00 (5)	0.00 (10)	-	-	-	-	-	-	-	-	-
Kelbey's Ridge 2	-	-	-	-	-	-	0.00 (1)	100.0 (1)	-	16.7 (12)	20.00 (5)	11.11 (9)
Tocorón	-	-	-	-	-	-	-	-	-	-	-	-

Table 6.25 Caries rates per site, by age group and tooth category. The number of observed teeth is indicated between the brackets.

cantly larger proportion of adults affected by caries than Escape, Juan Dolio, and Maisabel. Lavoutte and Tutu have a significantly greater proportion of adults affected by caries than Juan Dolio. No other significant differences were found. The preliminary assessments above indicate possible differences in foodways between the individual sites in the sample. However, as discussed in Chapter 4 (section 4.2.3), when comparing caries rates between groups, the effects of age, differential preservation of individual dental elements, and differential susceptibility of individual dental elements to carious lesions must be taken into account (Hillson 2001, 2008b; Wasterlain et al. 2009). The differences demonstrated above using the simple tooth count and individual count methods could (at least in part) result from differing age profiles and differentially preserved/affected dental elements. For this reason, these potential sources of variation must be controlled for in order to assess foodways based on caries prevalence. Table 6.25 presents the caries rates per site by age group (18–25, 26–35, 36–45, and 46+), and by tooth category (incisors and canines, premolars, and molars). As can be seen in Table 6.25 there is a trend for an increase in caries rate with age, which is particularly clear for the larger site assemblages of Anse à la Gourde, Chorro de Maíta, Escape, Manzanilla, Lavoutte, Punta Candelero, and Tutu. At the site of Punta Macao, caries rates rise until the age of 36–45 years, but clearly drop in the age group of 46+ years. Decreases in caries rates in the oldest age categories of populations that show a clear trend for age-related increase in caries rates have previously been noted previously (Wasterlain et al. 2009), and can be related to higher rates of AMTL in older age categories. Although AMTL is known to be caused by a variety of factors (see Chapters 2 and 4; sections 2.2.1 and 4.2.3), an important cause of AMTL is the destructive process of carious lesions, particularly in populations with high caries rates. As such, the drop off in caries rates may be related to high rates of AMTL in older age groups. As can be seen in Table 6.35, AMTL rates at Punta Macao clearly rise sharply in the oldest age groups. Wasterlain et al. (2009) found that increased AMTL of molars in older age groups coincided with an increase in caries rates of the anterior teeth, most likely because, with the loss of the molars, these were the only teeth left in the mouth and exposed to cariogenic factors. An increase in caries rates with age of incisors and canines, and premolars, can be seen at the some of the other larger site assemblages in Table 6.25: Anse à la Gourde, Chorro de Maíta, Punta Candelero, and Tutu. At Anse à la Gourde, caries rates also drop off in the oldest age group; again this may be related to the high AMTL rates in adults of 46+ years, particularly in the premolars and molars (Table 6.35). At Chorro de Maíta and Tutu, both caries and AMTL rates continue to rise with age (Tables 6.25 and 6.35). What is also clear from Table 6.25, is the fact that the molars are generally more frequently affected by caries in all age groups than the incisors and canines, and the premolars. Premolars, in turn, are more frequently affected by caries than incisors and canines. This reflects known differences in susceptibility of the different tooth classes to carious lesions. Molars, due to their intricate fissures tend to retain food remains and dental plaque more easily, leading to carious activity. Similarly, premolars retain food remains and plaque in fissures on the occlusal surface (Hillson 1996, 2001; Wasterlain et al. 2009). High rates of caries in incisors and canines are generally associated with populations consuming very large proportions of cariogenic foods, consisting of soft, sticky carbohydrates. In populations with low carbohydrate intake, the first molars are affected most by caries, with populations with slightly higher carbohydrate intake showing caries on the second and third molars as well as on the premolars (Hillson 2001, 2008b). As shown in Table 6.25, the sites of Anse à la Gourde, Santa Cruz, and Tutu have relatively high caries rates in the younger age groups, with high percentages of incisors and canines and premolars affected throughout. The sites of Chorro de Maíta, Lavoutte, Manzanilla, Punta Candelero, and Punta Macao have intermediate caries rates, with fewer incisors and canines and premolars affected throughout. The sites of Canashito, Diale 1, Escape, Juan Dolio, Malmok, Point de Caille, and Savaneta show a relatively low caries rate throughout, with few affected anterior teeth. However, these sites are represented by very few aged adults, and as such it is difficult to infer the relation between age and caries rates.

Overall, these data support the categories of high, medium, and low caries rates presented above using the simple tooth count method, with the exception of the site of Tutu. Based in the data presented in Table 6.25, Tutu fits the pattern of high carbohydrate intake, since relatively high rates of caries are seen in all age groups and tooth classes. It is possible that this pattern was masked through the use of the tooth count method, in which adults of unknown age were included. Maisabel shows very low caries rates for the younger age groups, and high rates for the oldest group (46+ years). Again, this may be the result of the inclusion of adults of unknown age in the tooth count method. Based on the data shown in Table 6.25, Maisabel shows caries rates that are more befitting of low carbohydrate intake groups.

Chronological comparisons

A preliminary investigation of caries rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences between the occupation phases at the sites of Maisabel, Punta Can

Occupation phase	18–25			26–35			36–45			46+			Total adults*	Ind. freq. %
	I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M		
Early	0.00 (12)	0.00 (4)	0.00 (11)	0.00 (22)	0.00 (15)	0.00 (18)	0.00 (10)	0.00 (2)	0.00 (6)	3.85 (26)	21.43 (14)	55.00 (20)	10.65 (169)	36.36 (11)
Late	0.00 (15)	0.00 (13)	4.35 (23)	0.00 (14)	0.00 (11)	0.00 (12)	0.00 (13)	0.00 (12)	0.00 (20)	2.50 (40)	14.29 (21)	58.82 (17)	8.65 (231)	33.33 (15)
Chi-square													χ^2(1, N=400)= 0.45, p= 0.61	χ^2(1, N=26)= 2.10, p= 0.20

Table 6.26 Caries rates at Maisabel, by age group, tooth category, and phase of occupation. The number of observed teeth/individuals is indicated between the brackets. * Includes adults of unknown age.

delero, and Tutu. No significant differences were found between the occupation phases at these three sites.

Maisabel – The rate of carious teeth drops slightly in the late phase of occupation. The number of affected individuals also drops slightly in the late period. These differences are not statistically significant. Comparison of caries rates per age group reveals no clear differences between the two occupation phases (Table 6.26).

Punta Candelero – The percentage of carious teeth rises slightly in the late phase of occupation, along with the number of affected individuals. These differences are not statistically significant (Table 6.27). Comparison of caries rates per age group reveals that the young middle adult group (26–35 years) in the middle occupation phase shows clearly higher caries rates than that of the late occupation phase. This group also shows substantially higher AMTL rates than the late group in this age category (Table 6.37). Apart from this, there are no clear differences between the two occupation phases (Table 6.27).

Occupation phase	**18–25**			**26–35**			**36–45**			**46+**			**Total adults***	**Ind. freq. %**
	I+C	**PM**	**M**	**I+C**	**PM**	**M**	**I+C**	**PM**	**M**	**I+C**	**PM**	**M**		
Middle	0.00 (23)	0.00 (18)	0.00 (24)	3.57 (28)	8.00 (25)	14.3 (28)	0.00 (18)	0.00 (11)	25.0 (12)	0.00 (9)	14.3 (7)	14.3 (7)	7.17 (251)	50.00 (20)
Late	0.00 (8)	0.00 (8)	75.0 (8)	0.00 (12)	0.00 (6)	0.00 (10)	0.00 (7)	0.00 (5)	12.5 (8)	0.00 (1)	-	-	9.41 (85)	60.00 (5)
Chi-square													χ^2(1, N=336)= 0.45, p= 0.49	χ^2(1, N=25)= 0.16, p= 1.00

Table 6.27 Caries rates at Punta Candelero, by age group, tooth category, and phase of occupation. The number of observed teeth/individuals is indicated between the brackets. * Includes adults of unknown age.

Tutu – The percentage of carious teeth and the number of affected individuals drop somewhat. These differences are not statistically significant (Table 6.28). Comparison of caries rates per age group shows that in the young and old middle adult age groups, the early phase occupation group has higher caries rates, excepting the molars of 36–45 year olds (Table 6.28). The latter may be related to high AMTL rates, particularly for molars, in the early phase group of 36–45 year olds, which may have led to a drop in caries rates (Wasterlain et al. 2009). Similarly, high AMTL rates may have affected the caries in the 46+ age group, effectively reducing the caries rate in the early group (Table 6.38). It seems, therefore, that the difference in caries rates between the early and late occupation phases at Tutu, based on the simple tooth count and individual count methods, may reflect a true difference in foodways, and is not simply an artefact of differing age profiles and preservation of the different categories of teeth.

Sex-based comparisons

A preliminary investigation of caries rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences between males and females. Of the entire sample, 11.71% (n= 285) of male teeth is affected by carious lesions. In females, 14.73% (n= 315) of teeth is affected. A chi-square test shows that females have a significantly higher caries prevalence (tooth count) than males (χ^2(1, N= 4572)= 9.06, p= 0.00). In total, 62.09% (n= 95) of males has at least one cavity. Of females, 64.19% (n= 95) has at least one cavity. The proportions of males and females affected is near enough the same (χ^2(1, N= 301)= 0.14, p= 0.72). No caries were observed at Canashito and Juan Dolio.

Occupation phase	18–25			26–35			36–45			46+			Total adults*	Ind. freq. %
	I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M		
Early	0.00 (10)	50.0 (6)	16.67 (6)	-	-	-	11.76 (17)	42.11 (19)	18.18 (11)	0.00 (26)	11.76 (17)	16.67 (12)	15.75 (127)	77.78 (9)
Late	0.00 (8)	0.00 (7)	0.00 (9)	-	-	-	8.70 (23)	13.64 (22)	46.67 (15)	0.00 (38)	4.88 (41)	22.22 (27)	10.94 (192)	75.00 (12)
Chi-square													χ^2(1, N=319)= 1.58, p= 0.23	χ^2(1, N=21)= 0.02, p= 1.00

Table 6.28 Caries rates at Tutu, by age group, tooth category, and phase of occupation. The number of observed teeth/individuals is indicated between the brackets. * Includes adults of unknown age.

Intra-site comparisons

A preliminary investigation of caries rates based on simple tooth count and individual count methods was performed for each individual site, in order to gain an insight into the potential differences between males and females. The results show statistically significant differences in caries prevalence (tooth count) between males and females at Anse à la Gourde, Maisabel, and Punta Candelero. Numbers are too small at the sites of Canashito, Diale 1, Escape, Kelbey's Ridge 2, Malmok, Mamora Bay, Point de Caille, Santa Cruz, Savaneta, Savanne Suazey, and Tocorón to reliably test for differences between the sexes.

To control for potential sources of variation resulting from differing age profiles and differentially preserved/affected dental elements, differences between the sexes were further investigated by age group (18–25, 26–35, 36–45, and 46+), and by tooth category (incisors and canines, premolars, and molars). Since numbers are too small at Canashito, Diale 1, Escape, Kelbey's Ridge 2, Malmok, Mamora Bay, Point de Caille, Santa Cruz, Savaneta, Savanne Suazey, and Tocorón to reliably test for differences between the sexes, these sites were omitted from these analyses. Caries rates for males and females per age group and tooth category can be found in Table 6.29.

Site		18–25			26–35			36–45			46+		
		I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M
Maisabel	**M**	0.00 (19)	0.00 (10)	3.85 (26)	0.00 (36)	0.00 (22)	0.00 (30)	-	-	-	0.00 (25)	5.88 (17)	46.15 (13)
	F	-	-	-	-	-	-	0.00 (22)	0.00 (14)	0.00 (26)	3.45 (29)	50.00 (10)	50.00 (12)
Punta Candelero	**M**	0.00 (20)	0.00 (16)	30.00 (20)	0.00 (24)	0.00 (17)	5.56 (18)	0.00 (21)	0.00 (14)	27.78 (18)	0.00 (28)	0.00 (20)	25.00 (16)
	F	0.00 (12)	0.00 (8)	0.00 (7)	16.67 (24)	5.56 (18)	24.00 (25)	0.00 (11)	0.00 (5)	14.29 (7)	12.50 (8)	16.67 (6)	28.57 (7)
Lavoutte	**M**	-	-	-	0.00 (31)	15.00 (20)	23.53 (34)	0.00 (22)	5.88 (17)	23.53 (17)	0.00 (16)	10.00 (10)	10.00 (10)
	F	0.00 (6)	0.00 (7)	25.00 (12)	0.00 (13)	0.00 (6)	10.00 (10)	18.75 (16)	44.44 (9)	16.67 (6)	0.00 (10)	0.00 (4)	50.00 (10)
Manzanilla	**M**	0.00 (13)	0.00 (8)	0.00 (13)	10.53 (19)	15.38 (13)	10.00 (20)	-	0.00 (1)	0.00 (3)	0.00 (7)	100.00 (2)	40.00 (5)
	F	0.00 (8)	28.57 (7)	0.00 (8)	-	-	-	-	-	-	11.11 (9)	0.00 (7)	33.33 (3)
Tutu	**M**	-	-	-	-	-	-	5.26 (19)	23.81 (21)	40.00 (15)	0.00 (18)	0.00 (21)	15.79 (19)
	F	0.00 (18)	23.08 (13)	6.67 (15)	-	-	-	15.79 (19)	33.33 (15)	20.00 (10)	0.00 (44)	8.57 (35)	25.00 (20)
Chorro de Maíta	**M**	3.77 (53)	0.00 (33)	21.05 (38)	0.00 (87)	5.66 (53)	19.12 (68)	0.00 (14)	44.44 (9)	8.33 (12)	10.00 (30)	42.86 (7)	50.00 (10)
	F	0.00 (76)	0.00 (48)	17.54 (57)	14.29 (28)	11.76 (17)	20.00 (10)	0.00 (8)	12.50 (8)	0.00 (4)	66.67 (6)	50.00 (4)	50.00 (2)
Punta Macao	**M**	0.00 (2)	0.00 (2)	0.00 (6)	0.00 (11)	0.00 (5)	100.0 (4)	11.76 (17)	28.57 (7)	33.33 (3)	0.00 (1)	0.00 (2)	-
	F	0.00 (7)	0.00 (3)	12.50 (8)	0.00 (8)	71.43 (7)	37.50 (8)	-	-	-	9.09 (11)	0.00 (4)	0.00 (3)
Anse à la Gourde	**M**	4.00 (25)	36.36 (11)	50.00 (20)	0.00 (93)	11.76 (34)	31.91 (47)	3.57 (28)	0.00 (15)	5.88 (17)	0.00 (30)	0.00 (6)	35.71 (14)
	F	0.00 (61)	5.71 (35)	26.15 (65)	5.68 (88)	38.24 (34)	41.03 (39	17.65 (34)	35.71 (15)	16.67 (12)	0.00 (17)	0.00 (5)	0.00 (1)

Table 6.29 Caries rates for males and females per site, by age group and tooth category. The number of observed teeth is indicated between the brackets.

Anse à la Gourde – There are clear differences between the sexes with regards to the prevalence of carious lesions in males and females. A chi-square test shows there is a significant difference between male (17.00%) and female (22.12%) caries rates, with females showing a higher caries rate than males (tooth count) (χ^2(1, N= 935)= 3.78, p= 0.05). No significant differences were found in the proportions of affected individuals between males (79.17%) and females (85.29%) (χ^2(1, N= 58)= 0.37, p= 0.73). In the youngest age group, males have higher caries rates than females for all tooth categories. In the young middle and old middle age groups, females show distinctly higher caries rates than males. Considering the small sample size, differences between males and females aged 46+ years, are less clear. However, females in this age group have distinctly higher rates of AMTL than males. Since caries is a major contributing factor to AMTL, it is possible that the trend of higher caries prevalence in females of 26–35 and 36–45 years was continued into the oldest age group at Anse à la Gourde.

Chorro de Maíta – Males (14.19%) show a higher frequency of carious teeth than females (11.72%), however, a chi-square test shows that the difference is not significant (χ^2(1, N= 859)= 1.15, p= 0.31). No significant differences were found between the proportions of affected males (80.77%) and females (69.23%) (χ^2(1, N= 52)= 0.92, p= 0.52). On examination of the data presented in Table 6.29, the difference between male and female caries rates based on the tooth count method is no longer apparent.

Diale 1 – The results of a chi-square test show that there is no significant difference in the frequency of carious lesions between males (12.50%) and females (0.00%) (χ^2(1, N= 50)= 4.43, p= 0.10), with a higher caries frequency in males than in females. Numbers are too small to test for significant differences in proportions of affected males and females.

Escape – A slight difference in caries rates was observed between males (4.26%) and females (3.16%), but a chi-square test demonstrates that this difference is not statistically significant (χ^2(1, N= 142)= 0.11, p= 1.00). No significant difference was found between the proportions of affected males (100.00%) and females (50.00%) (χ^2(1, N= 8)= 1.60, p= 0.46).

Kelbey's Ridge 2 – The results of a chi-square test show there is no significant difference in the frequency of carious lesions between males (57.14%) and females (25.00%) (χ^2(1, N= 39)= 2.78, p= 0.17). Since all males and females are affected by caries, and numbers are very small, comparison for statistically significant differences in individual count is omitted.

Lavoutte – A slight difference in caries rate was observed between the sexes. A chi-square test shows that the difference between male (11.89%) and female (13.79%) caries rates is not significant (χ^2(1, N= 330)= 0.27, p= 0.62). No significant differences were found between the proportions of affected males (80.00%) and females (70.00%) (χ^2(1, N= 20)= 0.27, p= 1.00). Examination of the data presented in Table 6.29, shows that, considering the small sample size, there are no clear differences between males and females when comparing the different tooth classes and age groups.

Maisabel – The results of a chi-square test show there is a significant difference in the frequency of carious lesions between males (5.41%) and females (14.84%) (χ^2(1, N= 350)= 8.96, p= 0.01), with a much higher caries frequency in females than in males. The proportions of affected males (33.33%) and females (37.50%) do not differ much, and a chi-square test found no significant difference between males and females (χ^2(1, N= 23)= 0.04, p= 1.00). Examination of the data presented in Table 6.29, reveals no further evidence of differences between male and female caries rates, since only the oldest age group contains individuals of both sexes for comparison. Since the male group is mostly comprised of young and young middle adults, and the female group is comprised of old middle and old adults, the significant difference in caries based on the tooth count method is likely to be an artefact of differing age profiles between the two groups.

Manzanilla – Females (13.64%) have a slightly higher caries frequency than males (11.48%). A chi-square test reveals that this difference is not significant (χ^2(1, N=

166)= 0.14, p= 0.79). The proportion of females (50.00%) affected by caries is also slightly higher than the proportion of males (40.00%), however, no significant difference was found (χ^2(1, N= 14)= 0.12, p= 1.00). Examination of the data presented in Table 6.29, reveals no further evidence of differences between male and female caries rates, since only the youngest and oldest age groups contain individuals of both sexes for comparison.

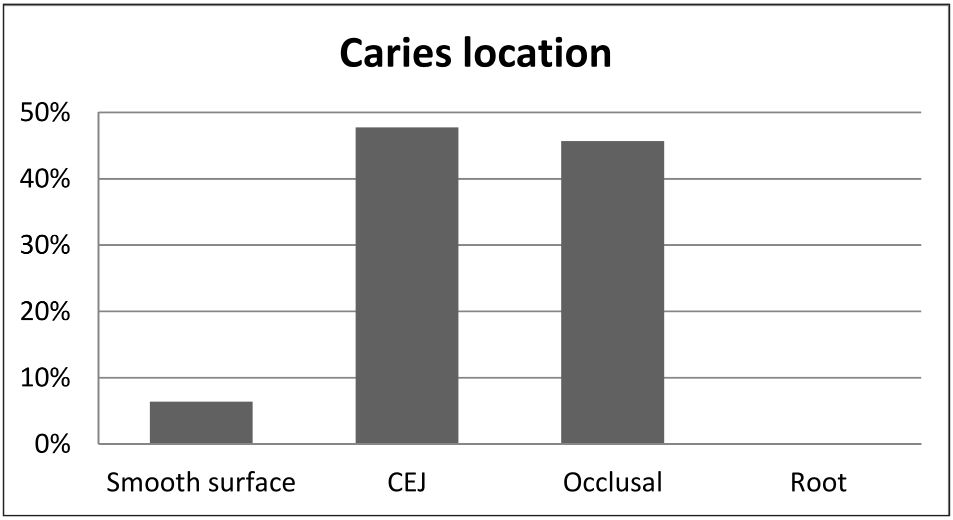


Figure 6.88 Prevalence of caries per location.

Punta Candelero – Females (13.87%) have a significantly higher caries rate than males (8.70%), as demonstrated by a chi-square test (χ^2(1, N= 518)= 3.31, p= 0.05). No significant differences were found between the proportions of affected males

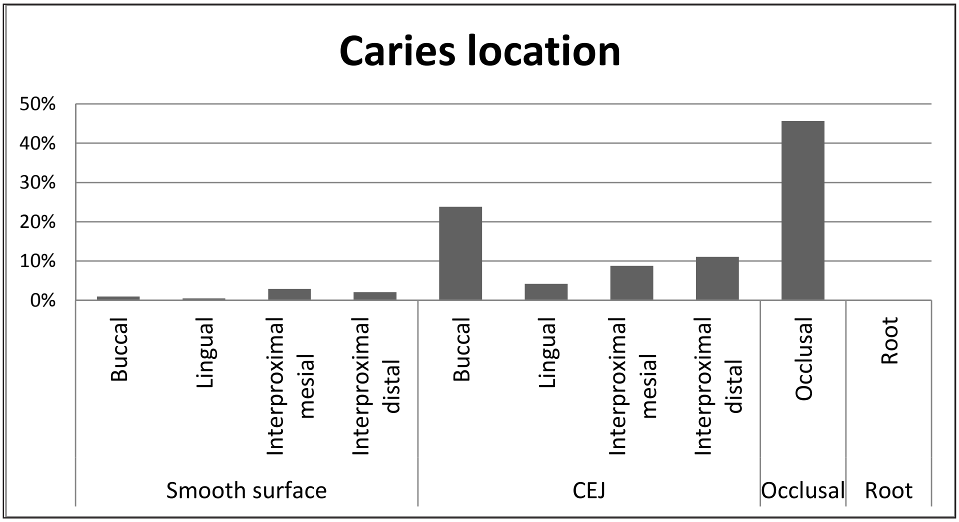


Figure 6.89 Prevalence of caries per location (detailed).

(68.42%) and females (63.64%) (χ^2(1, N= 30)= 0.07, p= 1.00). Examination of the data presented in Table 6.29, reveals that young middle and old female adults have higher caries rates than males. Furthermore, females aged 26–35 years show distinctly higher AMTL rates (Table 6.39), which for a substantial part may have resulted from higher caries rates.

Punta Macao – Even though there is a very large difference between the caries frequency (tooth count) for males (13.95%) and females (20.31%), no statistically significant difference was found with a chi-square test (χ^2(1, N= 150)= 1.07, p= 0.38). Furthermore, no significant difference was found between the proportions of affected males (50.00%) and females (66.67%) (χ^2(1, N= 14)= 0.39, p= 0.63). Due to the small sample size, and the lack of females aged 36–45 years, the difference in caries rate based on tooth count could not be investigated further.

Tutu – No clear difference in caries prevalence between males (12.93%) and females is present (12.56%). This is confirmed by a chi-square test (χ^2(1, N= 315)= 0.05, p= 0.86). A smaller proportion of females (71.43%) appears to be affected by caries than males (83.33%), however this difference is also not statistically significant (χ^2(1, N= 20)= 0.32, p= 1.00). Due to the lack of younger individuals of both sexes for comparison differences in affected tooth classes and between age groups could not be assessed.

Site	Smooth surface %	CEJ %	Occlusal %	Root %
Anse à la Gourde	8.19	41.52	50.29	0.00
Canashito	0.00	0.00	0.00	0.00
Chorro de Maíta	7.63	33.05	58.47	0.85
Diale 1	0.00	100.00	0.00	0.00
Escape	0.00	55.56	44.44	0.00
Juan Dolio	0.00	0.00	0.00	0.00
Kelbey’s Ridge 2	0.00	50.00	50.00	0.00
Lavoutte	4.65	62.79	32.56	0.00
Maisabel	0.00	70.00	30.00	0.00
Malmok	0.00	0.00	0.00	0.00
Mamora Bay	0.00	28.57	71.43	0.00
Manzanilla	6.25	68.75	25.00	0.00
Point de Caille	0.00	66.67	33.33	0.00
Punta Candelero	3.17	49.21	47.62	0.00
Punta Macao	3.85	38.46	57.69	0.00
Santa Cruz	9.10	45.45	45.45	0.00
Savaneta	100.00	0.00	0.00	0.00
Savanne Suazey	0.00	85.71	14.29	0.00
Tocorón	0.00	66.67	33.33	0.00
Tutu	10.00	57.50	32.50	0.00

Table 6.30 Frequencies of caries location per site.

Caries location

Caries location was recorded as smooth surface, cement-enamel junction (CEJ), occlusal, or root surface. These categories are further subdivided into a total of nine locations on the tooth. For the entire sample, CEJ followed by occlusal caries are most prevalent (Figure 6.88). Within the category of CEJ caries, the most frequent location is buccal and interproximal (Figure 6.89).

Table 6.30 displays the percentage of caries per location at the individual sites. These data show that there are substantial differences between the sites. Broadly speaking, the sites can be divided into those with a considerably larger proportion of CEJ caries than occlusal caries (Escape, Lavoutte, Maisabel, Manzanilla, Point de Caille, Savanne Suazey, Tocorón, and Tutu), and those with a considerably larger proportion of occlusal caries than CEJ caries (Anse à la Gourde, Chorro de Maíta, Mamora Bay, and Punta Macao). The remaining sites have a more or less equal proportion of CEJ and occlusal caries (Punta Candelero and Santa Cruz), or no caries at all (Canashito, Diale 1, Juan Dolio, and Malmok). Smooth surface caries occur in some of both major groups.

6.4.2 Dental calculus

The amount of accumulated calculus is, of course, in part related to age, as the older an individual becomes, the more calculus (s)he could potentially accumulate. Conversely, the more the tooth crowns wear away, the more calculus will wear away too. As discussed in Chapter 2 a wide array of other factors influence the rate of calculus deposition and the size of calculus deposits, meaning that small differences in the (mean) size of calculus accretions within or between populations are very difficult to interpret. Nonetheless, the size and type of calculus deposits was documented according to Brothwell (1981) and Hillson (1996).

The distribution of the calculus deposits throughout the dentition is also examined here, because although the formation of dental calculus has been shown to be related to dietary practices, the deposition of supragingival dental calculus throughout the dentition and on the surfaces of individual teeth is known to follow a particular ‘natural’ pattern in all humans (Bergström 1999; Corbett and Dawes 1998; Jin and Yip 2002; Parfitt 1959; Schroeder 1969; White 1997).

For the site of Tutu, presence and degree of calculus was not systematically recorded, as most deposits appear to have been lost or removed during cleaning prior to examination of the material (see also Larsen et al. 2002). Similarly, at Diale 1, Savaneta, Savanne Suazey, and Tocorón, calculus appears to have been lost during cleaning and/or transportation of the material, or simply due to drying and loss over time in storage.

Overall, calculus was observed in 41 of the 49 sites (83.67%). The frequency of calculus accretions (tooth count and individual count) per site with more than four individuals can be found in Table 6.31. The frequencies vary widely between the sites. A chi-square test ($\chi^2(19, N= 342) = 57.41, p= 0.00$) shows that at least two sites differ significantly from each other with regards to the frequency of

Site	**T.C. (n)**	**%**	**I.C. (n)**	**%**
Anse à la Gourde	473	50.32	46	75.41
Canashito	6	12.77	2	50.00
Chorro de Maíta	269	29.18	45	81.82
Diale 1	*3*	*6.00*	*1*	*20.00*
Escape	73	18.81	14	58.33
Juan Dolio	23	45.10	5	71.43
Kelbey's Ridge 2	18	46.15	1	33.33
Lavoutte	104	26.33	16	59.26
Maisabel	65	16.25	17	65.38
Malmok	13	21.31	3	75.00
Mamora Bay	9	12.00	2	50.00
Manzanilla	97	58.43	11	78.57
Point de Caille	49	74.24	4	100.00
Punta Candelero	422	58.94	45	91.84
Punta Macao	124	71.26	13	86.67
Santa Cruz	12	20.69	3	75.00
Savaneta	*4*	*5.33*	*1*	*20.00*
Savanne Suazey	*8*	*14.04*	*3*	*75.00*
Tocorón	*7*	*20.59*	*3*	*50.00*
Tutu	*39*	*12.23*	*6*	*28.57*

Table 6.31The frequency of calculus (tooth count and individual count) per site. In italics: sites where calculus was not systematically recorded because of loss due to cleaning or damage.

individuals affected by calculus. Post-hoc comparison of each of the sites reveals that Anse à la Gourde, Chorro de Maíta, Punta Candelero, and Punta Macao have a significantly larger proportion of individuals affected by calculus than Tutu. However, this is most likely an artefact of the non-systematic recording of calculus in the Tutu assemblage, as discussed above. Punta Candelero also shows a significantly larger proportion of individuals affected by calculus than Diale 1. No other significant differences between the sites were found.

Chronological comparisons

Maisabel – The proportion of affected teeth drops slightly in the late period (16.67%) in comparison to the early period (17.16%). The difference is not statistically significant (χ^2(1, N= 385)= 0.02, p= 0.89). Similarly, the proportion of affected individuals drops from the early to late phase (72.73% and 42.86%, respectively), although the difference is not significant (χ^2(1, N= 25)= 2.23, p= 0.23). The mean degree of calculus deposits also drops in the late phase (1.61) as opposed to the early phase (1.96). A Mann-Whitney U test demonstrates that this difference is not significant (U = 395.00, p= 0.16).

Punta Candelero – The proportion of affected teeth drops slightly in the late period (63.53%) in comparison to the middle period (64.94%). The difference is not statistically significant (χ^2(1, N= 336)= 0.06, p= 0.90). The proportion of affected individuals rises somewhat from the middle (90.00%) to the late (100.00%) phase. The difference is not statistically significant (χ^2(1, N= 25)= 0.54, p= 1.00). Similarly, the mean degree of calculus deposits rises slightly from the middle (1.22) to late (1.30) phase. A Mann-Whitney U test shows that this difference is not significant (U = 4104.00, p= 0.17).

Tutu – The proportion of affected teeth drops slightly in the late period (9.90%) when compared to the early period (15.75%). The difference is not statistically significant (χ^2(1, N= 319)= 2.44, p= 0.16). The proportion of affected individuals also drops somewhat (early: 33.33%, late: 25.00%), as does the mean degree of calculus deposits (early: 1.65, late: 1.56). These differences are also not statistically significant (χ^2(1, N= 21)= 0.18, p= 1.00) and (U = 11576.00, p= 0.23), respectively.

Sex-based comparisons

For the overall sample, the proportion of affected teeth is larger in males (43.76%) than in females (34.27%). The difference is statistically significant according to the results of a chi-square test (χ^2(1, N= 4557)= 42.82, p= 0.00). A Mann-Whitney U test showed that there is a statistically significant difference in the size of calculus deposits between males and females (U = 1772185.00, p= 0.00). Males are affected by larger calculus deposits than females.

Anse à la Gourde – The proportion of affected teeth in males and females is near enough equal; 49.38% of male teeth is affected, and 52.38% of female teeth is affected. When comparing the size of the calculus deposits in males and females, there also appears to be no difference between the sexes. A Mann-Whitney U test showed that there is no statistically significant difference in the size of calculus deposits between males and females (U = 25962.50, p= 0.82).

Chorro de Maíta – A chi-square test shows there is a significant difference between the proportion of teeth affected by calculus deposits in males (32.31%) and females (26.18%), with males more frequently affected than females (χ^2(1, N= 859)= 3.87, p= 0.05). When comparing the size of the calculus deposits in males and females, a Mann-Whitney U test shows that there is no statistically significant difference in the size of calculus deposits between males and females (U = 7395.00, p= 0.17).

Escape – A chi-square test shows there is a significant difference between the proportion of teeth affected by calculus deposits in males (31.91%) and females (12.63%) at Escape, with females more frequently affected than males (χ^2(1, N= 142)= 7.59, p= 0.01). A Mann-Whitney U test shows that males have significantly larger calculus accretions than females (U = 1814.00, p= 0.01).

Lavoutte – A chi-square test shows that the proportion of teeth affected by calculus deposits in males (38.38%) is significantly higher than in females (20.00%) at Lavoutte (χ^2(1, N= 330)= 13.00, p= 0.00). Furthermore, a Mann-Whitney U test shows that males have significantly larger calculus accretions than females (U =

10759.50, p= 0.00).

Maisabel – A chi-square test shows that the proportion of teeth affected by calculus deposits in females (24.22%) is significantly higher than in males (13.53%) at Maisabel (χ^2(1, N= 335)= 6.23, p= 0.02). Furthermore, a Mann-Whitney U test shows that females have significantly larger calculus accretions than males (U = 11200.50, p= 0.00).

Manzanilla – A chi-square test shows that there is no statistically significant difference between the proportion of teeth affected by calculus deposits in males (60.66%) than in females (52.27%) at Manzanilla (χ^2(1, N= 166)= 0.94, p= 0.38). A Mann-Whitney U test shows that there is no statistically significant difference in size of calculus accretions between males and females (U = 2197.50, p= 0.12).

Punta Candelero – A chi-square test shows that the proportion of teeth affected by calculus deposits in males (66.38%) is significantly higher than in females (55.49%) at Punta Candelero (χ^2(1, N= 518)= 5.84, p= 0.02). Furthermore, a Mann-Whitney U test shows that females have significantly larger calculus accretions than males (U = 26340.50, p= 0.05).

Punta Macao – A chi-square test shows that there is no statistically significant difference between the proportion of teeth affected by calculus deposits in males (68.60%) than in females (57.81%) at Punta Macao (χ^2(1, N= 150)= 1.86, p= 0.23). Furthermore, a Mann-Whitney U test shows that there is no significant difference in the size of calculus accretions between males and females (U = 2496.00, p= 0.28).

Tutu – Although male dentitions (13.79%) are slightly more frequently affected by calculus than female dentitions (11.56%), chi-square test shows that there is no statistically significant difference between the proportion of teeth affected by calculus deposits in males than in females (χ^2(1, N= 315)= 0.34, p= 0.60).

Unusual calculus deposits

Eight cases of unusual patterns of dental calculus deposits were identified in the assemblages of Argyle 2, Escape, Manzanilla, Punta Candelero, and Punta Macao. The calculus deposits are extremely large, and differ both in location on the individual teeth and distribution throughout the dental arch from the expected natural pattern of calculus deposition. None of the affected individuals are female. Six are male, and of the remaining two one is of indeterminate sex (due to its young age) and one is of unknown sex (due to poor preservation).

Argyle 2 individual 3

This male aged between 18–25 years shows very large calculus deposits on the lower right mandibular dentition, extending from the canine to the third molar. Of the right maxillary teeth, only the canine is present, and is equally affected by excessive calculus formation. The other upper right teeth were lost ante and post mortem. The deposits are largest on the buccal surfaces, but very heavy calculus accumulations were also found on the occlusal and lingual surfaces. Occlusal calculus

Figure 6.90 Manzanilla 255A, unusual calculus deposits on lower right mandibular teeth.

accumulations are rare, as they only form when these surfaces are redundant, or in other words, are not used in food mastication. Normal use of the teeth for mastication of foodstuffs prevents the formation of calculus deposits on the occlusal surfaces, as plaque is removed by the abrasive action of the food across the tooth. Large occlusal calculus deposits in the lower right dentition indicate that these teeth, and therefore also the occluding upper right teeth, were not used in normal food mastication. The ante mortem loss of the occluding upper right teeth could also cause redundancy of the lower teeth, however since some of the upper right teeth were lost post mortem, it is fair to assume that mastication was still possible.

Calculus deposits are also present on the left side of the dentition on the upper canine and first molar, but these deposits are much smaller and befit the normal pattern of calculus accumulation. No occlusal calculus was found on the left side of the dentition. It is likely that the left part of the dentition was used in all food mastication activities, something which is corroborated by the fact that the left dentition shows a higher mean degree of wear than the right dentition.

Escape 17

This adult of unknown sex aged between 36–45 years shows very large calculus deposits on the right dentition, extending from the upper third premolar to the lower third molar (the upper fourth premolar, upper third molar, and lower second molar are absent). The deposits are largest on the buccal surfaces, but very heavy calculus accumulations were also found on the occlusal and lingual surfaces, indicating that the right side of the dentition was not used in normal food mastication. No calculus was found on the left side of the dentition. It is likely that this side was used in all food mastication activities, as it has a higher mean degree of wear than the right dentition.

Manzanilla 255A

This male aged between 26–35 years was found interred together with the partial remains of a juvenile (255B, secondary interment) aged 2–4 years (Dorst 2008; Weston in prep.).

Very large calculus accumulations are present on the right mandibular dentition, extending from the lateral incisor to the second molar (the third molar, or wisdom tooth, was present, but only partially erupted and impacted)(Figure 6.90). Unfortunately, the right maxillary teeth were lost post mortem, but considering the severity of calculus accumulation in the lower right dentition, it is highly likely that these teeth were also affected by large calculus deposits. Deposits are largest on the buccal surfaces, but heavy calculus accumulations were also found on the occlusal and lingual surfaces. Large occlusal calculus deposits in the lower right dentition show that these teeth and the occluding upper right teeth were not used in normal food mastication. Another explanation for such large calculus deposits on the lower right teeth is the ante mortem loss of the occluding upper right teeth, thus making the lower teeth redundant and susceptible to calculus accumulation. In this case, however, the upper right teeth appear to have been lost post mortem. Calculus deposits are also present on the left side of the dentition and on the lingual surfaces of the lower incisors, but these deposits are much smaller and befit the normal pattern of calculus accumulation. No occlusal calculus was found on the left side of the dentition. It is likely that the left part of the dentition was used in all food mastication activities, since this part of the dentition shows a higher mean degree of wear than the right dentition (Mickleburgh 2012).

Manzanilla 267-269

This possible male aged between 26–35 years was buried on top of another adult individual, with two juvenile individuals later buried at intervals on top (Dorst 2008; Weston in prep.).

Very large calculus accumulations are present on the left side of both the upper and lower dentition from the canines to the second molars (the third molars are absent). The deposits are heaviest on the buccal surfaces, but large accumulations are also present on the occlusal and lingual surfaces. Occlusal calculus is present in both the left upper and lower quadrants, clearly indicating that these teeth were not used in normal mastication.

The right side of the dentition has practically no calculus. The right teeth also show a higher average degree of wear than the left teeth, indicating that this side performed most of the food mastication activities (Mickleburgh 2012).

Manzanilla 291

This individual of indeterminate sex aged between 14–16 years was found buried on the back with the legs flexed toward the torso (Dorst 2008; Weston in prep.).

Heavy calculus deposits were found on the buccal surfaces of the left upper teeth, extending from the canine to the second molar (the third molar is absent). These teeth also show relatively large lingual deposits. Occlusal calculus is present the upper left teeth, on both premolars and the first molar.

Although the lower left teeth lack large buccal calculus deposits, it appears that these may have been lost due to post-depositional processes or cleaning. Both lower premolars and the second molar have considerable occlusal deposits. The presence of occlusal calculus in the left portion of the dentition of this individual again indicates that this side the dentition must have been avoided during masticatory activities (Mickleburgh 2012).

Punta Candelero 54

This adult male shows heavy calculus deposits on the buccal surfaces of the right upper teeth from the lateral incisor to the fourth premolar (the molars are absent), and on the right lower dentition from the lateral incisor to the third molar. The lower molars also have occlusal calculus and the lower third molar also has a large lingual calculus deposit. The left side the dentition has only small calculus deposits befitting the normal pattern of accumulation, and is more severely worn than the right side.

Punta Candelero 56

This male aged between 16–18 years shows heavy calculus deposits on the buccal surfaces of the left teeth from the canines to the lower first and upper second molars. The premolars and the upper first and second molars also have occlusal calculus. The right side the dentition has no calculus deposits, and is slightly more severely worn than the left side.

Punta Macao 2

This male aged between 14–16 years appears to show the same pattern of calculus deposits described above for individuals from Argyle2, Manzanilla, and Punta Candelero. The pattern is less clear in this case, however, as only three teeth on the left side display the large calculus accretions (the other left teeth were absent). Heavy calculus deposits are found on the buccal surfaces of the upper left fourth premolar, upper first molar and the lower first molar. These teeth also have occlusal calculus. The right side the dentition has no calculus deposits. No difference in degree of wear between the left and right side of the dentition was observed, although the young age of this individual means wear would be very slight in any case.

6.4.3 Periapical abscesses

The rate of periapical abscesses (tooth count and individual count) is presented in Table 6.32. No periapical abscesses were found at the other sites in the sample. Overall the rates of periapical abscesses in the sample are not particularly high, but they clearly differ at the individual sites.

Figure 6.91 Cañas, Puerto Rico, periapical abscess.

Site	Periapical abscesses (T.C.) (n)	Frequency %	Periapical abscesses (I.C.) (n)	Frequency %
Chorro de Maíta	2	0.14	2	3.64
Escape	1	0.25	1	4.17
Tutu	1	0.25	1	4.76
Anse à la Gourde	6	0.52	5	8.20

Site	Periapical abscesses (T.C.) (n)	Frequency %	Periapical abscesses (I.C.) (n)	Frequency %
Kelbey's Ridge 2	1	1.08	1	33.33
Punta Macao	3	1.29	2	13.33
Punta Candelero	13	1.52	9	18.00
Diale 1	1	1.69	1	20.00
Canashito	1	1.92	1	25.00
Tocorón	1	2.27	1	16.67
El Cabo	2	3.77	1	50.00
La Caleta	1	4.00	1	100.00
Canas	2	13.33	1	33.33
Clarence Town cave	2	14.29	1	50.00
Indian Creek	3	60.00	1	100.00

Table 6.32 The frequency of periapical abscesses (tooth count and individual count) per site.

Sex-based differences

In the entire sample, 13.07% of males (n= 20) is affected by periapical abscesses. Of females, 3.38% are affected by periapical abscesses (n= 5). A chi-square test shows the difference is statistically significant (χ^2(1, N= 301)= 9.28, p= 0.00).

At most sites the numbers of affected individuals are so small that differences between the sexes cannot be reliably tested. For Anse à la Gourde the results of a chi-square test show that although males (n= 4) appear more frequently affected than females (n= 1), the difference is not statistically significant (χ^2(1, N= 58)= 3.37, p= 0.15). Similarly for Punta Candelero, males (n= 6) appear more frequently affected than females (n= 1), but the difference is not statistically significant (χ^2(1, N= 30)= 1.97, p= 0.22).

6.4.4 AMTL

AMTL is prevalent throughout the entire sample, although some significant differences were found between the different sites. In total 767 cases of AMTL were recorded in the adult population, amounting to 11.06% of the total number of observed tooth positions (n= 6938). In the total sample, 142 adult individuals with at least one ante mortem lost tooth were observed, amounting to 36.50% of the entire adult population (n= 389).

AMTL prevalence

An aim of this study is to assess differences in AMTL rates between the individual sites. A preliminary investigation of AMTL rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences between the sites. The rate of AMTL (tooth count) is calculated as follows: number of AMTL / total number of observed tooth positions (= observed teeth + unerupted teeth + AMTL + PMTL) = AMTL rate. The rate of AMTL (individual count) is calculated as follows: number of individuals with at least one ante mortem lost tooth / total number of individuals = AMTL rate.

The AMTL rates based on the tooth count method per site can be found in Table 6.33. As can be seen in this table, there appear to be considerable differences in the AMTL rates per site. These differences were tested using a chi-square test. This test determined a significant difference between at least two of the sites (χ^2(17, N= 6173)= 199.77, p= 0.00).

Site	N	Frequency % (T.C.)
Point de Caille	66	0.00
Savanne Suazey	57	0.00
Escape	394	2.79
Maisabel	432	3.94
Diale 1	88	5.68
Mamora Bay	84	5.95
Savaneta	75	6.67
Lavoutte	448	6.70
Santa Cruz	57	7.02
Punta Candelero	912	7.24
Canashito	52	9.62
Anse à la Gourde	1207	13.01
Punta Macao	257	14.40
Kelbey's Ridge 2	42	16.67
Chorro de Maíta	1296	17.36
Manzanilla	202	19.31
Tocorón	51	19.61
Tutu	443	19.64

Table 6.33 The AMTL frequency per site. Due to the lack (or poor preservation) of alveolar bone, Juan Dolio and Malmok were omitted from the analyses.

Table 6.34 shows the AMTL rates per site based on the individual count method, which assesses the frequency of individuals with at least ante mortem lost tooth in each site assemblage. As can be seen in this table, there appear to be considerable differences in the prevalence of AMTL per site. These differences were tested using a chi-square test. This test determined a significant difference between at least two of the sites (χ^2(17, N= 335)= 42.56, p= 0.00).

The preliminary assessments above indicate differences in AMTL rates between the individual sites in the sample. However, as discussed in Chapters 2 and 4 (sections 2.2.1 and 4.2.3), when comparing AMTL rates between groups, the effects of age, differential preservation of individual dental elements, and differential

Site	N	Frequency (individual count)
Point de Caille	4	0.00
Savanne Suazey	4	0.00
Diale 1	7	14.29
Escape	24	16.67
Savaneta	5	20.00
Maisabel	26	23.08
Canashito	4	25.00
Santa Cruz	4	25.00
Lavoutte	28	28.57
Manzanilla	14	28.57
Tocorón	6	33.33
Punta Candelero	50	34.00
Punta Macao	15	46.67
Mamora Bay	4	50.00
Anse à la Gourde	61	52.46
Chorro de Maíta	55	63.63
Kelbey's Ridge 2	3	66.67
Tutu	21	61.90

Table 6.34 The AMTL frequency (individual count) per site. Due to the lack (or poor preservation) of alveolar bone, Juan Dolio and Malmok were omitted from the analyses.

susceptibility of individual dental elements to ante mortem loss must be taken into account (Hillson 2001, 2008b; Wasterlain et al. 2009). The differences demonstrated above using the simple tooth count and individual count methods could (at least in part) result from differing age profiles and differentially preserved/affected dental elements. For this reason, these potential sources of variation must be controlled for.

Table 6.35 presents the AMTL rates per site by age group (18–25, 26–35, 36–45, and 46+), and by tooth category (incisors and canines, premolars, and molars). As can be seen in this table, individuals in older age groups generally have higher AMTL rates than individuals in younger age groups. However, because age-at-death estimations are not available for all adults, the numbers of individuals representing the different age categories at each site are considerably reduced. In some cases, such as Mamora Bay and Tocorón, none of the adults in the sample could be aged.

This complicates comparisons between the different sites. Nonetheless, as Table 6.35 shows, those sites identified as high AMTL rates based on the simple tooth count method, i.e. Anse à la Gourde, Chorro de Maíta, Manzanilla, Punta Candelero, and Tutu, also show relatively high AMTL rates. The sites of Anse à la Gourde, Chorro de Maíta, and Punta Candelero show relatively high rates in most age groups and tooth categories.

Site	18–25			26–35			36–45			46+		
	I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M
Point de Caille	0.00 (16)	0.00 (8)	0.00 (8)	-	-	-	-	-	-	0.00 (11)	0.00 (7)	0.00 (11)
Savanne Suazey	0.00 (4)	0.00 (5)	0.00 (10)	-	-	-	-	-	-	-	-	-
Escape	2.94 (34)	0.00 (31)	1.89 (53)	2.17 (46)	0.00 (46)	0.00 (47)	0.00 (24)	0.00 (20)	22.22 (18)	0.00 (11)	0.00 (12)	19.04 (21)
Maisabel	0.00 (30)	0.00 (17)	0.00 (35)	0.00 (36)	0.00 (26)	0.00 (30)	0.00 (22)	6.67 (15)	5.71 (35)	0.00 (76)	0.00 (32)	26.09 (46)
Diale 1	0.00 (14)	0.00 (13)	0.00 (15)	-	-	-	-	-	-	-	-	-
Mamora Bay	-	-	-	-	-	-	-	-	-	-	-	-
Savaneta	0.00 (9)	0.00 (7)	0.00 (6)	0.00 (20)	8.33 (12)	23.53 (17)	-	-	-	-	-	-
Lavoutte	0.00 (8)	0.00 (7)	0.00 (12)	2.04 (49)	5.88 (34)	8.33 (48)	0.00 (58)	3.33 (30)	31.82 (44)	0.00 (30)	5.00 (20)	16.67 (24)
Santa Cruz	0.00 (4)	40.00 (5)	11.11 (18)	0.00 (8)	0.00 (4)	0.00 (4)	0.00 (3)	0.00 (3)	0.00 (4)	-	-	-
Punta Candelero	0.00 (51)	0.00 (42)	0.00 (56)	12.90 (62)	13.04 (46)	21.21 (66)	2.86 (35)	4.35 (23)	6.67 (30)	8.51 (47)	8.00 (25)	14.81 (54)
Canashito	-	-	-	0.00 (6)	0.00 (6)	0.00 (6)	0.00 (6)	0.00 (3)	71.43 (7)	-	-	-
Anse à la Gourde	0.00 (86)	0.00 (51)	3.37 (89)	1.06 (189)	9.47 (95)	35.46 (141)	0.00 (63)	12.12 (33)	12.82 (39)	0.00 (50)	31.58 (19)	47.06 (51)
Punta Macao	0.00 (25)	0.00 (14)	0.00 (23)	0.00 (32)	9.09 (22)	39.29 (28)	0.00 (18)	25.00 (12)	50.00 (6)	27.27 (22)	18.18 (11)	75.00 (12)
Kelbey's Ridge 2	-	-	-	-	-	-	0.00 (4)	0.00 (4)	100.00 (6)	0.00 (12)	0.00 (8)	10.00 (10)
Chorro de Maíta	0.00 (146)	0.00 (91)	11.21 (116)	3.97 (151)	14.44 (90)	30.15 (136)	14.63 (41)	17.24 (29)	60.00 (40)	34.67 (75)	51.28 (39)	81.69 (71)
Manzanilla	0.00 (21)	0.00 (17)	0.00 (23)	0.00 (19)	0.00 (13)	0.00 (20)	-	0.00 (1)	0.00 (3)	40.00 (30)	46.67 (15)	69.23 (26)
Tocorón	-	-	-	-	-	-	-	-	-	-	-	-
Tutu	0.00 (19)	0.00 (13)	0.00 (22)	-	-	-	0.00 (38)	0.00 (41)	36.59 (41)	13.64 (88)	14.71 (68)	52.08 (96)

Table 6.35 AMTL rates per site, by age group and tooth category. The number of observed tooth positions is indicated between brackets.

Chronological comparisons

Maisabel – A statistically significant rise is seen in the frequency of AMTL in the late phase of occupation (Table 6.36). Although the proportion of affected individuals also rises in the later period, the difference is not statistically significant. These differences do not appear to be the result of differing age profiles of both groups. Half of both the early and late groups are older adults (46+ years). Comparison of AMTL rates per age group reveals that the greatest difference between the two groups comprises the oldest adults (46+ years), with older adults in the late phase of occupation clearly showing higher rates of AMTL that older adults in the early

Occupation phase	18–25			26–35			36–45			46+			Total adults*	Ind. freq. %
	I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M		
Early	0.00 (12)	0.00 (4)	0.00 (11)	0.00 (22)	0.00 (15)	0.00 (18)	0.00 (10)	33.33 (3)	9.09 (11)	0.00 (26)	0.00 (14)	0.00 (20)	1.14 (175)	9.09 (11)
Late	0.00 (20)	0.00 (15)	0.00 (24)	0.00 (14)	0.00 (11)	0.00 (12)	0.00 (13)	0.00 (12)	4.17 (24)	0.00 (50)	0.00 (21)	37.5 (32)	5.84 (257)	33.33 (15)
Chi-square													χ^2(1, N=432) = 6.07, p= 0.02	χ^2(1, N=26)= 2.10, p= 0.20

Table 6.36 AMTL rates at Maisabel, by age group, tooth category, and phase of occupation. The number of observed tooth positions/individuals is indicated between brackets. * Includes adults of unknown age.

phase of occupation (Table 6.36). As such, the significant difference between AMTL rates between the early and late phases of occupation at Maisabel based on the simple tooth count method, appears to reflect a true increase in rates, not resulting purely from differing age profiles.

Punta Candelero – A significant drop is seen in the frequency of AMTL in the late phase of occupation (Table 6.37). The proportion of affected individuals also drops in the later period but the difference is not statistically significant. An important factor in this difference may be the fact that the oldest age group (46+ years) is underrepresented in the late group. Nonetheless, as can be seen in Table 6.37, the early group shows clearly higher AMTL rates in the young middle adult and old middle adult age groups (26–35 and 36–45 years, respectively). As such, the difference between the two occupation phases likely represents a true drop in AMTL over time.

Occupation phase	18–25			26–35			36–45			46+			Total adults*	Ind. freq. %
	I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M		
Middle	0.00 (23)	0.00 (16)	0.00 (28)	17.95 (39)	11.4 (35)	18.42 (38)	4.76 (21)	7.14 (14)	7.14 (14)	6.25 (16)	20.0 (10)	41.7 (12)	11.11 (319)	35.00 (20)
Late	0.00 (8)	0.00 (7)	0.00 (8)	0.00 (12)	0.00 (7)	0.00 (11)	0.00 (7)	0.00 (5)	0.00 (9)	0.00 (1)	-	-	0.00 (85)	0.00 (4)
Chi-square													χ^2(1, N= 404)= 10.21, p= 0.00	χ^2(1, N= 24)= 1.98, p= 0.28

Table 6.37 AMTL rates at Punta Candelero, by age group, tooth category, and phase of occupation. The number of observed tooth positions/individuals is indicated between brackets. * Includes adults of unknown age.

Tutu – The frequency of AMTL drops in the late phase of occupation, however the difference is not statistically significant based on the results of a chi-square test. The proportion of affected individuals rises somewhat in the late period, but the difference is not statistically significant (Table 6.38). Comparison of AMTL rates per age group reveals that the greatest difference between the two groups comprises the oldest adults (46+ years), with older adults in the early phase of occupation clearly showing higher rates of AMTL that older adults in the late phase of occupation (Table 6.38).

Occupation phase	18–25			26–35			36–45			46+			Total adults*	Ind. freq. %
	I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M		
Early	0.00 (11)	0.00 (7)	0.00 (12)	-	-	-	0.00 (17)	0.00 (19)	31.25 (16)	20.59 (34)	29.17 (24)	63.64 (33)	23.03	55.56 (9)
Late	0.00 (8)	0.00 (6)	0.00 (10)	-	-	-	0.00 (23)	0.00 (22)	38.46 (26)	9.26 (54)	2.27 (44)	46.03 (63)	17.36	66.67 (12)
Chi-square													χ^2(1, N=443)= 2.17, p= 0.15	χ^2(1, N=21)= 0.27, p= 0.67

Table 6.38 AMTL rates at Tutu, by age group, tooth category, and phase of occupation. The number of observed tooth positions is indicated between brackets. * Includes adults of unknown age.

Sex-based comparisons

A preliminary investigation of AMTL rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences between males and females. A difference was observed between the prevalence of AMTL (tooth count) in males and females in the total sample. Of the entire sample, 12.03% (n= 336) of observed male tooth positions is affected by carious lesions. In females, 15.76% (n= 396) of observed tooth positions is affected. A chi-square test demonstrates that this difference is statistically significant (χ^2(1, N= 5305)= 15.51, p= 0.00). The proportion of females affected by AMTL (45.27%, n= 67) is almost the same as the proportion of males (45.10%, n= 69) (χ^2(1, N= 301)= 0.00, p= 1.00).

No AMTL was observed at Point de Caille and Savanne Suazey. Due to the lack (or poor preservation) of alveolar bone, Juan Dolio and Malmok were omitted from the analyses.

Intra-site comparisons

A preliminary investigation of AMTL rates based on simple tooth count and individual count methods was performed for each individual site, in order to gain an insight into the potential differences between males and females. The results show statistically significant differences in AMTL rate between males and females at Anse à la Gourde, Manzanilla, and Punta Candelero. At these three sites, females show significantly higher rates of AMTL than males. Numbers are too small at the sites of Canashito, Diale 1, Kelbey's Ridge 2, Mamora Bay, Point de Caille, Santa Cruz, Savaneta, Savanne Suazey, and Tocorón to reliably test for differences between the sexes.

To investigate potential sources of variation resulting from differing age profiles and differentially preserved/affected dental elements, differences between the sexes were further studied by age group (18–25, 26–35, 36–45, and 46+), and by tooth category (incisors and canines, premolars, and molars). Since numbers are too small at Canashito, Diale 1, Kelbey's Ridge 2, Mamora Bay, Point de Caille, Santa Cruz, Savaneta, Savanne Suazey, and Tocorón to reliably test for differences between the sexes, these sites were omitted from these analyses.

Site		18–25			26–35			36–45			46+		
		I+C	PM	M	I+C	PM	M	I+C	PM	M	I+C	PM	M
Escape	**M**	11.11 (9)	0.00 (7)	8.33 (12)	-	-	-	0.00 (8)	0.00 (7)	0.00 (5)	-	-	-
	F	0.00 (8)	0.00 (5)	0.00 (9)	0.00 (14)	0.00 (11)	0.00 (17)	0.00 (5)	0.00 (4)	57.14 (7)	0.00 (2)	0.00 (2)	0.00 (8)
Maisabel	**M**	0.00 (25)	0.00 (12)	0.00 (27)	0.00 (36)	0.00 (26)	0.00 (30)	-	-	-	0.00 (29)	0.00 (21)	36.00 (25)
	F	-	-	-	-	-	-	0.00 (23)	6.67 (15)	5.71 (35)	0.00 (35)	13.33 (15)	18.75 (16)
Lavoutte	**M**	-	-	-	2.78 (36)	7.41 (27)	10.53 (38)	0.00 (28)	14.29 (21)	25.00 (24)	0.00 (18)	7.69 (13)	15.38 (13)
	F	0.00 (8)	0.00 (7)	0.00 (12)	0.00 (13)	0.00 (7)	0.00 (10)	0.00 (18)	10.00 (10)	50.00 (12)	0.00 (12)	0.00 (7)	16.67 (12)
Punta Candelero	**M**	0.00 (20)	0.00 (16)	0.00 (20)	0.00 (29)	0.00 (22)	4.35 (23)	4.17 (24)	5.88 (17)	9.09 (22)	7.89 (38)	12.00 (25)	26.92 (26)
	F	0.00 (12)	0.00 (8)	0.00 (7)	22.22 (36)	23.33 (30)	31.71 (41)	0.00 (11)	0.00 (6)	0.00 (8)	11.11 (9)	0.00 (7)	11.11 (9)
Anse à la Gourde	**M**	0.00 (25)	0.00 (14)	7.69 (26)	0.00 (96)	6.67 (45)	22.54 (71)	0.00 (29)	0.00 (17)	8.00 (25)	0.00 (33)	11.11 (9)	40.00 (25)
	F	0.00 (63)	0.00 (36)	1.47 (68)	2.00 (100)	10.20 (49)	44.74 (76)	0.00 (34)	18.18 (22)	17.65 (17)	0.00 (17)	25.00 (8)	70.00 (20)
Punta Macao	**M**	0.00 (2)	0.00 (2)	0.00 (6)	0.00 (18)	12.50 (8)	60.00 (10)	0.00 (18)	25.00 (12)	42.86 (7)	83.33 (6)	40.00 (5)	100.00 (3)
	F	0.00 (12)	0.00 (8)	0.00 (11)	0.00 (14)	0.00 (11)	27.78 (18)	-	-	-	5.56 (18)	10.00 (10)	66.67 (9)
Chorro de Maíta	**M**	0.00 (55)	0.00 (35)	8.00 (50)	0.00 (110)	7.14 (70)	21.90 (105)	21.43 (28)	26.32 (19)	57.14 (28)	17.31 (52)	33.33 (36)	76.00 (50)
	F	0.00 (92)	0.00 (61)	11.69 (77)	14.63 (41)	26.67 (30)	58.06 (31)	0.00 (13)	0.00 (10)	61.54 (13)	65.38 (26)	70.59 (17)	90.91 (22)
Manzanilla	**M**	0.00 (13)	0.00 (9)	0.00 (14)	0.00 (19)	0.00 (13)	10.00 (20)	-	0.00 (1)	0.00 (3)	46.15 (13)	71.43 (7)	58.33 (12)
	F	0.00 (8)	0.00 (8)	0.00 (9)	-	-	-	-	-	-	35.29 (17)	36.36 (11)	78.57 (14)
Tutu	**M**	-	-	-	-	-	-	0.00 (21)	0.00 (23)	33.33 (24)	18.52 (27)	0.00 (21)	37.50 (32)
	F	0.00 (19)	0.00 (15)	0.00 (22)	-	-	-	0.00 (19)	0.00 (18)	38.89 (18)	11.86 (59)	17.78 (45)	59.38 (64)

Table 6.39 AMTL rates by site, sex, age group, and tooth category. The number of observed tooth positions is indicated between brackets.

Due to the lack (or poor preservation) of alveolar bone, Juan Dolio and Malmok were omitted from the analyses. AMTL rates for males and females per age group and tooth category can be found in Table 6.39. Because both sex and age-at-death estimations are not available for all adults, the numbers of individuals representing the different sex and age categories at each site are further reduced, complicating comparisons between the different sites.

Anse à la Gourde – A significant difference was observed between the rate of AMTL in males (11.35%) and females (16.91%) using a chi-square test. Female dentitions were found to be more frequently affected by AMTL than male dentitions (χ^2(1, N= 1082)= 6.62, p= 0.01). Although a greater proportion of males was found to be affected by AMTL, no significant difference was found in the proportion of affected males or females (χ^2(1, N=58)= 0.17 p= 0.79). As can be seen in Table 6.39, AMTL rates in females are distinctly higher overall for all age categories and tooth classes, excepting the 18–25 years age group. AMTL rates of premolars and molars, particularly in the 26–35, 36–45, and 46+ years age groups are clearly higher in females than in males.

Chorro de Maíta – The rate of AMTL in males (18.04%) and females is (18.42%) close to equal. A chi-square test confirms that there is no significant difference (χ^2(1, N= 1235)= 0.03, p= 0.88). No significant difference was found in the proportion of males or females affected (χ^2(1, N= 52)= 0.79, p= 0.56). However, the data presented in Table 6.39 show that in all age groups except 36–45 years, females have substantially higher AMTL rates than males in all tooth classes. In the 36–45 years age group, females have a higher AMTL rate in molars, but males have much higher rates for incisors and canines and premolars. Overall, the pattern shown in Table 6.39 suggests females at Chorro de Maíta suffered more frequently from AMTL than males.

Escape – Results are derived from only a small number of individuals, in part due to the very poor condition of the material, which prevented assessment of the alveolar bone. The available data imply that there is no difference between the frequency (tooth count) of AMTL in males and females.

Lavoutte – There is a slight difference in the rate of AMTL between males (8.72%) and females (5.52%), with males more frequently affected than females. A chi-square test shows this difference is not statistically significant (χ^2(1, N= 381)= 1.40, p= 0.32). No significant difference was found in the proportion of males or females affected (χ^2(1, N= 21)= 1.53, p= 0.36). Based on the data presented in Table 6.39, there is no clear difference between males and females. Since the youngest age group (18–25 years) is represented only by females, this age group could not be assessed for sex-based differences. In the young middle adult age group, males show higher rates for all tooth classes than females. In the oldest two age groups, females have higher AMTL rates in molars, but lower rates in premolars than males.

Maisabel – There is a slight difference in the AMTL rates between males (3.80%) and females (5.56%), with females slightly more frequently affected than males. A chi-square test shows that this difference is not statistically significant (χ^2(1, N= 384)= 0.58, p= 0.46). Although females are clearly more frequently affected by AMTL than males, no significant difference was found in the proportions of affected males or females (χ^2(1, N= 23)= 3.64, p= 0.13). The data in Table 6.39 suggest that the slight differences between males and females may be the result of differing age profiles of the male and female groups at Maisabel. Only the oldest age category is represented by both males and females, and the majority of males belong to the youngest two age groups, while all females belong to the oldest two age groups.

Manzanilla – Female dentitions (31.34%) were found to have a higher AMTL rate than male dentitions (13.33%) (χ^2(1, N= 202)= 9.32, p= 0.00). No significant difference was found in the proportions of affected males and females (χ^2(1, N= 14)= 1.26 p= 0.52). Due to the lack of females aged 26–35 and 36–45 years, males and females in these age groups could not be compared (Table 6.39). In the youngest age group, no differences are seen, while in the oldest age group, females show higher rates for molars, but males show higher rates for incisors and canines and premolars. As such, the significant difference observed between males and females based on the simple tooth count method appears to be the result of differing preservation of male and female teeth at Manzanilla.

Punta Candelero – A significant difference was observed between the rates of AMTL in males (5.58%) and females (13.70%) using a chi-square test. Female dentitions were found to be more frequently affected by AMTL than male dentitions (χ^2(1, N= 613)= 11.94, p= 0.00). No significant difference was found in the proportion of males or females affected (χ^2(1, N= 31)= 0.22 p= 0.72). On examination of the data presented in Table 6.39, it is clear that females have distinctly higher AMTL rates in the 26–35 age category, but males have higher caries rates in the oldest two age groups (excepting in incisors and canines in the 46+ years category). This, however, may be the result of the fact that there are far fewer females in the older two age classes than males.

Punta Macao – Male dentitions (18.40%) appear to display a higher rate of AMTL than female dentitions (12.28%). This difference is not significant based on a chi-square test (χ^2(1, N= 239)= 1.71, p= 0.21). No significant difference was found in the proportion of males or females affected (χ^2(1, N= 12)= 0.34, p= 1.00). The difference between the sexes, although not statistically significant, is echoed in the results shown in Table 6.39. In the young middle adult and old adult age groups, males have higher AMTL rates than females.

Tutu – Although female dentitions (21.53%) were found to be more frequently affected by AMTL than male dentitions (16.56%), no significant difference was found with a chi-square test (χ^2(1, N= 439)= 1.54, p= 0.26). No significant difference was found in the proportions of males and females affected (χ^2(1, N= 20)= 0.01, p= 1.00). Using the data presented in Table 6.39, only the oldest two age groups could be compared for sex-based differences. These data appear to confirm the tendency for higher AMTL rates in females than in males.

6.4.5 Hypercementosis

Hypercementosis occurs infrequently in all assemblages included in this study. Numbers of individuals affected are low, and the number of teeth affected per in dividual is equally low (Table 6.40). No significant differences were found between

Site	Individual count (N)	Tooth count (N)
Anse à la Gourde	8	11
Canas	1	2
Canashito	0	0
Chorro de Maíta	5	6
Clarence town cave	1	2
Collores	1	5
Diale 1	1	1
El Cabo	2	14
Escape	1	2
Heywoods	2	3
Juan Dolio	0	0
Kelbey's Ridge 2	1	2
La Caleta	1	1
La Mina	1	6
Lavoutte	2	2
Maisabel	1	3
Malmok	2	8
Mamora Bay	0	0
Manigat Cave	1	5
Manzanilla	0	0
Punta Candelero	11	17
Punta Macao	4	7
Santa Cruz	1	2
Savaneta	0	0
Savanne Suazey	0	0
St. Croix (unkn. site)	1	1
St. Kitts (unkn. site)	1	2
Tocorón	1	4
Tutu	0	0

Table 6.40 The frequency of hypercementosis per site.

the sexes of individuals from difference periods of occupation at any of the sites. Of the affected teeth, most belong to the posterior dentition (68.13%). No association was found between non-alimentary use of the teeth and hypercementosis. The mean degree of wear of teeth with hypercementosis ($\overline{X} = 3.38$) is very slightly lower than the mean degree of wear for teeth without hypercementosis ($\overline{X} = 3.47$).

Figure 6.92 Punta Candalero 1 (C3), hypercementosis.

6.4.6 Juvenile pathology

Caries

For the overall juvenile population (n= 69), the caries rate is relatively high, with 4.81% (n= 46) of teeth affected, and 28.99% (n= 20) of individuals affected. Nonetheless, as is generally the case in juveniles, the tooth count and individual count proportions are smaller than in the overall adult population (see section 6.4.1). Table 6.41 shows the juvenile caries rates (tooth count and individual count) per site. At most sites juveniles do not have carious lesions, however the numbers of juvenile individuals are very small. The sites with at least four juveniles tend to show carious lesions, excepting Punta Macao, where the four juveniles present are very young. The percentage of juvenile caries at Anse à la Gourde is extremely high. For the greater part this is due to individual 377, who has an exceptionally high number of caries. However, this seems to be a unique case of rampant caries (discussed in detail below). At Tutu, the caries rate is relatively high; here the caries prevalence is not driven up by a single anomalous individual. Juveniles at Chorro de Maíta also have a high caries rate, but this is most likely related to the older ages of these

Site	**N individuals**	**Prevalence % T.C.**	**Prevalence % I.C.**
Anse à la Gourde	8	22.78/3.80*	37.50
Chorro de Maíta	18	6.09	50.00
Collores	1	0.00	0.00
Diale 1	2	0.00	0.00
Escape	1	0.00	0.00
Esperanza	1	0.00	0.00
Kelbey's Ridge 2	3	0.00	0.00
Lavoutte	3	0.00	0.00
Maisabel	6	1.11	16.67
Manzanilla	4	2.86	50.00
Punta Candelero	6	2.47	33.33
Punta Macao	4	0.00	0.00
Santa Cruz	2	0.00	0.00
Santa Elena	1	0.00	0.00
Savaneta	2	0.00	0.00
Savanne Suazey	1	0.00	0.00
Spring Bay 1C	1	0.00	0.00
Tutu	5	6.49	60.00
Total	69	4.81	28.99

Table 6.41 Juvenile caries frequency (tooth count and individual count) by site. * Respectively with and without individual 377. T.C.= tooth count method, I.C.= individual count method.

juveniles.

Caries Location

As in adults, caries location was recorded as smooth surface, cement-enamel junction (CEJ), occlusal, or root surface, categories which are further subdivided into a total of nine locations on the tooth. For the entire sample of juveniles, occlusal caries are most prevalent (65%). The majority of the remaining caries are located on the smooth surfaces (22.50%). Only 12.50% are located at the CEJ. With the exception of individual 377 from the site of Anse à la Gourde, discussed below, all juveniles affected by caries were over three years of age (3–11 years).

Rampant caries

One juvenile from the site of Anse à la Gourde (377) was found to have an exceptionally high number of carious teeth. This child, estimated at 2–3 years of age, counted 15 carious teeth in a total of 17 observed elements. This appears to be a case of what is known in modern clinical dentistry as Early Childhood Caries (ECC) or rampant caries. ECC is a virulent form of dental caries, which is most likely caused by an infection of Streptococcus mutans. The disease can rapidly destroy the entire deciduous dentition, usually starting with smooth-surface caries on the maxillary incisors, and progressing with smooth surface and occlusal caries of the deciduous premolars and the remaining dentition (Berkowitz 2003; Hallet and O'Rourke 2003).

Dental calculus

A total of 17 juveniles (24.64%) were found to be affected by dental calculus. The mean degree of calculus in these individual is 1.23; overall the calculus deposits are slight, except in Manzanilla individual 291 (discussed in section 6.4.3 for his/her unusual calculus deposits). No individuals under the ages of 2–4 years were found

Site	Affected juveniles (n)
Chorro de Maíta	3
Collores	1
Kelbey's Ridge 2	1
Lavoutte	1
Maisabel	2
Manzanilla	4
Punta Candelero	4
Punta Macao	1

Table 6.42 Juveniles affected by calculus per site.

to have calculus accumulation (Table 6.42).

Periapical abscesses
One abscess was observed in a juvenile (4–5 years) individual (102) from Chorro de Maíta, at the location of element 7.5.

AMTL
Three (4.35%) of the juveniles in the entire sample had lost at least one tooth ante mortem. All three belong to the assemblage of Chorro de Maíta, of which two are close to adolescence. The high rate of juvenile AMTL at Chorro de Maíta (1.79%) is remarkable, and could be associated with the high caries rate in juveniles at the site (Table 6.43).

Chorro de Maíta	Age	Element(s)
41	12–13	4.3
80	14–16	3.6, 4.6
84	3–5	6.1, 6.2

Table 6.43 Juvenile AMTL.

Hypercementosis
No teeth with evidence of hypercementosis were observed in any of the 69 juvenile individuals in the sample.

6.5 Dental defects

6.5.1 Enamel hypoplasia

Enamel hypoplasia in various forms were observed moderately frequently in the entire assemblage (Table 6.44). However, this dental defect was only scored when numerous elements belonging to one individual are affected by the disorder (in the case of pit type hypoplasia), and when at least one tooth crown is affected around the entire or most of the circumference (in the case of linear enamel hypoplasia). Relatively few individuals in the entire sample presented with such patterns of hypoplasia 8.52% (n= 39). In total, 2.10% of teeth are affected by hypoplasia. A total of 7.43% of females is affected (n= 11), and a total of 9.80% of males (n= 15). The majority of observed hypoplasia are linear (75.74%), with a small proportion of pit type hypoplasia (24.26%). Linear enamel hypoplasia (LEH) are more frequently associated with a period of physiological stress, whereas pit type hypoplasia may reflect local-

Figure 6.93 Punta Candelero 4 (B3), linear enamel hypoplasia of the upper left second molar.

ized trauma (Goodman and Rose 1991). Depending on the location of the enamel defect in the dentition and on the tooth crown(s), the age at which the defect occurred can be estimated. The dental elements most frequently affected by LEH are the upper canines. This is followed by the incisors (both central and lateral). A large number of premolar and molars (including third molars) are also affected by LEH. This indicates bouts of physiological stress leading to growth arrest in tooth crown formation were not isolated to the younger years of childhood. The upper canine crowns are generally formed between the ages of six months and six years. The initial bud formation of the third molars starts around nine to ten years of age, with the crowns generally fully formed by the age of fourteen (Langsjoen 1998). Those individuals who are affected by LEH of the second or third molars (Chorro de Maíta 22; Maisabel 14, 18, and 19A; Mamora Bay 1; Punta Candelero 4 (B3), and 32; St. Kitts 511) also show hypoplastic defects of most other elements in the dentition, indicating a long history of physiological stress.


Figure 6.94 Maisabel 14, linear enamel hypoplasia (two separate bands) of the lower right central incisor.

Site	Tooth count %	N	Individual count %	N
Anse à la Gourde	1.08	11	10.14	7
Canashito	0.00	0	0.00	0
Chorro de Maíta	1.83	22	8.22	6
Diale 1	0.00	0	0.00	0
Escape	0.00	0	0.00	0
Juan Dolio	0.00	0	0.00	0
Kelbey's Ridge 2	4.21	4	16.67	1
Maisabel	11.02	54	28.13	9
Malmok	0.00	0	0.00	0
Mamora Bay	1.33	1	25.00	1
Manzanilla	8.49	23	22.22	4
Lavoutte	0.44	2	3.33	1
Punta Candelero	1.76	14	9.09	5
Punta Macao	0.00	0	0.00	0
Point de Caille	0.00	0	0.00	0
Santa Cruz	0.00	0	0.00	0
Savaneta	0.00	0	0.00	0
Savanne Suazey	0.00	0	0.00	0
Tocorón	5.88	2	16.67	1
Tutu	11.00	23	19.23	5

Table 6.44 The frequency of enamel hypoplasia per site.

Chronological comparisons

Maisabel – No significant difference was observed in the prevalence of hypoplasia between the Early group (14.20%) and the Late group (11.69%) (χ^2(1, N= 400)= 1.67, p= 0.20). On examination of the individual count, there appears to be an increase in the numbers of affected individuals in the Late period (n= 6) as opposed to the Early period (n= 2), however this difference is not statistically significant (χ^2(1, N= 26)= 1.42, p= 0.40).

Punta Candelero – Chronological comparisons could not be made for Punta Candelero, since only one individual with enamel hypoplasia could securely be assigned to a period of occupation.

Tutu – No significant difference was observed in the number of teeth affected by enamel hypoplasia between the early phase (1.57%) and the late phase (3.13%) (χ^2(1, N= 319)= 0.75, p= 0.49). No differences were found in the number of affected individuals in the early phase (n= 1) as opposed to the late phase (n= 2) (χ^2(1, N= 21)= 0.13, p= 1.00).

Sex-based comparisons

Of the total sample, 7.19% of males (n= 11) and 10.81% of females (n= 16) are affected by hypoplasia. The slight difference in prevalence is not statistically significant, as demonstrated by a chi-square test (χ^2(1, N= 301)= 1.21, p= 0.32). With regards to the frequency of affected teeth (tooth count) in males (2.55%) and females (2.38%), no statistically significant difference was found (χ^2(1, N= 4752)= 0.13, p= 0.78). Numbers at the individual sites are too small for sex-based comparisons.

Juvenile enamel hypoplasia

A total of seven juveniles (10.14%) of the total juvenile sample were found to be affected by enamel hypoplasia. This includes 3 juveniles from Chorro de Maíta, one from Kelbey's Ridge 2, one from Maisabel, and two from Manzanilla. In all cases, the hypoplasia affect the incisors and premolars of the permanent dentition. No molars or deciduous teeth are affected. Both linear (47.62%) and pit (52.38%) hypoplasia were observed.

6.5.2 Discolouration and Opacities

A total of 36 individuals were found to have at least one tooth (but often more) affected by some form of discolouration (Table 6.45). No difference between the number of males and females affected was observed. A large proportion of those affected (40%) is juvenile.

Most individuals have red-brown or orange-brown staining on the buccal surfaces of almost all teeth or just the anterior teeth (n= 21). Occlusal, interproximal or lingual

Figure 6.95 Maisabel 27, symmetrical red-brown staining of the labial surfaces of the deciduous upper central incisors.

surfaces are generally not affected by this type of discolouration. There is some evidence that the staining occurred ante or peri mortem, as the stained area on the crown surface appears to follow the contours of where the gingiva would have been (i.e., it does not reach the cement-enamel junction or the root surface), how

Site	**Individual**	**Sex / age**	**Discolouration**
Anse à la Gourde	219	Child	Staining
Anse à la Gourde	238B	Female	Staining
Anse à la Gourde	349A	Male	Fluorosis
Anse à la Gourde	1126A	Female	Fluorosis
Chorro de Maíta	7A	Child	Staining
Chorro de Maíta	10	Child	Staining
Chorro de Maíta	16A	Male	Staining
Collores	162	Child	Staining
Diale 1	157	Male	Fluorosis
Escape	2	Female	Fluorosis
Escape	23A	Unknown	Residue
Kelbey's Ridge 2	132	Female	Residue
Kelbey's Ridge 2	166	Child	Residue
Kelbey's Ridge 2	313	Child	Staining
Lavoutte	B2	Male	Residue
Lavoutte	57-03	Child	Fluorosis
Lavoutte	67-05	Female	Staining
Lavoutte	67-12	Female	Staining
Lavoutte	67-18	Indet.	Residue
Lavoutte	67-19	Indet.	Residue
Lavoutte	68-11	Female	Fluorosis
Maisabel	1	Indet.	Staining
Maisabel	3	Child	Staining
Maisabel	9	Male	Staining
Maisabel	11	Male	Staining
Maisabel	15	Male	Fluorosis
Maisabel	19A	Female	Staining
Maisabel	24	Child	Staining
Maisabel	27	Child	Staining
Monserrate	163	Male	Staining
Punta Candelero	1 (N5)	Child	Staining
Punta Macao	6.2	Child	Staining
Spring Bay 1c	1	Child	Staining
Santa Cruz	1	Unknown	Residue
Santa Elena	2	Child	Staining
St. Kitts	511	Unknown	Fluorosis

Table 6.45 Discolouration per site and type.

ever it is not clear whether the staining was caused by intrinsic or extrinsic factors (Figure 6.95). A further 8 individuals showed signs of dental fluorosis, in the form of white and/or grey opaqueness of the enamel and white, grey, or yellow-brown mottling (Figure 6.96).

The discolouration in the final 7 individuals was caused by a layer of black or brown-black residue on the teeth (Figure 6.97). The residue resembles a tar or bitumen-like substance, and is generally deposited on only a small number of adjacent teeth. Conclusive identification of the black substance awaits further analysis.

Figure 6.96 Maisabel 9, grey-brown mottling of the occlusal surface of the upper left second molar; most likely dental fluorosis.

6.6 Chronological comparisons

The broad chronological comparisons between the Early Ceramic Age and the Late Ceramic Age are based on categorization of individual site assemblages and periods of occupation at individual sites as discussed in Chapter 5 (section 5.4). The Early Ceramic Age group comprises 79 adult individuals (female= 23, male= 21); the Late Ceramic Age group consists of 258 adults (female= 113, male= 114). The adult age distributions for the two groups are somewhat different (Appendix B). The adult age categories in the Early Ceramic Age are almost equally represented, however in the Late Ceramic Age young adults and young middle adults are slightly more common than old middle adults and mature adults.

Figure 6.97 Lavoutte 67-19, black residue on the buccal surface of the upper right third premolar; not to be confused with adhering soil (light brown).

The chronological comparisons between the Early Ceramic Age and the Late Ceramic Age in the Lesser and Southern Antilles are also based on the categorization discussed in Chapter 5 (section 5.4). The Early Ceramic Age group comprises 40 adult individuals (female= 8, male= 10); the Late Ceramic Age group consists of 147 adults (female= 57, male= 48). The adult age distributions for the two groups are similar (Appendix B).

6.6.1 Early Ceramic Age versus Late Ceramic Age

Dental wear

Rate of wear

A total of 148 adjacent first and second mandibular molars (n= 296) was selected to assess potential differences in the rate of occlusal surface wear between the Early Ceramic Age group and the Late Ceramic Age group using principle axis analysis.

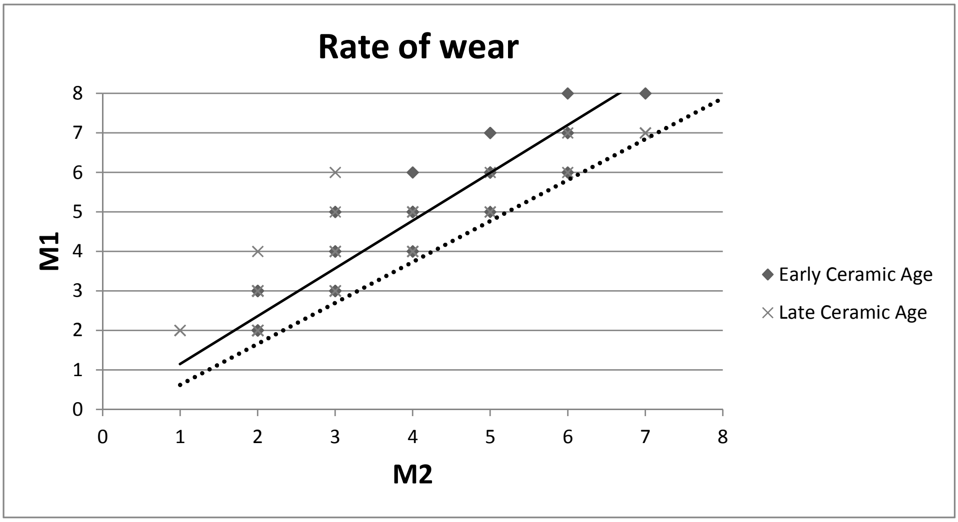


Figure 6.98 Scatterplot of M1–M2 wear scores by period, shown with principle axes. Note differences in slope steepness.

The equations of principal axes were calculated for adjacent first and second left mandibular molars. To compare wear rates, the principle axis equation was determined by plotting the wear score of M1 on the Y1 (X) axis, and M2 on the Y2 (Y) axis (Sokal and Rohlf 1981:594–601). A steep principle axis slope (b) indicates a rapid rate of wear, whereas a gentle principle axis slope indicates a slow rate of wear. Since this method avoids the effects of age on the degree of dental wear, significant differences between the rate of wear (the principle axis slopes) of different sites can be taken to indicate differences in food consistency or food preparation techniques. Rapid rates of wear are usually associated with tough, abrasive diets (often hunter-gatherer or hunter-fisher diets). Slower rates of wear are more often associated with refined, less abrasive diets (processed agricultural produce) (Smith 1982, 1984; Larsen 1997; Lukacs 1996; Sciulli 1997; Kieser et al. 2001; Fujita and Ogura 2009).

Period	b	Principle Axis Equation	CL (95%)
Early Ceramic Age	1.210	0.063 + 1.210Y	0.936 < b < 1.586
Late Ceramic Age	1.037	0.418 + 1.037Y	0.753 < b < 1.434

Table 6.46 Principle axis slope (b), equation, and 95% confidence limits: Early and Late Ceramic Age.

Principle axis analysis was performed using those adults in the Early and Late Ceramic Age groups with observed adjacent first and second left mandibular molars. The slopes, equation and confidence limits of the principle axis analyses can be found in Table 6.46. As can be seen in this table, the gradients of the slopes of the two periods differ, reflecting differences in the rate of wear at each site. This suggests that food consistency and/or food preparation techniques differed per period. In the Early Ceramic Age, the rate of wear (slope (b)= 1.210) was more rapid than in the Late Ceramic Age (slope (b)= 1.037).

As discussed by Scott (1979a), who compared the results of both the Scott (1979b) and Molnar (1971) dental wear scoring methods when used in principle axis analysis, the use of the 8 category Molnar method may lead to (greater) overlap in the confidence limits for the different groups in the comparison (see also Chapter 4 section 4.2.2). The results in Table 6.46 show that the slopes (b) for the Early and Late Ceramic Age groups do indeed fall within the confidence limits for both groups. However, both the slopes (b) and confidence limits for the Early Ceramic Age group are higher than those for the Late Ceramic Age group. As such, principle axis analysis using the Molnar (1971) dental wear scoring system has revealed differences in rate of wear in the two groups; these differences are visualized in Figure 6.98. This figure shows the principle axis slopes for both groups, together with the plotted wear scores of adjacent first and second molars (M2 on the x-axis, and corresponding M1 on the y-axis), and thus visually displays the differences in rate of wear in both periods. Note in particular the differences in slope steepness, which indicate variation in rate of wear.

These results suggest that food consistency and food preparation techniques in the Early Ceramic Age were more abrasive to the dentition than those of the Late Ceramic Age.

Direction of wear

In both groups, the most frequently observed direction of molar wear – with the exception of the natural form – is horizontal. In the Early Ceramic Age group 78.53% is worn horizontally. In the Late Ceramic Age groups 57.99% is worn horizontally. The proportion of obliquely worn molars is greater in the Late Ceramic Age group (37.90%) than the Early Ceramic Age group (19.77%).

Occlusal surface shape

In both groups, the most frequently observed occlusal surface shape – with the exception of the natural form – is flat, followed by cupped. In the Early Ceramic Age group flat wear is very slightly more prevalent than in the Late Ceramic Age group (57.99% and 52.63%, respectively). In the Late Ceramic Age group cupped wear is very slightly more prevalent than in the Early Ceramic Age group (33.54% and 38.60%, respectively).

Dental chipping

The frequency of dental chipping (tooth count) is lower in the Early Ceramic Age group (9.55%, n= 114) than in the Late Ceramic Age group (17.94%, n= 634). The difference is statistically significant as demonstrated by a chi-square test (χ^2(1, N= 4728)= 47.20, p= 0.00). The frequency of individuals affected by dental chipping (individual count) is similar for both groups: 60.76% in the Early Ceramic Age group (n= 48) and 58.91% in the Late Ceramic Age group (n= 152). A chi-square test confirms there is no significant difference (χ^2(1, N= 337)= 0.09, p= 0.80).

In both groups, chipping is most frequently found in the occlusal interproximal surfaces followed by the occlusal buccal surface. No differences were apparent between the groups with regards to the frequency of maxillary or mandibular chipping.

In the Early Ceramic Age group, the posterior dentition (38.62%) is more frequently affected by chipping than the anterior dentition (15.81%). This difference is statistically significant (χ^2(1, N= 1168)= 66.70, p= 0.00). In the Late Ceramic Age group, the posterior dentition (41.42%) is also significantly more frequently affected by chipping than the anterior dentition (25.58%) (χ^2(1, N= 3449)= 93.23, p= 0.00), although the difference between the anterior and posterior teeth is smaller.

A comparison of the overall frequencies of both anterior and posterior chipping of the Early Ceramic Age group and the Late Ceramic Age groups, shows a significant difference between the two, with the latter group far more frequently affected and with a greater proportion of anterior chipping than the early group (χ^2(2, N= 4617)= 155.59, p= 0.00).

LSAMAT

The proportion of individuals affected by LSAMAT in both groups is almost equal. Of the Early Ceramic Age group 49.37% of the individuals (n= 39) is affected by LSAMAT. Of the Late Ceramic Age group 49.22% (n= 127) is affected by LSAMAT. A chi-square test confirms that there is no statistically significant difference between the caries rates in the Early and Late Ceramic Ages (χ^2(1, N= 337)= 0.00, p= 1.00).

All individuals found to have Type 1 LSAMAT belong to the Late Ceramic Age group. Type 2 LSAMAT was observed in both groups.

Non-alimentary tooth use: teeth as tools

Of the individuals showing non-alimentary dental wear who could be assigned to one of the two groups (n= 57), 19.30% belong to the Early Ceramic Age group (n= 11), and 80.70% belong to the Late Ceramic Age group (n= 46). This difference appears large, however, of the total number of individuals in the Early Ceramic Age group, only 13.92% displayed non-alimentary dental wear. Of the total number of individuals in the Late Ceramic Age group, 17.83% showed non-alimentary wear. While the proportion of individuals affected by non-alimentary dental wear is still slightly larger in the Late Ceramic Age, a chi-square test revealed no significant difference in proportion of individuals affected by non-alimentary dental wear between the two periods (χ^2(1, N= 337)= 0.66, p= 0.50).

Dental Pathology

Caries

In the Early Ceramic Age group, 78 carious lesions were recorded in the adult population, amounting to 6.53% of the total number of observed permanent teeth (n= 1,194). Of all adults, 34 individuals with at least one carious lesion were observed, amounting to 43.04% of the entire adult population (n= 79). Males (7.13%) in the Early Ceramic Age groups are less frequently affected by caries than females (9.23%), however, the difference is not statistically significant (χ^2(1, N=800)= 1.19, p= 0.30).

In the Late Ceramic Age group, 524 carious lesions were recorded in the adult population, amounting to 14.83% of the total number of observed permanent teeth (n= 3,534). Of all adults, 183 individuals with at least one carious lesion were observed, amounting to 70.93% of the entire adult population (n= 258). Males (13.03%) in the Late Ceramic Age groups are less frequently affected by caries than females (13.64%), however, the difference is very slight and is not statistically significant (χ^2(1, N=3,302)= 0.26, p= 0.61).

One aim of this study is to assess differences in caries rates between the two main Ceramic Age periods, to investigate potential differences in foodways. A preliminary investigation of caries rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences between the two. The rate of caries based on the tooth count method in the Late Ceramic Age appears to be distinctly higher than that of the Early Ceramic Age. The statistical significance of this difference was tested using a chi-square test. This test determined a significant difference between the Early and Late Ceramic Age (χ^2(1, N=4,728)= 55.26, p= 0.00). The frequency of individuals affected

ECA		**MALE**		**FEMALE**		**TOTAL**	
Age	Tooth category	N	% Carious	N	% Carious	N	% Carious
18–25	Incisors & Canines	36	0.00	30	0.00	66	0.00
	Premolars	62	4.84 (3)	20	15.00 (3)	82	7.32
	Molars	38	5.13 (2)	22	13.64 (3)	60	8.33
26–35	Incisors & Canines	59	5.08 (3)	13	0.00	72	4.17
	Premolars	46	0.00	25	0.04 (1)	71	1.41
	Molars	57	5.26 (3)	33	6.06 (2)	90	5.56
36–45	Incisors & Canines	41	2.44 (1)	40	2.50 (1)	81	2.47
	Premolars	33	15.15 (5)	27	14.81 (4)	60	15.00
	Molars	22	22.73 (5)	28	7.14 (2)	50	14.00
46+	Incisors & Canines	21	0.00	47	2.13 (1)	68	1.47
	Premolars	12	16.67 (2)	29	13.79 (4)	41	14.63
	Molars	19	36.84 (7)	32	28.13 (9)	51	31.37

Table 6.47 Early Ceramic Age caries rates by sex/age, and tooth category. Numbers of observed caries are given between brackets.

by caries also differs significantly, with the Late Ceramic Age group far more frequently affected than the Early Ceramic Age group ($\chi^2(1, N=337)= 20.52, p= 0.00$). The preliminary assessments above indicate possible differences in foodways between the two periods. However, as discussed in Chapter 4 (section 4.2.3), when comparing caries rates between groups, the effects of age, differential preservation of individual dental elements, and differential susceptibility of individual dental elements to carious lesions must be taken into account (Hillson 2001, 2008b; Wasterlain et al. 2009). The differences demonstrated above using the simple tooth count and individual count methods could (at least in part) result from differing age profiles and differentially preserved/affected dental elements. These potential sources of variation must be controlled for in order to assess foodways based on caries prevalence. Table 6.47 and Table 6.49 present the caries rates by age group (18–25, 26–35, 36–45, and 46+), by sex, and by tooth category (incisors and canines, premolars, and molars), for the Early Ceramic Age and the Late Ceramic Age, respectively.

As can be seen in Table 6.47, in males, the frequency of caries clearly increases with age, particularly in the molars and premolars. In females, the increase in caries rates with age is also clear, although the young middle adult (26–35 years) group shows slightly lower rates than the young adult (18–25 years). This may be related to the much higher rate of AMTL in females in this age group (Table 6.51) (Wasterlain et al. 2009).

The fact that the frequency of carious lesions is associated with age is similarly reflected in Table 6.48, which shows an increase in caries frequency per age category. This table combines all teeth for males and females. Interestingly, the frequency of caries drops slightly in the age group 26–35 years, but this is most likely the result of the small number of individuals in the sample and the fact that one female individual (Burial 4, Tutu) in age group 18–25 years has a relatively large number of carious lesions (4 cavities), thus inflating the frequency for this age group.

Caries rate %	**18–25**	**26–35**	**36–45**	**46+**
Male	3.06	3.70	11.46	17.31
Female	8.33	3.70	7.37	12.96
Total	5.29	3.70	9.42	14.38

Table 6.48 Early Ceramic Age caries rates by sex/age.

Overall, in both males and females, the molars are more frequently affected by caries than the premolars and incisors and canines. Premolars also tend to be more frequently affected than incisors and canines, although this is less apparent for the younger middle adult age group (26–35 years). These differences reflect differential susceptibility of the different tooth classes to carious lesions (Hillson 1996, 2001; Wasterlain et al. 2009).

In the youngest age group (18–25 years), females have higher caries rates than males for premolars and molars. In the young middle age group (26–35 years), females show very slightly higher rate for molars and premolars than males, but not for incisors and canines. In the middle adult age group (36–45 years), males have higher caries frequency rates in premolars and molars than females, while the rates for incisors and canines are similar. In the old adult age group (46+ years) males again show very slightly higher rates than females for premolars and molars, but not for incisors and canines. In this oldest age group females have distinctly higher AMTL rates (Table 6.51), which may be related to the lower caries rates observed in this group. Although using the tooth count method a slight (non-significant) differences was observed between male and female caries rates in the Early Ceramic Age, the assessment of caries rates by age and tooth class reveals no clear differences between the sexes.

LCA		MALE		FEMALE		TOTAL	
Age	**Tooth category**	**N**	**% Carious**	**N**	**% Carious**	**N**	**% Carious**
18–25	Incisors & Canines	115	2.61 (3)	200	1.00 (2)	315	1.59
	Premolars	85	4.71 (4)	143	6.99 (10)	228	6.14
	Molars	110	22.73 (25)	213	17.84 (38)	323	19.50
26–35	Incisors & Canines	291	0.34 (1)	177	9.04 (16)	468	3.63
	Premolars	192	15.10 (29)	102	31.37 (32)	294	20.75
	Molars	235	20.85 (49)	90	25.56 (23)	325	22.15
36–45	Incisors & Canines	114	2.63 (3)	91	13.19 (12)	205	7.32
	Premolars	83	13.25 (11)	55	23.64 (13)	138	17.39
	Molars	79	18.99 (15)	48	21.08 (5)	127	15.75
46+	Incisors & Canines	126	3.17 (4)	104	11.54 (12)	230	6.96
	Premolars	76	14.47 (11)	66	16.67 (11)	142	15.49
	Molars	72	23.61 (17)	43	32.56 (14)	115	26.96

Table 6.49 Late Ceramic Age caries rates by sex/age, and tooth category. Numbers of observed caries are given between brackets.

Table 6.49 displays caries rates of the Late Ceramic Age group by sex and age group and tooth class. As can be seen in this table, the frequency of caries increases with age, particularly in the premolars. In both sexes, the increase in caries rates with age is most clear in the young and young middle adult age groups (18–25 and 26–35 years). In the oldest two age groups, the increase in caries is less prominent, and in some tooth classes a slight decrease is seen in comparison to the 26–35 years group. The latter could be related to increasing AMTL rates in these age groups (Table 6.52), which in part would have been caused by caries (Wasterlain et al. 2009).

The fact that the frequency of carious lesions is associated with age is similarly reflected in Table 6.50, which shows an increase in caries frequency per age category.

Caries rate %	18–25	26–35	36–45	46+
Male	10.32	11.00	10.51	11.68
Female	8.99	19.24	15.46	17.37
Total	9.47	13.80	12.55	14.17

Table 6.50 Late Ceramic Age caries rates by sex/age.

This table combines all teeth for males and females. Interestingly, the frequency of caries drops slightly in the age group 36–45 years, but this could be related to the rising AMTL rates with age (Table 6.52).

In general, in both males and females, the molars are more frequently affected by caries than the premolars and incisors and canines, although with age the frequencies of carious premolars increase and (in females) sometimes outweigh the molar frequencies. The latter is likely correlated with the increase in AMTL in molars in the older age categories (Table 6.49). Premolars are also more frequently affected than incisors and canines. These differences again reflect differential susceptibility of the different tooth classes to carious lesions (Hillson 1996, 2001; Wasterlain et al. 2009).

In the youngest age group (18–25 years), males have higher caries rates than females for incisors and canines and molars. In the oldest three age groups, females show very clearly higher caries rates than males in all tooth classes. Females also show distinctly higher AMTL rates overall. Despite the fact that using the tooth count method no differences were observed between males and females, the assessment of caries rates by age and tooth class, while taking into account the relation between caries and AMTL, indicates that foodways differed between males and females in the Late Ceramic Age.

Comparison of caries rates between the Early and Late Ceramic Age groups based on the data presented in Tables 6.47 and 6.49 reveals distinct differences. In general, caries rates in the Late Ceramic Age group are much higher for all age groups and tooth classes. The Late Ceramic Age group shows distinctly higher caries rates in incisors and canines and premolars, for all age groups. For example, in the youngest age group (18–25 years), no caries were observed in incisors and canines of the Early Ceramic Age group, although low caries rates were observed for this age category of the Late Ceramic Age. High rates of caries in incisors and canines are commonly associated with populations consuming very large proportions of cariogenic foods, consisting of soft, sticky carbohydrates. In populations with low carbohydrate intake, the first molars are affected most by caries, and in populations with slightly higher carbohydrate intake caries are seen more frequently on the second and third molars. With increasing caries rates, the premolars are also affected (Hillson 2001, 2008b). The distinctly higher rates of caries, in particular in the incisors and canines and premolars, of the Late Ceramic Age group, suggest that foodways differed between the two periods. A far greater proportion of cariogenic foods, possibly combined with more refined processing techniques, would have been consumed in the later period.

AMTL

In the Early Ceramic Age group, 108 ante mortem lost teeth were recorded in the adult population, amounting to 7.68% of the total number of observed tooth positions (n= 1,406). Of all adults, 24 individuals with at least ante mortem lost tooth were observed, amounting to 30.38% of the entire adult population (n= 79). Males (7.41%) in the Early Ceramic Age groups are statistically significantly less frequently affected by AMTL than females (12.91%) (χ^2(1, N=943)= 7.87, p= 0.01).
In the Late Ceramic Age group, 616 ante mortem lost teeth were recorded in the adult population, amounting to 12.84% of the total number of observed tooth positions (n= 4,798). Of all adults, 121 individuals with at least one ante mortem lost tooth were observed, amounting to 46.90% of the entire adult population (n= 258). Males (12.76%) in the Late Ceramic Age groups are less frequently affected by AMTL than females (14.76%), however, the difference is just shy of statistical significance (χ^2(1, N=4,394)= 3.70, p= 0.06).
One aim of this study is to assess differences in AMTL rates between the two main Ceramic Age periods. A preliminary investigation of AMTL rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences. The rate of AMTL based on the tooth count method in the Late Ceramic Age appears to be distinctly higher than that of the Early Ceramic Age. The statistical significance of this difference was tested using a chi-square test. This test determined a significant difference between the Early and Late Ceramic Age (χ^2(1, N=6,204)= 28.06, p= 0.00). The frequency of individuals affected by AMTL also differs significantly, with the Late Ceramic Age group far more frequently affected than the Early Ceramic Age group (χ^2(1, N=337)= 6.73, p= 0.01).

ECA		MALE		FEMALE		TOTAL	
Age	**Tooth category**	**N**	**% AMTL**	**N**	**% AMTL**	**N**	**% AMTL**
18–25	Incisors & Canines	46	2.17 (1)	31	0.00 (0)	77	1.30 (1)
	Premolars	22	0.00 (0)	19	0.00 (0)	31	0.00 (0)
	Molars	44	13.64 (6)	28	0.00 (0)	72	8.33 (6)
26–35	Incisors & Canines	64	0.00 (0)	30	23.33 (7)	94	7.45 (7)
	Premolars	49	0.00 (0)	30	13.33 (4)	79	5.06 (4)
	Molars	62	1.61 (1)	41	14.63 (6)	103	6.80 (7)
36–45	Incisors & Canines	45	2.22 (1)	42	0.00 (0)	97	1.03 (1)
	Premolars	35	2.86 (1)	28	3.57 (1)	63	3.17 (2)
	Molars	37	40.54 (15)	38	13.16 (5)	75	26.67 (20)
46+	Incisors & Canines	28	3.57 (1)	55	12.73 (7)	83	9.64 (8)
	Premolars	17	17.65 (3)	38	21.05 (8)	55	20.00 (11)
	Molars	27	25.93 (7)	53	39.62 (21)	80	35.00 (28)

Table 6.51 Early Ceramic Age AMTL rates by sex/age, and tooth category. Numbers of observed ante mortem lost teeth are given between brackets.

As can be seen in Table 6.51, the frequency of AMTL is generally higher in the older age categories, showing its relation with age. In females, the increase in caries rates with age is also clear, although the young middle adult (26–35 years) group shows somewhat higher rates than the young adults and old middle adults (18–25 and 36–45 years).

A significant difference between AMTL rate in males and females was found in the Early Ceramic Age group using the tooth count method. Examination of the data presented in Table 6.51 indicates that overall, females in all age groups (excepting the youngest) tend to have higher AMTL rates. The difference is particularly apparent in the oldest age group.

The rate of AMTL is clearly associated with age, as much higher rates are seen in the older age categories than the younger age groups (Table 6.52). Although the difference in AMTL rates between males and females in the Late Ceramic Age based on the tooth count method was found to be just shy of statistical significance, examination of the data presented in Table 6.52 indicates that overall, females in all age groups tend to have higher AMTL rates.

LCA		**MALE**		**FEMALE**		**TOTAL**	
Age	**Tooth category**	**N**	**% AMTL**	**N**	**% AMTL**	**N**	**% AMTL**
18–25	Incisors & Canines	112	0.00 (0)	232	0.00 (0)	344	0.00 (0)
	Premolars	94	0.00 (0)	166	1.20 (2)	260	0.77 (2)
	Molars	135	4.44 (6)	240	5.00 (12)	375	4.80 (18)
26–35	Incisors & Canines	341	0.29 (1)	207	3.86 (8)	548	1.64 (9)
	Premolars	218	6.88 (15)	131	12.98 (17)	349	9.17 (32)
	Molars	302	16.89 (51)	172	38.95 (67)	474	24.89 (118)
36–45	Incisors & Canines	139	4.32 (6)	98	0.00 (0)	237	2.53 (6)
	Premolars	101	10.89 (11)	64	9.38 (6)	165	10.30 (17)
	Molars	127	30.71 (39)	81	34.57 (38)	208	37.02 (77)
46+	Incisors & Canines	176	14.20 (25)	154	16.23 (25)	330	15.15 (50)
	Premolars	115	18.26 (21)	100	25.00 (25)	215	21.40 (46)
	Molars	157	50.32 (79)	130	60.00 (78)	287	54.70 (157)

Table 6.52 Late Ceramic Age AMTL rates by sex/age, and tooth category. Numbers of observed ante mortem lost teeth are given between brackets.

Comparison of AMTL rates between the Early and Late Ceramic Age groups based on the data presented in Tables 6.51 and 6.52 reveals distinct differences. In general, AMTL rates in the Late Ceramic Age group are much higher for all age groups and tooth classes.

The rate of AMTL is clearly associated with age, as much higher rates are seen in the older age categories than the younger age groups (Table 6.52). Although the difference in AMTL rates between males and females in the Late Ceramic Age based on the tooth count method was found to be just shy of statistical significance, examination of the data presented in Table 6.52 indicates that overall, fe-

males in all age groups tend to have higher AMTL rates.

Comparison of AMTL rates between the Early and Late Ceramic Age groups based on the data presented in Tables 6.51 and 6.52 reveals distinct differences. In general, AMTL rates in the Late Ceramic Age group are much higher for all age groups and tooth classes.

Other

Other forms of dental pathology were also assessed for potential differences between the Early and Late Ceramic Age. A chi-square test demonstrates that there is a statistically significant difference in the prevalence of calculus between the Early and Late Ceramic Ages (Table 6.53); the prevalence is higher in the Late Ceramic Age. The Late Ceramic Age group has a slightly lower prevalence of periapical abscesses, however the difference is not significant. Likewise, the Late Ceramic Age group shows a lower hypercementosis prevalence, which is also not statistically significant.

Pathology T.C. %	Abscess	N	Calculus	N	Hypercementosis	N
ECA	0.75 (9)	1206	29.82 (356)	1206	2.40 (29)	1206
LCA	0.43 (16)	3748	36.71 (1376)	3748	1.79 (67)	3748
Chi-square	χ^2(1, N=4728)= 1.54, p= 0.25		χ^2(1, N=4728)= 31.98, p= 0.00		χ^2(1, N=4728)= 1.27, p= 0.29	

Table 6.53 The frequency of pathology (tooth count) in the Early Ceramic Age and Late Ceramic Age groups.

The frequency of individuals affected by periapical abscesses and calculus is near enough the same for both groups. The proportion of individuals affected by hypercementosis is slightly smaller in the Late Ceramic Age group, however the difference between the two groups is not significant (Table 6.54).

Pathology I.C. %	Abscess	N	Calculus	N	Hypercementosis	N
ECA	6.33 (5)	79	65.82 (52)	79	15.19 (12)	79
LCA	7.75 (20)	258	68.22 (176)	258	12.02 (31)	258
Chi-square	χ^2(1, N=337)= 0.18, p= 0.81		χ^2(1, N=337)= 0.16, p= 0.68		χ^2(1, N=337)= 0.36, p= 0.56	

Table 6.54 The frequency of pathology (individual count) in the Early Ceramic Age and Late Ceramic Age groups.

Dental Defects

Enamel hypoplasia

The prevalence of linear enamel hypoplasia (tooth count) in the Early Ceramic

Age group is 0.75% (n= 9). In the Late Ceramic Age groups the prevalence is 2.21% (n= 78). A chi-square test shows the difference is statistically significant ($\chi^2(1, N= 4728)= 10.44, p= 0.00$). The proportion of individuals affected by linear enamel hypoplasia in the Early Ceramic Age group is 3.80% (n= 3). The proportion of individuals affected by linear enamel hypoplasia in the Late Ceramic Age group is 9.69% (n= 25). Despite the apparent large difference, a chi-square test did not reveal statistical significance ($\chi^2(1, N= 337)= 2.76, p= 0.11$).

Discolouration and Opacities

Discolouration of all kinds is slightly more frequent in the Late Ceramic Age group (5.04%, n= 13) than the Early Ceramic Age group (3.80%, n= 3). The difference is not significant ($\chi^2(1, N= 337)= 0.21, p= 0.77$).

6.6.2 Lesser and Southern Antilles: Early Ceramic Age versus Late Ceramic Age

Dental wear

Rate of wear

A total of 68 adjacent first and second mandibular molars (n= 136) was selected to assess potential differences in the rate of occlusal surface wear between the Early Ceramic Age group and the Late Ceramic Age group using principle axis analysis. The equations of principal axes were calculated for adjacent first and second left mandibular molars. To compare wear rates, the principle axis equation was determined by plotting the wear score of M1 on the Y1 (X) axis, and M2 on the Y2 (Y) axis (Sokal and Rohlf 1981:594–601). A steep principle axis slope (b) indicates a rapid rate of wear, whereas a gentle principle axis slope indicates a slow rate of wear. Since this method avoids the effects of age on the degree of dental wear, significant differences between the rate of wear (the principle axis slopes) of different sites can be taken to indicate differences in food consistency or food preparation techniques. Rapid rates of wear are usually associated with tough, abrasive diets (often hunter-gatherer or hunter-fisher diets). Slower rates of wear are more often associated with refined, less abrasive diets (processed agricultural produce) (Smith 1982, 1984; Larsen 1997; Lukacs 1996; Sciulli 1997; Kieser et al. 2001; Fujita and Ogura 2009).

Principle axis analysis was performed using those adults in the Early and Late

Period	b	Principle Axis Equation	CL (95%)
Early Ceramic Age	1.219	0.023 + 1.219Y	0.967 < b < 1.552
Late Ceramic Age	0.955	0.669 + 0.955Y	0.654 < b < 1.385

Table 6.55 Principle axis slope (b), equation, and 95% confidence limits: Early and Late Ceramic Age (Lesser and Southern Antilles).

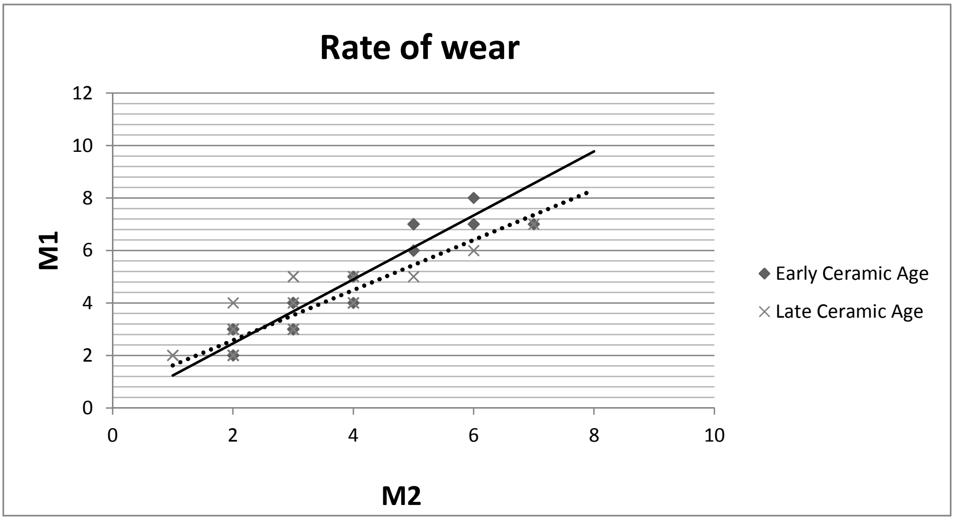


Figure 6.99 Scatterplot of M1–M2 wear scores by period, shown with principle axes. Note differences in slope steepness.

Ceramic Age groups with observed adjacent first and second left mandibular molars. The slopes, equation and confidence limits of the principle axis analyses can be found in Table 6.55. As can be seen in this table, the gradients of the slopes of the two periods differ, reflecting differences in the rate of wear at each site. This suggests that food consistency and/or food preparation techniques differed per period. In the Early Ceramic Age, the rate of wear (slope (b)= 1.219) was more rapid than in the Late Ceramic Age (slope (b)= 0.955).

As discussed by Scott (1979a), who compared the results of both the Scott (1979b) and Molnar (1971) dental wear scoring methods when used in principle axis analysis, the use of the 8 category Molnar method may lead to (greater) overlap in the confidence limits for the different groups in the comparison (see also Chapter 4 section 4.2.2). The results in Table 6.55 show that the slopes (b) for the Early and Late Ceramic Age groups do indeed fall within the confidence limits for both groups. However, both the slopes (b) and confidence limits for the Early Ceramic Age group are higher than those for the Late Ceramic Age group. As such, principle axis analysis using the Molnar (1971) dental wear scoring system has revealed differences in rate of wear in the two groups; these differences are visualized in Figure 6.99. This figure shows the principle axis slopes for both groups, together with the plotted wear scores of adjacent first and second molars (M2 on the x-axis, and corresponding M1 on the y-axis), and thus visually displays the differences in rate of wear in both periods. Note in particular the differences in slope steepness, which indicate variation in rate of wear.

These results suggest that food consistency and food preparation techniques in the Early Ceramic Age were more abrasive to the dentition than those of the Late Ceramic Age.

Direction of wear

In the Early Ceramic Age the most frequently observed direction of wear is horizontal (79.81%), followed by oblique (20.19%). In the Late Ceramic Age the most frequently observed direction of wear is oblique (56.96%), followed by horizontal (43.04%).

Occlusal surface shape

In the Early Ceramic Age the most frequently observed occlusal surface shape is flat (59.62%), followed by cupped (36.54%). In the Late Ceramic Age the most frequently observed direction of wear is cupped (48.81%), followed by flat (41.66%).

Dental chipping

The frequency of dental chipping (tooth count) is twice as great in the Late Ceramic Age (18.59%, n= 339) than the Early Ceramic Age (9.27%, n= 56). The difference is statistically significant, as demonstrated by a chi-square test (χ^2(1, N= 2428)= 28.90, p= 0.00). The frequency of individuals affected by dental chipping (individual count) is higher in the Late Ceramic (61.22%, n= 90) than in the Early Ceramic Age (47.50%, n= 19). A chi-square test shows this difference is not statistically significant (χ^2(1, N= 187)= 2.44, p= 0.15).

In both groups, chipping is most frequently found in the occlusal buccal and lingual surfaces, followed by the interproximal surfaces. No differences were apparent between the groups with regards to the frequency of maxillary or mandibular chipping.

In the Early Ceramic Age group, the posterior dentition (24.60%) is more frequently affected by chipping than the anterior dentition (4.31%). This difference is statistically significant (χ^2(1, N= 587)= 38.62, p= 0.00). In the Late Ceramic Age group, the posterior dentition (41.24%) is also significantly more frequently affected by chipping than the anterior dentition (32.43%) (χ^2(1, N= 1707)= 14.05, p= 0.00), although the difference between the anterior and posterior teeth is smaller.

A comparison of the overall frequencies of both anterior and posterior chipping of the Early Ceramic Age group and the Late Ceramic Age group, shows a significant difference between the two, with the late group far more frequently affected and with a greater proportion of anterior chipping than the early group (χ^2(2, N= 2294)= 101.56, p= 0.00).

LSAMAT

The proportion of individuals affected by LSAMAT in both groups differs little. In the Early Ceramic Age 37.50% of the individuals (n= 15) is affected by LSAMAT. In the Late Ceramic Age 40.14% (n= 59) is affected by LSAMAT. A chi-square test demonstrates that there is no statistically significant difference between the caries rates in the Early and Late Ceramic Ages (χ^2(1, N= 187)= 0.09, p= 0.86).

All individuals found to have Type 1 LSAMAT belong to the Late Ceramic Age group. Type 2 LSAMAT was observed in both groups.

Non-alimentary tooth use: teeth as tools

Of the individuals showing non-alimentary dental wear from sites in the Lesser Antilles and southern Caribbean Islands (n= 24), 20.83% belong to the Early Ceramic Age group (n= 5), and 79.17% belong to the Late Ceramic Age group (n= 19). This difference appears large, however, of the total number of individuals in the Early Ceramic Age group, only 12.50% displayed non-alimentary dental wear. Of the total number of individuals in the Late Ceramic Age group, 12.92% showed non-alimentary wear. While the proportion of individuals affected by non-alimentary dental wear is still slightly larger in the Late Ceramic Age, the difference is clearly very small. A chi-square confirms that there is no significant difference in the proportion of individuals affected by non-alimentary dental wear between the two periods (χ^2(1, N= 187)= 0.01, p= 1.00).

Dental Pathology

Caries

In the Early Ceramic Age group, 22 carious lesions were recorded in the adult population, amounting to 3.64% of the total number of observed permanent teeth (n= 605). Of all adults, 12 individuals with at least one carious lesion were observed, amounting to 30.00% of the entire adult population (n= 40). Males (6.98%) in the Early Ceramic Age groups are more frequently affected by caries than females (2.46%), however, the difference is not statistically significant (χ^2(1, N=294)= 3.01, p= 0.11).

In the Late Ceramic Age group, 292 carious lesions were recorded in the adult population, amounting to 14.83% of the total number of observed permanent teeth (n= 1,824). Of all adults, 90 individuals with at least one carious lesion were observed, amounting to 61.22% of the entire adult population (n= 147). Males (14.53%) in the Late Ceramic Age groups are less frequently affected by caries than females (16.39%), however, the difference is not statistically significant (χ^2(1, N=1,592)= 1.20, p= 0.30).

A preliminary investigation of caries rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences between the Early and Late Ceramic Age groups. The rate of caries based on the tooth count method in the Late Ceramic Age appears to be distinctly higher than that of the Early Ceramic Age. The statistical significance of this difference was tested using a chi-square test. This test determined a significant difference between the Early and Late Ceramic Age (χ^2(1, N= 2,428)= 61.63, p= 0.00). The frequency of individuals affected by caries also differs significantly, with the Late Ceramic Age group far more frequently affected than the Early Ceramic Age group (χ^2(1, N= 187)= 12.37, p= 0.00).

The preliminary assessments above indicate possible differences in foodways between the two periods. However, these differences could (at least in part) result from differing age profiles and differentially preserved/affected dental elements.

Table 6.56 and Table 6.58 present the caries rates by age group, by sex, and by tooth, for the Early Ceramic Age and the Late Ceramic Age in the Lesser and Southern Antilles.

In general, in both males and females, the molars are more frequently affected by caries than the premolars and incisors and canines. This reflects known differences in the susceptibility of the different tooth classes to caries (Hillson 1996, 2001; Wasterlain et al. 2009).

ECA		MALE		FEMALE		TOTAL	
Age	**Tooth category**	**N**	**% Carious**	**N**	**% Carious**	**N**	**% Carious**
18–25	Incisors & Canines	20	0.00 (0)	8	0.00 (0)	28	0.00 (0)
	Premolars	11	9.09 (1)	5	0.00 (0)	16	6.25 (1)
	Molars	17	11.76 (2)	9	11.11 (1)	26	11.54 (3)
26–35	Incisors & Canines	13	15.38 (2)	20	0.00 (0)	33	6.06 (2)
	Premolars	12	0.00 (0)	17	0.00 (0)	29	0.00 (0)
	Molars	21	9.52 (2)	24	0.00 (0)	45	4.44 (2)
36–45	Incisors & Canines	25	0.00 (0)	10	10.00 (1)	35	2.86 (1)
	Premolars	15	6.67 (1)	6	0.00 (0)	21	4.76 (1)
	Molars	12	0.00 (0)	7	0.00 (0)	19	0.00 (0)
46+	Incisors & Canines	7	0.00 (0)	2	0.00 (0)	9	0.00 (0)
	Premolars	2	100.00 (2)	2	0.00 (0)	4	50.00 (2)
	Molars	5	40.00 (2)	8	12.50 (1)	13	23.08 (3)

Table 6.56 Early Ceramic Age caries rates by sex/age, and tooth category (Lesser and Southern Antilles). Numbers of observed caries are given between brackets.

Although the oldest age category has the highest caries rates in both males and females (Table 6.56), there is no clear relation between caries and age; the young middle and old middle adults have lower rates than the young and old adults. The dip in caries rates in the middle two age groups can also be seen in Table 6.57. This table combines all teeth for males and females. In part this dip may be related to the large proportion of ante mortem lost molars in the 36–45 years category (Table 6.60).

Caries rate %	**18–25**	**26–35**	**36–45**	**46+**
Male	6.25	8.70	1.92	28.57
Female	4.55	0.00	4.35	8.33
Total	5.71	3.74	2.67	19.23

Table 6.57 Early Ceramic Age caries rates by sex/age (Lesser and Southern Antilles).

In females, the rate of caries is relatively low overall, and lesions are restricted to molars only. Males also show caries in the incisors and canines, and premolars. This difference could indicate that males consumed larger amounts of cariogenic foods, since higher rates of caries in incisors and canines and premolars are commonly associated with populations consuming larger proportions of cariogenic foods, consisting of soft, sticky carbohydrates. In populations with low carbohydrate intake, the first molars are affected most by caries, and in populations with slightly higher carbohydrate intake caries are seen more frequently on the second and third molars (Hillson 2001, 2008b; Wasterlain et al. 2009).

Table 6.58 displays caries rates of the Late Ceramic Age group by sex and age group and tooth class. High rates of caries are already seen in the youngest age group. In females, caries rates for all tooth classes clearly increase, with very high rates in all teeth in the 26–35 age group. A dip in female rates is seen for all tooth classes in the 36–45 age group, followed by an increase in molar rates only in the oldest age group. In males, there is a trend for decreasing caries rates with age. In particular, premolar and molar rates dip in the 36–45 age group. In the oldest age group a slight increase is seen in the rate of molar caries, but incisors and canines and premolars show lower rates than the old middle adult age group. These trends in male and female caries rates in relation to age are also apparent in Table 6.59, which combines all teeth for males and females.

LCA		**MALE**		**FEMALE**		**TOTAL**	
Age	**Tooth Category**	**N**	**% Carious**	**N**	**% Carious**	**N**	**% Carious**
18–25	**Incisors & Canines**	41	2.44 (1)	103	0.97 (1)	144	1.39 (2)
	Premolars	26	23.08 (6)	64	7.81 (5)	90	12.22 (11)
	Molars	39	33.33 (13)	119	19.33 (23)	158	22.78 (36)
26–35	**Incisors & Canines**	149	0.67 (1)	118	8.47 (10)	267	4.12 (11)
	Premolars	89	22.47 (20)	61	36.07 (22)	150	28.00 (42)
	Molars	106	26.42 (28)	57	31.59 (18)	163	28.22 (46)
36–45	**Incisors & Canines**	51	1.96 (1)	50	18.00 (9)	101	9.90 (10)
	Premolars	37	8.11 (3)	25	36.00 (9)	62	19.35 (12)
	Molars	39	12.82 (5)	18	16.67 (3)	57	14.04 (8)
46+	**Incisors & Canines**	55	0.00 (0)	51	7.84 (4)	106	3.77 (4)
	Premolars	23	4.35 (1)	25	12.00 (3)	48	8.33 (4)
	Molars	37	18.92 (7)	26	34.62 (9)	63	25.40 (16)

Table 6.58 Late Ceramic Age caries rates by sex/age, and tooth category (Lesser and Southern Antilles). Numbers of observed caries are given between brackets.

Caries rate	**18–25**	**26–35**	**36–45**	**46+**
Male	18.87	14.24	7.09	6.96
Female	10.14	21.19	22.58	15.69
Total	12.50	17.07	13.64	11.06

Table 6.59 Late Ceramic Age caries rates by sex/age (Lesser and Southern Antilles).

In general, in both males and females, the molars are more frequently affected by caries than the premolars and incisors and canines, although with age the frequencies of carious premolars increase and (in females) sometimes outweigh the molar frequencies. The latter is likely correlated with the increase in AMTL in molars in the older age categories (Table 6.61). Premolars are also more frequently affected than incisors and canines. These differences again reflect differential susceptibility of the different tooth classes to carious lesions (Hillson 1996, 2001; Wasterlain et al. 2009).

In the youngest age group (18–25 years), males have higher caries rates than females in all tooth classes. In the oldest three age groups, females show clearly higher caries rates than males in all tooth classes. Females also show distinctly higher AMTL rates overall. Despite the fact that using the tooth count method no significant difference in caries rate was observed between males and females, the assessment of caries rates by age and tooth class, indicates that foodways likely differed between males and females in the Late Ceramic Age in the Lesser and Southern Antilles.

Comparison of caries rates between the Early and Late Ceramic Age groups based on the data presented in Tables 6.56 and 6.58 reveals distinct differences. In general, caries rates in the Late Ceramic Age group are much higher for all age groups and tooth classes. The Late Ceramic Age group shows distinctly higher caries rates in incisors and canines and premolars, for both males and females and all age groups. High rates of caries in incisors and canines are generally associated with the consumption of large proportions of cariogenic foods, consisting of soft, sticky carbohydrates. In populations with low carbohydrate intake, the first molars are affected most by caries, and in populations with slightly higher carbohydrate intake caries are seen more frequently on the second and third molars. With increasing caries rates, the premolars are also affected (Hillson 2001, 2008b). The distinctly higher rates of caries overall, and in particular in the incisors and canines and premolars, of the Late Ceramic Age group, suggest that foodways differed between the two periods. A far greater proportion of cariogenic foods, possibly combined with more refined processing techniques, would have been consumed in the later period.

AMTL

In the Early Ceramic Age group, 27 ante mortem lost teeth were recorded in the adult population, amounting to 4.17% of the total number of observed tooth positions (n= 647). Of all adults, 8 individuals with at least ante mortem lost tooth were observed, amounting to 20.00% of the entire adult population (n= 40). Males (9.47%) in the Early Ceramic Age groups are statistically significantly more frequently affected by AMTL than females (3.13%) (χ^2(1, N=318)= 4.79, p= 0.04).

In the Late Ceramic Age group, 249 ante mortem lost teeth were recorded in the adult population, amounting to 11.62% of the total number of observed tooth positions (n= 2,143). Of all adults, 50 individuals with at least one ante mortem lost tooth were observed, amounting to 34.01% of the entire adult population (n= 147). Males (10.37%) in the Late Ceramic Age groups are significantly less frequently affected by AMTL than females (14.33%) (χ^2(1, N=1.930)= 6.89, p= 0.01).

ECA		MALE		FEMALE		TOTAL	
Age	**Tooth category**	**N**	**% AMTL**	**N**	**% AMTL**	**N**	**% AMTL**
18–25	**Incisors & Canines**	22	4.55 (1)	8	0.00 (0)	30	3.33 (1)
	Premolars	13	0.00 (0)	6	0.00 (0)	19	0.00 (0)
	Molars	23	26.09 (6)	9	0.00 (0)	32	18.75 (6)
26–35	**Incisors & Canines**	13	0.00 (0)	20	0.00 (0)	33	0.00 (0)
	Premolars	11	0.00 (0)	14	0.00 (0)	25	0.00 (0)
	Molars	21	0.00 (0)	26	0.00 (0)	47	0.00 (0)
36–45	**Incisors & Canines**	25	0.00 (0)	10	0.00 (0)	35	0.00 (0)
	Premolars	18	0.00 (0)	7	0.00 (0)	25	0.00 (0)
	Molars	20	40.00 (8)	11	36.36 (4)	31	38.71 (12)
46+	**Incisors & Canines**	7	0.00 (0)	2	0.00 (0)	9	0.00 (0)
	Premolars	3	33.33 (1)	2	0.00 (0)	5	20.00 (1)
	Molars	7	28.57 (2)	8	0.00 (0)	15	13.33 (2)

Table 6.60 Early Ceramic Age AMTL rates by sex/age, and tooth category (Lesser and Southern Antilles). Numbers of observed ante mortem lost teeth are given between brackets.

A preliminary investigation of AMTL rates based on simple tooth count and individual count methods was performed, in order to gain an insight into the potential differences. The rate of AMTL based on the tooth count method in the Late Ceramic Age appears to be distinctly higher than that of the Early Ceramic Age. The statistical significance of this difference was tested using a chi-square test. This test determined a significant difference between the Early and Late Ceramic Age (χ^2(1, N=2.790)= 30.91, p= 0.00). The frequency of individuals affected by AMTL does not differ significantly, although the Late Ceramic Age group is more frequently affected than the Early Ceramic Age group (χ^2(1, N=187)= 2.89, p= 0.12).

LCA		MALE		FEMALE		TOTAL	
Age	**Tooth category**	**N**	**% AMTL**	**N**	**% AMTL**	**N**	**% AMTL**
18–25	**Incisors & Canines**	41	0.00 (0)	105	0.00 (0)	149	0.00 (0)
	Premolars	27	0.00 (0)	67	2.99 (2)	94	2.13 (2)
	Molars	42	4.76 (2)	123	2.44 (3)	167	2.99 (5)
26–35	**Incisors & Canines**	156	0.64 (1)	125	1.60 (2)	281	1.07 (3)
	Premolars	83	6.02 (5)	62	9.68 (6)	145	7.59 (11)
	Molars	130	15.38 (20)	97	39.18 (38)	227	25.55 (58)
36–45	**Incisors & Canines**	61	0.00 (0)	52	0.00 (0)	113	0.00 (0)
	Premolars	37	2.70 (1)	28	14.29 (4)	65	7.69 (5)
	Molars	58	24.14 (14)	29	31.03 (9)	87	28.74 (25)

LCA		**MALE**		**FEMALE**		**TOTAL**	
Age	**Tooth category**	**N**	**% AMTL**	**N**	**% AMTL**	**N**	**% AMTL**
46+	**Incisors & Canines**	66	9.09 (6)	61	9.84 (6)	127	9.45 (12)
	Premolars	27	18.52 (5)	29	17.24 (5)	56	17.86 (10)
	Molars	55	30.91 (17)	56	50.00 (28)	111	40.54 (45)

Table 6.61 Late Ceramic Age AMTL rates by sex/age, and tooth category (Lesser and Southern Antilles). Numbers of observed ante mortem lost teeth are given between brackets.

Although there is not a very clear trend of increasing AMTL rates with age, the rates observed in the older age groups are generally higher than in the younger age groups (Table 6.60). Overall, males are more frequently affected than females. Female AMTL is restricted to the molars in the 36–45 years age group. In males, incisors and canines are affected the 18–25 years age group, and premolars are affected in the 46+ years age group. These data appear to support the statistically significant difference found using a simple tooth count method, where males have higher AMTL rates than females.

The rate of AMTL is clearly associated with age, as much higher rates are seen in the older age categories than the younger age groups (Table 6.61). Examination of the data presented in Table 6.61 confirms the significant difference between males and females found using the tooth count method, with females in all age groups showing higher AMTL rates.

Based on the data presented in Tables 6.60 and 6.61, there are distinct differences between the Early and Late Ceramic Age groups. In general, AMTL rates in the Late Ceramic Age group are much higher for all age groups and tooth classes.

Other

A chi-square test shows that there is a statistically significant difference in calculus prevalence between the Early and Late Ceramic Age in the Lesser and Southern Antilles (Table 6.62). The Late Ceramic Age group has a slightly lower prevalence of periapical abscesses, however the difference is not significant. Likewise, the Late Ceramic Age group shows a lower hypercementosis prevalence, which is again not statistically significant. Comparisons based on the individual count method found no significant differences. The percentage of indi-

Pathology T.C. %	Abscess	N	Calculus	N	Hypercementosis	N
ECA	0.50 (3)	605	22.64 (137)	605	1.65 (10)	605
LCA	0.33 (6)	1824	41.61 (759)	1824	0.93 (17)	1824
Chi-square	χ^2(1, N= 2428)= 0.35, p= 0.70		χ^2(1, N= 2428)= 69.83, p= 0.00		χ^2(1, N= 2428)= 2.16, p= 0.18	

Table 6.62 The frequency of pathology (tooth count) in the Lesser and Southern Antilles: Early Ceramic Age versus Late Ceramic Age.

viduals affected by periapical abscesses is slightly lower in the Late Ceramic Age group (Table 6.63).

Pathology I.C. %	Abscess	N	Calculus	N	Hypercementosis	N
ECA	7.50 (3)	40	62.50 (25)	40	7.50 (3)	40
LCA	4.08 (6)	147	60.54 (89)	147	8.16 (12)	147
Chi-square	χ^2(1, N= 187)= 0.80, p= 0.41		χ^2(1, N= 187)= 0.05, p= 0.86		χ^2(1, N=187)= 0.02, p= 1.00	

Table 6.63 The frequency of pathology (individual count) in the Lesser and Southern Antilles: Early Ceramic Age versus Late Ceramic Age.

Dental Defects

Enamel hypoplasia

None of the Early Ceramic Age individuals have linear enamel hypoplasia. In the Late Ceramic Age the prevalence (tooth count) is 1.37% (n= 25). A chi-square test shows the difference is statistically significant (χ^2(1, N= 2428)= 8.36, p= 0.00). The proportion of individuals affected by linear enamel hypoplasia in the Late Ceramic Age group is 7.48% (n= 11). Despite the apparent large difference, a chi-square test did not reveal statistical significance (χ^2(1, N= 187)= 3.18, p= 0.12).

Discolouration and Opacities

Discolouration of all kinds is slightly more frequent in the Late Ceramic Age individuals (7.48%, n= 11) than the Early Ceramic Age individuals (5.00%, n= 2). The difference is not significant (χ^2(1, N= 187)= 0.30, p= 0.74).

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 Candelero, 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 Candelero, and Tutu, which show lower rates of wear, show a slightly smaller spatial distribution, and overlap considerably in time. Lavoutte, Maisabel, and Punta Candelero 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 Candelero 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 Newsom 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
Canímar Abajo	"high"		4000–1000 B.C.E.	
Solapa de Sílex	"high"		2987 ±37 B.P.	Crespo and Jiménez 2004; Martínez-López et al. 2011
Cienfuegos	0.86 (adult)		2360–1785 B.P.	Rodríguez Montoro 2010
Preacher's Cave, Eleuthera	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 Leguminoseae (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 ±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 ±1.80‰ (s.d. 2), and a mean bone collagen $\delta^{15}N$ value of 12.10 ±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 ±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 Tocorón, Venezuela (Atiles 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

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[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; Lieverse 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 accumulation. 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-

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[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 C_4/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 Candelero, 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 ass 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 Cruxent 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 Candelero, 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 Candelero 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 $\delta^{13}C$ 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 that 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 causational 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 causational 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 [Lopéz 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 Valdés1851:266 [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 considerable 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 predetermined 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 Candelero 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 Candelero 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 individual are all females, and originate from the sites of Anse à la Gourde, Punta Candelero, 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; Tavarez 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 interpretation 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 from 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 causational 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 an 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 cementoenamel 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.

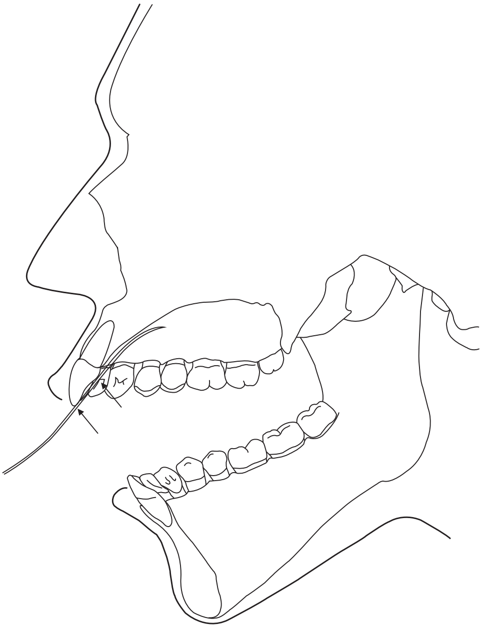

Figure 7.2 The pressure points for dragging a fibrous plant material across the lingual surface of the upper front teeth needed to create forms of LSAMAT described in section 7.5. To create a large exposed dentine patch around the cingulum, the highest amount of pressure would need to be exerted at this 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 dejimos 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-Mèndez 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 ethnohistorical 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 C_4 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 Blos 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, 1 σ [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 sugars) 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.

CHAPTER 8 TEETH TELL TALES

8.1 INTRODUCTION

This study focussed on traces of daily lifeways left on the human dentition, i.e., patterns of dental wear and pathology, and temporal and spatial variation therein in the pre-Columbian Caribbean archipelago. The central question guiding this research was aimed at investigating how evidence from human dentitions contributes to knowledge of the lifeways and cultural practices of the pre-Columbian Amerindians of the insular Caribbean. In answering this central research question, the study was divided into three key aspects of lifeways and cultural practices: foodways, health and disease, and certain (gender-related) craft activities. As stated at the outset this study was designed to integrate information from dental wear and pathology into current knowledge from studies of palaeodiet, palaeopathology, and craft production in the region. The multi-disciplinary approach, which combines archaeological, bioarchaeological, ethnohistoric, and ethnographic data, as well as evidence from clinical dentistry has enabled a more sophisticated understanding of the dental anthropological data produced in this study. Below, the conclusions of this research are presented following the three main sub-questions (sections 8.2, 8.3, and 8.4) and the main research question (section 8.6) that were outlined in Chapter 1. Section 8.5 deals with the unique case of Intentional Dental Modification at the site of Chorro de Maíta (Cuba), and illustrates how dental anthropological data can be used in the reconstruction of individual life histories. Future directions of research are discussed in section 8.7.

8.2 FOODWAYS

As a key aspect of lifeways and cultural practices, foodways formed an important feature of this study. The investigation concentrated on what dental wear and pathology reveal about foodways in the pre-Columbian Caribbean region. The focus was laid on temporal and spatial patterns in wear and pathology, and how these may be related to sociocultural, sociopolitical, and environmental developments in the region.

One of the most notable outcomes of this investigation into foodways is the degree of variation observed between the different sites. While this study shows that the great majority of those sites would have comprised communities with mixed-economy subsistence practices, who relied heavily on agricultural/horticultural produce, nonetheless it is clear from the results that foodways in each community varied according to the local environment and sociocultural identity. Throughout the region, foodways changed over time. These broad scale changes mirror broad scale developments, such as climate change, population growth, and/or increasing social complexity.

8.2.1 Community foodways

Although most sites show a (very) large agricultural/horticultural component in the diet, particularly in the Late Ceramic Age (A.D. 600/800–1500), based on the differences found here between the sites it seems that the communities at each individual settlement adapted to their own particular surroundings and needs. This supports earlier findings which indicate the distinctive adaptability of each community to their particular surroundings (Newsom and Wing 2004). Undoubtedly, this would have for a large part been affected by the local environment and ecology. In the Caribbean this could potentially be related particularly to the proximity to marine resources, which can heavily influence dental wear and pathology. However, with the exception of Escape (St. Vincent) and perhaps Canashito (Aruba), none of the sites in this study show evidence of a predominantly marine or terrestrial protein oriented diet. At all other sites foodways are characterized by a mixed food economy, with substantial amounts of refined staple plant foods. The greatest differences observed between the sites in this study regard the proportion of consumed starchy and sugary carbohydrates. For the region as a whole, the agricultural/horticultural portion of the diet can be considered significant even at sites that are clearly ideally situated to exploit marine resources. At some sites, this heavy focus on the agricultural/horticultural component of the diet is surprising considering previous carbon and nitrogen stable isotope studies, the site setting, and the amount and diversity of (marine) faunal remains recovered. For example, at Anse à la Gourde (Guadeloupe), the location of the site, isotopic studies, and marine fauna remains indicate that the inhabitants likely consumed a heavily protein oriented diet. Yet the results from this study indicate that Anse à la Gourde must have been one of the most agriculturally/horticulturally oriented communities in the dataset, with its inhabitants consuming very large proportions of cariogenic plant foods, mostly processed starches.

8.2.2 Social differentiation and foodways

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. 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. Although the effects of biological differences (particularly regarding pathology) between men and women cannot be discounted, considering the differences in degree of wear and severity of other types of mastication damage to the teeth (posterior chipping), it is deemed more likely here that the dentitions truly reflect small differences in foodways. These differences may very well be related to daily task activities, such as staple food preparation by females, as well as different preferences for preparation of foods and more frequent food consumption by females. The limited differences observed between male and female foodways suggest that no major sex-based status differentiation was expressed through access to and consumption of food.

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 as explained above, no indications were found for the expression of status differentiation in daily (staple) food consumption throughout the Ceramic Age occupation of the region.

Children in the Ceramic Age Caribbean started eating solid foods from the age of 1–2 years onward. According to stable isotopic analyses children would have been weaned completely from breast milk around the age of 2.5–4 years. From this age onward, the effects of carbohydrate consumption (particularly starches and sugars) are apparent in juvenile dentitions, showing that at this age children were (regularly) fed cariogenic plant foods. As such, it appears that the transition from a breast milk dependant infant to a young child consuming solid foods would have been relatively gradual. Weaning diets are known to sometimes differ substantially from adult diets, often including more refined, boiled and sweet or sweetened foods, which may continue to comprise the juvenile diet for a number of years (Lewis 2007).

8.2.3 Changing foodways

Significant temporal differences in foodways in the pre-Columbian Caribbean were observed. At individual sites, temporal differences were either absent, or not great enough to significantly impact the dentitions. Only at the site of Tutu (St. Thomas) were significant differences apparent between the early and late occupation phases of the settlement. However, this site may have been abandoned for around 200 years between the two phases, suggesting that customary foodways may have been broken with for very specific sociocultural reasons. On a broader, regional scale there is a significant shift toward more refined (i.e., more heavily processed), agriculturally oriented foodways in the Late Ceramic Age. Since the dental anthropological data reflect both changes in food types and food preparation techniques, it is likely that an important factor in this significant change was the refinement of food preparation techniques over time. As broad scale carbon and nitrogen studies of larger populations pertaining to both main Ceramic phases of occupation of the region are yet to be done, currently no comparative data on proportions of carbohydrate and protein consumption are available. Nonetheless, since the shift toward refined, processed plant food consumption observed in the Late Ceramic Age group in this study is very substantial, it is unlikely to be the result of changing food preparation techniques alone, and as such reflects a true shift in diet composition in the region over time.

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 intensified agriculture traditionally associated with Late Ceramic Age chiefdom societies of the Greater Antilles, evidence from the dentitions of its inhabitants demonstrates that highly refined starchy and sugary plant foods comprised a major part of the diet.

The reasons for this shift in foodways are unclear. In the Greater Antilles intensified 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 sociopolitical 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 unpredictable 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/horticultural 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 significantly during this period.

8.3 Health and disease

The research focussed on what dental pathology reveals about oral and general health and disease patterns in the pre-Columbian Caribbean over time, and how this compares to other lines of evidence on past health in the region.

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 inflammation, and most adults would have suffered from inflammation of the gums and periodontal ligaments, ante mortem tooth loss, and sometimes from abscesses.

Women generally suffered higher rates of dental disease than men. Most observed differences between male and female dental health and disease are the result of slightly differing foodways between the sexes, as described above, although it cannot be ruled out that biological and hormonal differences between the sexes played a role (Lukacs and Largaespada 2006).

8.3.1 Community health and disease

The dental pathology observed at the various sites is for a large part the result of differing foodways. Nonetheless, the observed variation indicates that pre-Columbian communities in the Caribbean archipelago were affected differently by dental diseases and the associated problems with general health and physiology. The rate of dental defects associated with non-specific physiological or metabolic disorders also differs per community, probably indicating that physiological stress typically associated with population growth and increased density was more prevalent in some communities than others due to local (environmental) conditions. No patterns were observed in the spatial or temporal distribution of the degree of dental pathology and defects, i.e., the pathology load, again suggesting that individual local communities each adapted to their specific environment in their own way.

8.3.2 Changing health and disease

There were notable changes in oral health and disease patterns in the pre-Columbian Caribbean region over time in the Ceramic Age (400 B.C. – A.D. 1500). For a large part, these changes are associated with the changes in foodways described above. Deterioration of oral health conditions as a result of changing foodways would have impacted the general health and physiology and burdened the immune system, leading to pain, inflammation and restricted ability to masticate and consume food.

Dental defects such as linear enamel hypoplasia increased over time. Such dental defects have been documented globally in prehistoric societies and increases in their prevalence are associated with population growth and greater population density (Larsen 1995; Larsen and Walker 2010). The observed increase in dental defects in the Late Ceramic Age suggests physiological stress due to malnutrition, infectious disease, or other health issues (including weaning stress) was more common in this period. Worldwide, signs of growing physiological stress have been related to increasing population sizes, competition over resources, and crowding (Larsen 1997). This picture concurs with the results of previous studies in the Caribbean that found that the prevalence of infectious disease increased over time (Crespo Torres 2008; Rothschild et al. 2000; Sandford et al. 2002; Sandford et al. 2005).

As has often been demonstrated in other regions of the world, a greater reliance on agricultural/horticultural produce and increasingly refined foods, growing population size and density, and a greater prevalence of infectious disease, along with developmental defects and physiological stress, appear to coincide in the pre-Columbian Caribbean. This is not to say that population health decreased dramatically over time in the region: as yet there is no evidence for rapid or radical change, such as documented for other regions and periods where for example neolithization and urbanisation played a role.

8.4 CRAFT ACTIVITIES

This part of the research aimed to identify any indications for the use of the teeth as tools in the pre-Columbian Caribbean, and assess whether these could be linked to particular craft activities. Furthermore, key focal points were potential indications for age and/or gender-related divisions in these practices, and evaluating whether 'non-alimentary activities' could be elucidated using ethnographic and ethnohistoric information.

General non-alimentary use of the teeth was commonplace throughout the region and over time. Pre-Columbian Caribbean people would have used their teeth on a daily basis to perform a variety of tasks, such as clamping or holding materials in order to keep the hands free for other actions, or the cracking of nuts and shellfish. A substantial portion of the entire sample (13.10%)[10] shows evidence of more specific uses of the teeth, related to craft activities and manufacture of goods. 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.

8.4.1 Teeth as tools

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

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[10] Excluding the six individuals with Type 1 'non-alimentary wear', which could in fact be the result of dental erosion.

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.

8.4.2 Caribbean crafting

This study has identified a number of individuals who used their teeth in crafting activities, such as basketry and/or cordage manufacture, and the use of the bow drill, perhaps to fabricate stone or shell beads, and other ornaments. The crafted objects are lacking, however, as is other information on the production process, such as whether crafters were fulltime specialists or whether their craft 'specialization' was related to food production. Investigation of the mortuary treatment of the crafts(wo)men found no indications for status differentiation. For these reasons it was beyond the scope of this study to investigate the existence of a specialized craft production system controlled by a politically elite class.

Craft activities using the teeth probably consisted of highly personal, non-standardized crafting technology and techniques, which contrasts with the standardized production process and the passing on of techniques and skills usually associated with craft specialization. The crafts(wo)men identified in this study present a picture of 'idiosyncratic artisans', and while it is possible that there was an elite class of specialized crafts(wo)men in the pre-Columbian Caribbean, their craft activities do not appear to have involved the use of the teeth as tools. More 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.

The use of the teeth as tools, both for general and specific task activities increased over time in the region. This difference could indicate a more varied and active daily routine, involving a greater variety of task activities, perhaps associated with the growing communities of the Late Ceramic Age.

8.5 Dental anthropology and individual life histories

Using dental anthropological analyses, it is sometimes possible to reveal aspects of individual persons' lifeways, regarding their biology as well as their social identity and cultural practices. In the case of individual 72B from the site of Chorro de Maíta, Cuba, dental anthropological analysis has uncovered more than just information on her lifeways, but also potentially on grander sociocultural processes in the region at the time of the first colonial encounters with Europeans. 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 (Williams and White 2006). 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 (Valcárcel Rojas 2012). The mortuary evidence suggests that individual 72B was not alone in migrating to Cuba: those who buried her knew the mortuary customs of her area of origin, and treated her in the appropriate manner in death. This case demonstrates the value of a multi-disciplinary approach, in this case combining dental anthropological research, other osteoarchaeological work, and evidence from mortuary practices.

8.6 Lifeways and cultural practices in the pre-Columbian Caribbean

The main aim of this research was to investigate how evidence from human dentitions contributes to knowledge of the lifeways and cultural practices of the pre-Columbian Amerindians of the Caribbean archipelago.

Evidence from human dentitions has revealed hitherto unexplored aspects of lifeways and cultural practices in the pre-Columbian Caribbean. Individuals, 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. Nonetheless, the dental evidence indicates that most communities represented in this study consumed large amounts of cariogenic plant foods, with the exception of the individuals at the sites of Canashito (Aruba) and Escape (St. Vincent), showing that agricultural/horticultural practices formed an important aspect of daily lifeways for most Ceramic Age Caribbean Amerindians. Sex-based labour division, perhaps related to these 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.

The changes in foodways over time were paired with changes in oral and general health. For the greater part, these changes are related to the increase in the consumption of processed carbohydrates, but are likely also symptomatic of population growth and increasing population density. Although overall there is an increase in dental disease over time, differences were observed between the individual sites, again suggesting that local conditions and sociocultural choices influenced health. 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.

A range of task and craft activities were performed with the teeth. Pre-Columbian Caribbean Amerindians frequently used their teeth in general task activities (such as clamping objects), likely on a daily basis, showing that the mouth and dentition formed an integral part of embodied practice. Specific craft activities using the teeth were performed by a smaller portion of the population, and were associated more strongly with males than females. These craft activities included the fabrication of cordage, basketry, and perhaps the oral use of bow drills. No evidence for standardized production, often associated with craft specialization, was found. It seems that these craft activities involved highly personal, non-standardized crafting technology and techniques; the Amerindian crafts(wo)men could be characterized as 'idiosyncratic artisans', each adopting their own body techniques in the crafting process. The increase in the use of the teeth as tools over time could perhaps be related to the growing communities of the Late Ceramic Age, possibly involving a greater variety of task activities.

Finally, on an individual level dental anthropological analysis has uncovered information on the life history of a young female buried at the site of Chorro de Maíta (Cuba), which in turn has revealed grander sociocultural processes in the region at the time of the first colonial encounters with Europeans.

8.7 Future directions

The temporal changes in foodways throughout the Caribbean islands revealed through analysis of dental wear and pathology could be considered the most significant outcome of this study. Yet an important part of the pre-Columbian era in the insular Caribbean was not represented: the Lithic and Archaic Age. In part this is due to the general sparseness of recovered human skeletal material belonging to this period. Some preceramic skeletal material exists, however, and comparison of the dental wear and pathology with the results of this study will undoubtedly enrich our understanding of pre-Columbian Caribbean foodways, health and disease, and crafting. Similarly, the Early Ceramic Age period population of the Greater Antilles was sorely underrepresented in this study, due to the lack of available dental material. In the light of the great differences observed between the Early and Late Ceramic Age in the Lesser Antilles, Early Ceramic Age dental material from the Greater Antilles warrants equal attention.

Smaller scale intra-site temporal differences in foodways proved more difficult to trace. In part this is due to the relatively small sample sizes of human skeletal remains belonging to each occupation phase. At some sites, such as Manzanilla (Trinidad), and Anse à la Gourde (Guadeloupe) larger scale or complete radiocarbon dating of the human skeletal remains may produce sufficiently large samples per occupation period to allow comparisons to potentially track changes or continuity in foodways over time, inviting future work on this subject.

This study has demonstrated that dental anthropological data can reveal craft activities performed by individual humans in the pre-Columbian Caribbean. To further explore craft activities in this region the combined analysis of various occupational and activity markers on the skeletal frame, such as musculoskeletal stress markers (MSM) is needed. The bioarchaeological study of crafting sheds a unique light on these activities, since it centres on the crafts(wo)men, as opposed to the (finished) craft product.

This study has also shown the potential of studying juvenile dental wear in order to understand weaning practices in the past. More detailed investigation into juvenile patterns of dental wear can provide a more sophisticated understanding of the duration of weaning. Currently, due to the fact that 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, meaning that the age at which the weaning process starts can be hard to estimate. The combined use of juvenile dental wear studies and oxygen and carbon and nitrogen stable isotope analysis can contribute significantly to this issue. It is posited here that juvenile dental wear must be assessed in a similar fashion to adult dental wear: i.e., it must be graded per dental element for loss of crown height, direction of surface wear, and occlusal surface shape (see for example Clement and Freyne 2012).

Finally, without the multi-disciplinary approach used in this study, it would not have been possible to answer the main research questions posed in Chapter 1. Dental anthropological analyses alone could not have provided the necessary sociocultural context within which the results of this research ought to be interpreted. Future dental anthropological work in the region, therefore, must similarly be part of an integrated, multi-disciplinary research design – perhaps including lines of research not explored here – which dissolves disciplinary boundaries in order to understand the Caribbean past.

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APPENDIX A – SAMPLES

The complete table of the 458 individuals included in this study, listing sex, age, and relative or absolute dating where known.

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Anse à la Gourde	Guadeloupe	50A	Female	adult	LCA	
Anse à la Gourde	Guadeloupe	89	Female	18–25	LCA	
Anse à la Gourde	Guadeloupe	108A	Male	36–45	LCA	
Anse à la Gourde	Guadeloupe	137A	Indet.	adult	LCA	
Anse à la Gourde	Guadeloupe	139	Male	46+	LCA	
Anse à la Gourde	Guadeloupe	159	Female	18–25	LCA	
Anse à la Gourde	Guadeloupe	171A	Male	18–25	LCA	
Anse à la Gourde	Guadeloupe	195	Child	4–5	LCA	
Anse à la Gourde	Guadeloupe	196	Male	30+	LCA	
Anse à la Gourde	Guadeloupe	197	Male	18–25	LCA	
Anse à la Gourde	Guadeloupe	200	Female	adult	LCA	
Anse à la Gourde	Guadeloupe	202	Female	adult	LCA	
Anse à la Gourde	Guadeloupe	206A	Male	adult	LCA	
Anse à la Gourde	Guadeloupe	207	Female	36–45	LCA	
Anse à la Gourde	Guadeloupe	212	Female	adult	LCA	
Anse à la Gourde	Guadeloupe	219	Child	9–11	LCA	
Anse à la Gourde	Guadeloupe	238B	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	241	Indet.	adult	LCA	
Anse à la Gourde	Guadeloupe	253	Female	30+	LCA	
Anse à la Gourde	Guadeloupe	288	Male	26–35	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Anse à la Gourde	Guadeloupe	291	Child	4–9	LCA	
Anse à la Gourde	Guadeloupe	292	Male	36–45	LCA	
Anse à la Gourde	Guadeloupe	304	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	307	Male	46+	LCA	
Anse à la Gourde	Guadeloupe	311	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	332	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	335	Female	adult	LCA	
Anse à la Gourde	Guadeloupe	339	Male	adult	LCA	
Anse à la Gourde	Guadeloupe	342	Male	26–35	LCA	
Anse à la Gourde	Guadeloupe	348	Indet.	adult	LCA	
Anse à la Gourde	Guadeloupe	349A	Male	26–35	LCA	
Anse à la Gourde	Guadeloupe	349C	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	350	Female	36–45	LCA	
Anse à la Gourde	Guadeloupe	377	Child	2–3	LCA	
Anse à la Gourde	Guadeloupe	378	Female	18–25	LCA	
Anse à la Gourde	Guadeloupe	430	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	447	Female	18–25	LCA	
Anse à la Gourde	Guadeloupe	450A	Male	26–35	LCA	
Anse à la Gourde	Guadeloupe	451	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	452	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	454	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	529	Female	18–25	LCA	
Anse à la Gourde	Guadeloupe	706	Male	26–35	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Anse à la Gourde	Guadeloupe	726	Male	26–35	LCA	
Anse à la Gourde	Guadeloupe	953	Female	adult	LCA	
Anse à la Gourde	Guadeloupe	1126A	Female	adult	LCA	
Anse à la Gourde	Guadeloupe	1203	Male	26–35	LCA	
Anse à la Gourde	Guadeloupe	1207	Child	juvenile	LCA	
Anse à la Gourde	Guadeloupe	1226	Male	26–35	LCA	
Anse à la Gourde	Guadeloupe	1413	Child	3–4	LCA	
Anse à la Gourde	Guadeloupe	1496A	Male	18–25	LCA	
Anse à la Gourde	Guadeloupe	1651	Male	26–35	LCA	
Anse à la Gourde	Guadeloupe	1922	Child	0.5–1	LCA	
Anse à la Gourde	Guadeloupe	1944	Child	5–7	LCA	
Anse à la Gourde	Guadeloupe	1945	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	1947	Male	46+	LCA	
Anse à la Gourde	Guadeloupe	1948	Male	46+	LCA	
Anse à la Gourde	Guadeloupe	1958	Female	46+	LCA	
Anse à la Gourde	Guadeloupe	2005	Female	18–25	LCA	
Anse à la Gourde	Guadeloupe	2106	Male	30+	LCA	
Anse à la Gourde	Guadeloupe	2107	Female	13–15	LCA	
Anse à la Gourde	Guadeloupe	2109	Female	adult	LCA	
Anse à la Gourde	Guadeloupe	2140	Male	30+	LCA	
Anse à la Gourde	Guadeloupe	2212	Female	46+	LCA	
Anse à la Gourde	Guadeloupe	2213	Female	46+	LCA	
Anse à la Gourde	Guadeloupe	2214	Female	36–45	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Anse à la Gourde	Guadeloupe	2215	Female	26–35	LCA	
Anse à la Gourde	Guadeloupe	2216	Male	36–45	LCA	
Anse à la Gourde	Guadeloupe	2217	Female	18–25	LCA	
Argyle	St. Vincent	23–19	Unknown		LCA	
Argyle	St. Vincent	42–15	Unknown		LCA	
Argyle 2	St. Vincent	1	Male	36–45	ECA	
Argyle 2	St. Vincent	2	Unknown	adult	ECA	
Argyle 2	St. Vincent	3	Male	18–25	ECA	
Buccament West	St. Vincent	1	Unknown	25–35	?	
Cañas	Puerto Rico	164	Female	adult	ECA	
Cañas	Puerto Rico	11844	Unknown	adult	ECA	
Cañas	Puerto Rico	11853	Unknown	adult	ECA	
Canashito	Aruba	1	Female	26–35	ECA	
Canashito	Aruba	2	Male	36–45	ECA	
Canashito	Aruba	3	Unknown	adult	ECA	
Canashito	Aruba	5	Male	adult	ECA	
Chorro de Maíta	Cuba	1	Female	adult	LCA	
Chorro de Maíta	Cuba	2A	Female	36–45	LCA	
Chorro de Maíta	Cuba	2B	Child	9–10	LCA	
Chorro de Maíta	Cuba	3	Female	26–35	LCA	
Chorro de Maíta	Cuba	4	Male	46+	LCA	
Chorro de Maíta	Cuba	6	Child	6–9	LCA	
Chorro de Maíta	Cuba	7A	Child	7–9	LCA	
Chorro de Maíta	Cuba	8A	Child	12–13	LCA	
Chorro de Maíta	Cuba	10	Child	2–3	LCA	
Chorro de Maíta	Cuba	12	Child	5–6	LCA	
Chorro de Maíta	Cuba	13	Child	4–5	LCA	
Chorro de Maíta	Cuba	14A	Indet.	26–35	LCA	
Chorro de Maíta	Cuba	14B	Child	6–8	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Chorro de Maíta	Cuba	16A	Male	18–25	LCA	
Chorro de Maíta	Cuba	17B	Child	1.5–2	LCA	
Chorro de Maíta	Cuba	18	Child	5–6	LCA	
Chorro de Maíta	Cuba	19	Female	18–25	LCA	
Chorro de Maíta	Cuba	20	Male	26–35	LCA	
Chorro de Maíta	Cuba	21	Female	46+	LCA	
Chorro de Maíta	Cuba	22	Male	16–18	LCA	
Chorro de Maíta	Cuba	24	Child	10–11	LCA	
Chorro de Maíta	Cuba	25	Male	26–35	LCA	
Chorro de Maíta	Cuba	26	Male	18–25	LCA	
Chorro de Maíta	Cuba	29	Male	26–35	LCA	
Chorro de Maíta	Cuba	32	Child	7–8	LCA	
Chorro de Maíta	Cuba	33A	Female	26–35	LCA	
Chorro de Maíta	Cuba	34	Male	26–35	LCA	
Chorro de Maíta	Cuba	35	Female	18–25	LCA	
Chorro de Maíta	Cuba	36	Child	14–15	LCA	
Chorro de Maíta	Cuba	37	Female	18–25	LCA	
Chorro de Maíta	Cuba	39	Male	46+	LCA	
Chorro de Maíta	Cuba	41	Child	12–13	LCA	
Chorro de Maíta	Cuba	42	Male	26–35	LCA	
Chorro de Maíta	Cuba	45	Male	26–35	LCA	
Chorro de Maíta	Cuba	46	Female	adult	LCA	
Chorro de Maíta	Cuba	47	Male	26–35	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Chorro de Maíta	Cuba	51	Male	18–25	LCA	
Chorro de Maíta	Cuba	53	Female	26–35	LCA	
Chorro de Maíta	Cuba	55	Female	36–45	LCA	
Chorro de Maíta	Cuba	57A	Female	26–35	LCA	
Chorro de Maíta	Cuba	59	Male	46+	LCA	
Chorro de Maíta	Cuba	61	Female	adult	LCA	
Chorro de Maíta	Cuba	62	Male	46+	LCA	
Chorro de Maíta	Cuba	64	Child	10–12	LCA	
Chorro de Maíta	Cuba	65	Male	18–25	LCA	
Chorro de Maíta	Cuba	67	Female	18–25	LCA	
Chorro de Maíta	Cuba	68	Female	18–25	LCA	
Chorro de Maíta	Cuba	69A	Child	6–8	LCA	
Chorro de Maíta	Cuba	70	Female	18–25	LCA	
Chorro de Maíta	Cuba	72B	Female	18–25	LCA	
Chorro de Maíta	Cuba	73	Female	18–25	LCA	
Chorro de Maíta	Cuba	74	Male	36–45	LCA	
Chorro de Maíta	Cuba	75A	Female	14–16	LCA	
Chorro de Maíta	Cuba	75C	Male	18–25	LCA	
Chorro de Maíta	Cuba	78	Male	26–35	LCA	
Chorro de Maíta	Cuba	79	Unknown	15–18	LCA	
Chorro de Maíta	Cuba	80	Unknown	14–16	LCA	
Chorro de Maíta	Cuba	81	Female	18–25	LCA	
Chorro de Maíta	Cuba	82	Female	14–16	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Chorro de Maíta	Cuba	83	Female	15–16	LCA	
Chorro de Maíta	Cuba	84	Child	3–5	LCA	
Chorro de Maíta	Cuba	86	Female	18–25	LCA	
Chorro de Maíta	Cuba	87A	Female	26–35	LCA	
Chorro de Maíta	Cuba	89	Male	26–35	LCA	
Chorro de Maíta	Cuba	91	Male	46+	LCA	
Chorro de Maíta	Cuba	92	Male	36–45	LCA	
Chorro de Maíta	Cuba	93	Female	46+	LCA	
Chorro de Maíta	Cuba	94	Child	9–11	LCA	
Chorro de Maíta	Cuba	97	Male	26–35	LCA	
Chorro de Maíta	Cuba	98	Female	46+	LCA	
Chorro de Maíta	Cuba	103	Male	26–35	LCA	
Chorro de Maíta	Cuba	105A	Male	36–45	LCA	
Chorro de Maíta	Cuba	106	Male	46+	LCA	
Clarence town cave	Bahamas	4687	Male	26–35	LCA	
Clarence town cave	Bahamas	4688	Female	26–35	LCA	
Collores	Puerto Rico	161	Female	adult	ECA	
Collores	Puerto Rico	162	Child	3	ECA	
Coto	Puerto Rico	266173	Unknown	adult	LCA	
Diale 1	Haiti	149A	Female	18–25	LCA	
Diale 1	Haiti	149B	Child	9–10	LCA	
Diale 1	Haiti	154	Female	18–25	LCA	
Diale 1	Haiti	155	Child	1.5–2.5	LCA	
Diale 1	Haiti	157/159	Male	18–25	LCA	
Diale 1	Haiti	159	Male	adult	LCA	
Diale 1	Haiti	160	Female	22+	LCA	
El Cabo	Dom. Rep.	85-31-01	Female	26–35	LCA	
El Cabo	Dom. Rep.	85-34-06	Male	26–35	LCA	
Escape	St. Vincent	1	Female	26–35	ECA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Escape	St. Vincent	2	Female	36–45	ECA	
Escape	St. Vincent	4	Female	46+	ECA	
Escape	St. Vincent	5	Unknown	26–35	ECA	
Escape	St. Vincent	7	Male	18–25	ECA	
Escape	St. Vincent	9	Unknown	adult	ECA	
Escape	St. Vincent	12	Unknown	26–35	ECA	
Escape	St. Vincent	14	Female	18–25	ECA	
Escape	St. Vincent	15	Unknown	adult	ECA	
Escape	St. Vincent	16	Unknown	46+	ECA	
Escape	St. Vincent	17	Unknown	36–45	ECA	
Escape	St. Vincent	18	Unknown	26–35	ECA	
Escape	St. Vincent	19	Unknown	46+	ECA	
Escape	St. Vincent	20	Unknown	18–25	ECA	
Escape	St. Vincent	22	Unknown	26–35	ECA	
Escape	St. Vincent	23A	Unknown	16–18	ECA	
Escape	St. Vincent	23B	Unknown	36–45	ECA	
Escape	St. Vincent	24	Female	26–35	ECA	
Escape	St. Vincent	25A	Child	6	ECA	
Escape	St. Vincent	28	Unknown	18–25	ECA	
Escape	St. Vincent	29	Female	adult	ECA	
Escape	St. Vincent	32	Unknown	adult	ECA	
Escape	St. Vincent	33	Unknown	18–25	ECA	
Escape	St. Vincent	34	Unknown	18–25	ECA	
Escape	St. Vincent	36	Male	36–45	ECA	
Esperanza, Vieques	Puerto Rico	2	Child	4–5	?	
Gordon Hill cave	Bahamas	4693	Unknown	adult	LCA	
Gordon Hill cave	Bahamas	4694	Male	26–35	LCA	
Hacienda Grande	Puerto Rico	23	Female	26–35	?	
Hacienda Grande	Puerto Rico	30	Male	36–45	?	
Heywoods	Barbados	11	Unknown	18–25	?	
Heywoods	Barbados	35	Unknown	36–45	?	
Heywoods	Barbados	61	Female	18–25	?	
Higuey	Dom. Rep.	1	Male	26–35	LCA	
Indian Creek	Antigua	254343	Unknown	adult	ECA	
Juan Dolio	Dom. Rep.	8	Male	26–35	LCA	
Juan Dolio	Dom. Rep.	10	Female	18–25	LCA	
Juan Dolio	Dom. Rep.	22	Male	18–25	LCA	
Juan Dolio	Dom. Rep.	39	Female	18–25	LCA	
Juan Dolio	Dom. Rep.	62	Female	adult	LCA	
Juan Dolio	Dom. Rep.	69	Male	adult	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Juan Dolio	Dom. Rep.	70	Female	16–18	LCA	
Kelbey's Ridge 2	Saba	68	Male	36–45	LCA	
Kelbey's Ridge 2	Saba	132	Female	46+	LCA	
Kelbey's Ridge 2	Saba	148	Female	30+	LCA	
Kelbey's Ridge 2	Saba	166	Child	10–12	LCA	
Kelbey's Ridge 2	Saba	313	Child	11–13	LCA	
Kelbey's Ridge 2	Saba	337	Child	2–3	LCA	
La Caleta	Dom. Rep.	190	Male	36–45	LCA	
La Mina	Puerto Rico	1	Female	36–45	LCA	
Lavoutte	St. Lucia	1	Male	36–45	LCA	
Lavoutte	St. Lucia	2	Male	46+	LCA	
Lavoutte	St. Lucia	3	Unknown	?	LCA	
Lavoutte	St. Lucia	4	Unknown	?	LCA	
Lavoutte	St. Lucia	5	Unknown	?	LCA	
Lavoutte	St. Lucia	57-03	Child	10–12	LCA	
Lavoutte	St. Lucia	57-08	Indet.	adult	LCA	
Lavoutte	St. Lucia	57-11	Female	adult	LCA	
Lavoutte	St. Lucia	57-17	Female	36–45	LCA	
Lavoutte	St. Lucia	57-23	Female	26–35	LCA	cal. A.D. 2σ 1323–1446
Lavoutte	St. Lucia	58-22	Male	36–45	LCA	cal. A.D. 2σ 1320–1442
Lavoutte	St. Lucia	58-23A	Female	18–25	LCA	cal. A.D. 2σ 1325–1460
Lavoutte	St. Lucia	58-23B	Male	26–35	LCA	
Lavoutte	St. Lucia	67-05	Female	26–35	LCA	
Lavoutte	St. Lucia	67-12	Female	adult	LCA	
Lavoutte	St. Lucia	67-14	Child	4–5	LCA	
Lavoutte	St. Lucia	67-18	Indet.	18+	LCA	
Lavoutte	St. Lucia	67-19	Indet.	15–18	LCA	
Lavoutte	St. Lucia	67-27	Male	Adult	LCA	
Lavoutte	St. Lucia	67-31	Male	36–45	LCA	
Lavoutte	St. Lucia	67-33	Male	46+	LCA	
Lavoutte	St. Lucia	68-01	Male	26–35	LCA	cal. A.D. 2σ 1233–1307
Lavoutte	St. Lucia	68-04	Male	26–35	LCA	cal. A.D. 2σ 1304–1422
Lavoutte	St. Lucia	68-05	Female	36–45	LCA	
Lavoutte	St. Lucia	68-07	Male	26–35	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Lavoutte	St. Lucia	68-08	Child	4–5	LCA	
Lavoutte	St. Lucia	68-11	Female	46+	LCA	cal. A.D. 2σ 1321–1444
Lavoutte	St. Lucia	68-20	Female	36–45	LCA	cal. A.D. 2σ 1293–1408
Lavoutte	St. Lucia	69-01	Male	36–45	LCA	
Lavoutte	St. Lucia	69-02	Female	14–16	LCA	cal. A.D. 2σ 1426–1619
Lavoutte	St. Lucia	69-05	Indet.	36–45	LCA	cal. A.D. 2σ 1190–1295
Maisabel	Puerto Rico	1	Indet.	Adult	ECA	cal. A.D. 2σ 588–804
Maisabel	Puerto Rico	2	Male	26–35	ECA	cal. A.D. 2σ 667–1060
Maisabel	Puerto Rico	3	Child	1–2	LCA	cal. A.D. 2σ 995–1187
Maisabel	Puerto Rico	4	Male	46+	LCA	cal. A.D. 2σ 983–1210
Maisabel	Puerto Rico	5	Female	adult	ECA	cal. A.D. 2σ 775–994
Maisabel	Puerto Rico	6	Male	46+	ECA	cal. A.D. 2σ 600–865
Maisabel	Puerto Rico	7	Male	46+	LCA	cal. A.D. 2σ 932–1162
Maisabel	Puerto Rico	8	Child	2–3	LCA	cal. A.D. 2σ 1055–1262
Maisabel	Puerto Rico	9	Male	26–35	LCA	cal. A.D. 2σ 939–1234
Maisabel	Puerto Rico	10	Female	46+	ECA	cal. A.D. 2σ 606–785
Maisabel	Puerto Rico	11	Male	46+	LCA	cal. A.D. 2σ 1297–1458
Maisabel	Puerto Rico	12	Male	adult	LCA	
Maisabel	Puerto Rico	13	Indet.	18–25	LCA	
Maisabel	Puerto Rico	14	Male	18–25	ECA	cal. A.D. 2σ 526–718
Maisabel	Puerto Rico	15	Male	adult	ECA	cal. A.D. 2σ 630–1005
Maisabel	Puerto Rico	16	Child	4–5	ECA	cal. A.D. 2σ 772–993
Maisabel	Puerto Rico	17	Male	26–35	ECA	cal. A.D. 2σ 778–1029
Maisabel	Puerto Rico	18	Female	36–45	LCA	cal. A.D. 2σ 940–1153
Maisabel	Puerto Rico	19A	Female	36–45	LCA	
Maisabel	Puerto Rico	19B	Male	18–25	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Maisabel	Puerto Rico	19C	Female	46+	LCA	cal. A.D. 2σ 1034–1319
Maisabel	Puerto Rico	20	Male	26–35	LCA	cal. A.D. 2σ 1055–1262
Maisabel	Puerto Rico	21	Female	36–45	ECA	cal. A.D. 2σ 757–979
Maisabel	Puerto Rico	22	Male	18–25	LCA	cal. A.D. 2σ 861–1230
Maisabel	Puerto Rico	23	Female	46+	LCA	cal. A.D. 2σ 1057–1277
Maisabel	Puerto Rico	24	Child	1–1.5	LCA	
Maisabel	Puerto Rico	25	Female	46+	ECA	cal. A.D. 2σ 772–993
Maisabel	Puerto Rico	26	Male	46+	LCA	cal. A.D. 2σ 1029–1248
Maisabel	Puerto Rico	27	Child	1.5–2	ECA	cal. A.D. 2σ 678–903
Maisabel	Puerto Rico	28	Male	46+	ECA	
Maisabel	Puerto Rico	29	Indet.	46+	LCA	cal. A.D. 2σ 1020–1218
Maisabel	Puerto Rico	31	Child	2–4	LCA	cal. A.D. 2σ 1042–1255
Malmok	Aruba	6	Unknown	26–35	ECA	
Malmok	Aruba	10	Female	36–45	ECA	
Malmok	Aruba	13	Unknown	36–45	ECA	
Malmok	Aruba	490	Male	26–35	ECA	
Mamora Bay	Antigua	1	Unknown	adult	LCA	
Mamora Bay	Antigua	2	Unknown	adult	LCA	
Mamora Bay	Antigua	3	Unknown	adult	LCA	
Mamora Bay	Antigua	4	Unknown	adult	LCA	
Manigat Cave	Haiti	509	Male	adult	LCA	
Manigat Cave	Haiti	264649	Unknown	adult	LCA	
Manigat Cave	Haiti	264654	Unknown	adult	LCA	
Manzanilla	Trinidad	118	Female	18–25	LCA	
Manzanilla	Trinidad	119	Male	46+	ECA	
Manzanilla	Trinidad	180A	Female	18–25	LCA	
Manzanilla	Trinidad	180B	Male	36–45	LCA	
Manzanilla	Trinidad	189A	Child	9–10	LCA	
Manzanilla	Trinidad	189B	Male	26–35	LCA	
Manzanilla	Trinidad	214	Male	18–25	ECA	
Manzanilla	Trinidad	244	Male	18–25	LCA	
Manzanilla	Trinidad	251	Female	46+	LCA	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Manzanilla	Trinidad	255	Male	26–35	LCA	
Manzanilla	Trinidad	265	Female	46+	LCA	
Manzanilla	Trinidad	267A	Child	9–11	?	
Manzanilla	Trinidad	267B	Male	adult	?	
Manzanilla	Trinidad	267/269	Male	26–35	ECA	
Manzanilla	Trinidad	273	Male	46+	LCA	
Manzanilla	Trinidad	291	Child	14–16	LCA	
Manzanilla	Trinidad	292	Child	10–12	LCA	
Manzanilla	Trinidad	294	Male	18–25	LCA	
María de la Cruz cave	Puerto Rico	228073	Unknown	15–17	ECA	
Monserrate	Puerto Rico	163	Male	18–25	ECA	
Monserrate	Puerto Rico	11868	Unknown	adult	ECA	
Point de Caille	St. Lucia	30	Female	46+	LCA	
Point de Caille	St. Lucia	32	Female	18–25	LCA	
Point de Caille	St. Lucia	34	Male	46+	LCA	
Point de Caille	St. Lucia	36	Male	18–25	LCA	
Punta Candelero	Puerto Rico	1–F1	Female	26–35	ECA	
Punta Candelero	Puerto Rico	2–A3/A6?	Unknown	adult	ECA	
Punta Candelero	Puerto Rico	3–A6	Unknown	adult	LCA	
Punta Candelero	Puerto Rico	4–A/B6?	Unknown	adult	ECA	
Punta Candelero	Puerto Rico	5–B3	Female	26–35	ECA	
Punta Candelero	Puerto Rico	6–B6	Female	26–35	ECA	
Punta Candelero	Puerto Rico	7–B6	Male	46+	ECA	
Punta Candelero	Puerto Rico	9–B3	Female	36–45	ECA	
Punta Candelero	Puerto Rico	10–B3	Male	26–35	ECA	
Punta Candelero	Puerto Rico	1–A2	Male	18–25	LCA	
Punta Candelero	Puerto Rico	13–B1	Male	26–35	ECA	
Punta Candelero	Puerto Rico	14–II temp	Child	7–8	?	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Punta Candelero	Puerto Rico	2–A6	Unknown	adult	ECA	
Punta Candelero	Puerto Rico	23–B2	Unknown	adult	?	
Punta Candelero	Puerto Rico	24–A4/B4	Female	adult	?	
Punta Candelero	Puerto Rico	29–A3	Male	36–45	ECA	
Punta Candelero	Puerto Rico	30–A2/A3	Male	26–35	ECA	
Punta Candelero	Puerto Rico	32	Female	16–18	?	
Punta Candelero	Puerto Rico	33A–A1	Male	46+	ECA	
Punta Candelero	Puerto Rico	33B–A1	Male	adult	?	
Punta Candelero	Puerto Rico	36–A2	Male	46+	?	
Punta Candelero	Puerto Rico	38–B1	Unknown	adult	?	
Punta Candelero	Puerto Rico	40 II temp	Child	3–5	?	
Punta Candelero	Puerto Rico	43B–A1/ B1	Male	18–25	?	
Punta Candelero	Puerto Rico	45–I/D1	Male	46+	LCA	
Punta Candelero	Puerto Rico	46–D8	Male	36–45	LCA	
Punta Candelero	Puerto Rico	48–B4	Female	26–35	?	
Punta Candelero	Puerto Rico	52–F2	Unknown	adult	?	
Punta Candelero	Puerto Rico	54–F5	Male	adult	?	
Punta Candelero	Puerto Rico	56–A6	Male	16–18	?	
Punta Candelero	Puerto Rico	59–B5	Male	adult	?	
Punta Candelero	Puerto Rico	7–B3	Female	18–25	ECA	
Punta Candelero	Puerto Rico	1–A3	Unknown	adult	?	
Punta Candelero	Puerto Rico	1–C block 2	Child	2–3	?	
Punta Candelero	Puerto Rico	1–A6	Child	5–7	?	

Site	Island/ Country	Individual	Sex	Age	Period	Radiocarbon date
Punta Candelero	Puerto Rico	1–N5	Child	4–5	?	
Punta Candelero	Puerto Rico	1–B6	Male	46+	?	
Punta Candelero	Puerto Rico	1–W	Unknown	adult	ECA	
Punta Candelero	Puerto Rico	1–Z	Unknown	18–25	ECA	
Punta Candelero	Puerto Rico	1–Y	Unknown	26–35	?	
Punta Candelero	Puerto Rico	1–Q	Male	36–45	ECA	
Punta Candelero	Puerto Rico	1–M	Unknown	adult	?	
Punta Candelero	Puerto Rico	1–J	Unknown	18–25	ECA	
Punta Candelero	Puerto Rico	1–F4	Unknown	adult	?	
Punta Candelero	Puerto Rico	1–D1	Male	26–35	ECA	
Punta Candelero	Puerto Rico	1A–D1	Female	46+	?	
Punta Candelero	Puerto Rico	Ass. 1–C3	Male	36–45	?	
Punta Candelero	Puerto Rico	1–C3	Female	26–35	LCA	
Punta Candelero	Puerto Rico	Ass. 1–B4	Unknown	18–25	?	
Punta Candelero	Puerto Rico	1–B4	Male	46+	ECA	
Punta Candelero	Puerto Rico	Sec. block 2–L2	Unknown	adult	ECA	
Punta Candelero	Puerto Rico	A3–sec.	Unknown	adult	ECA	
Punta Candelero	Puerto Rico	2–A3	Unknown	18–25	?	
Punta Candelero	Puerto Rico	3–B3	Unknown	adult	?	
Punta Candelero	Puerto Rico	4–B3	Female	26–35	?	
Punta Candelero	Puerto Rico	2–B4	Child	6–7	ECA	
Punta Macao	Dom. Rep.	1	Female	46+	LCA	
Punta Macao	Dom. Rep.	2.1	Male	14–16	LCA	
Punta Macao	Dom. Rep.	5.1	Female	26–35	LCA	
Punta Macao	Dom. Rep.	6.1	Female	18–25	LCA	

Site	**Island/ Country**	**Individual**	**Sex**	**Age**	**Period**	**Radiocarbon date**
Punta Macao	Dom. Rep.	6.2	Child	4–5	LCA	
Punta Macao	Dom. Rep.	9.1	Male	46+	LCA	
Punta Macao	Dom. Rep.	10.1	Child	4–5	LCA	
Punta Macao	Dom. Rep.	11	Male	26–35	LCA	
Punta Macao	Dom. Rep.	12.1	Male	36–45	LCA	
Punta Macao	Dom. Rep.	13	Male	36–45	LCA	
Punta Macao	Dom. Rep.	14.1	Female	46+	LCA	
Punta Macao	Dom. Rep.	16.1	Male	adult	LCA	
Punta Macao	Dom. Rep.	17.1	Unknown	18–25	LCA	
Punta Macao	Dom. Rep.	18	Male	18–25	LCA	
Punta Macao	Dom. Rep.	20.1	Child	0.3–0.5	LCA	
Punta Macao	Dom. Rep.	21.1	Child	2–4	LCA	
Punta Macao	Dom. Rep.	25	Female	26–35	LCA	
Punta Macao	Dom. Rep.	29.1	Male	26–35	LCA	
Punta Macao	Dom. Rep.	29.2	Female	26–35	LCA	
Saladero	Venezuela	279	Unknown	adult	ECA	
Saladero	Venezuela	280	Unknown	adult	ECA	
Saladero	Venezuela	281	Unknown	adult	ECA	
Santa Cruz	Aruba	1	Unknown	18–25	LCA	
Santa Cruz	Aruba	6	Child	4–5	LCA	
Santa Cruz	Aruba	7	Female	18–25	LCA	
Santa Cruz	Aruba	78	Unknown	36–45	LCA	
Santa Cruz	Aruba	301/302	Male	26–35	LCA	
Santa Cruz	Aruba	999	Child	11–12	LCA	
Santa Elena	Puerto Rico	152	Female	46+	LCA	
Santa Elena	Puerto Rico	153	Child	3–4	LCA	
Santa Isabel	Puerto Rico	170 5042	Male	adult	LCA	
Savaneta	Aruba	1	Male	26–35	LCA	
Savaneta	Aruba	5	Child	13	LCA	
Savaneta	Aruba	8	Female	26–35	LCA	
Savaneta	Aruba	12	Male	18–25	LCA	
Savaneta	Aruba	233G–A	Female	18–25	LCA	
Savaneta	Aruba	233G–B	Female	adult	LCA	
Savaneta	Aruba	Urn	Child	7	LCA	
Savanne Suazey	Grenada	98017	Female	18–25	LCA	
Savanne Suazey	Grenada	98018	Child	2.5–3.5	LCA	
Savanne Suazey	Grenada	98019	Male	adult	LCA	
Savanne Suazey	Grenada	98020	Female	adult	LCA	
Savanne Suazey	Grenada	98021	Male	adult	LCA	

Site	**Island/ Country**	**Individual**	**Sex**	**Age**	**Period**	**Radiocarbon date**
Simon Beach	Grenada	1	Unknown	adult	ECA	
Spring Bay 1c	Saba	1	Child	2–4	LCA	
Unknown site	St. Croix	496	Male	26–35	LCA	
Unknown site	St. Kitts	510	Male	adult	LCA	
Unknown site	St. Kitts	511	Unknown	adult	LCA	
Tanki Flip	Aruba	200	Unknown	adult	LCA	
Tanki Flip	Aruba	488	Unknown	18–25	LCA	
Tocorón	Venezuela	383	Female	adult	LCA	
Tocorón	Venezuela	385	Male	adult	LCA	
Tocorón	Venezuela	268953	Unknown	adult	LCA	
Tocorón	Venezuela	268957	Male	adult	LCA	
Tocorón	Venezuela	268964	Male	adult	LCA	
Tocorón	Venezuela	268958	Unknown	adult	LCA	
Tutu	St. Thomas	1	Female	46+	LCA	cal. A.D. 2σ 1170–1310
Tutu	St. Thomas	2	Female	46+	LCA	cal. A.D. 2σ 1305–1445
Tutu	St. Thomas	3	Female	46+	ECA	cal. A.D. 2σ 785–960
Tutu	St. Thomas	4	Female	18–25	ECA	cal. A.D. 2σ 620–675
Tutu	St. Thomas	5	Female	46+	LCA	cal. A.D. 2σ 1435–1535
Tutu	St. Thomas	6	Child	5.5–7	LCA	cal. A.D. 2σ 1300–1435
Tutu	St. Thomas	9	Male	46+	LCA	cal. A.D. 2σ 1210–1310
Tutu	St. Thomas	10	Female	46+	ECA	cal. A.D. 2σ 450–640
Tutu	St. Thomas	12	Male	46+	LCA	cal. A.D. 2σ 1295–1410
Tutu	St. Thomas	13	Female	46+	ECA	cal. A.D. 2σ 605–665
Tutu	St. Thomas	13A	Female	46+	ECA	cal. A.D. 2σ 560–665
Tutu	St. Thomas	16	Female	36–45	ECA	cal. A.D. 2σ 640–870
Tutu	St. Thomas	19	Female	46+	LCA	cal. A.D. 2σ 1200–1400
Tutu	St. Thomas	20	Child	9	LCA	cal. A.D. 2σ 1400–1485

Site	**Island/ Country**	**Individual**	**Sex**	**Age**	**Period**	**Radiocarbon date**
Tutu	St. Thomas	21	Male	36–45	ECA	cal. A.D. 2σ 450–640
Tutu	St. Thomas	22B	Child	4–5	LCA	cal. A.D. 2σ 1275–1310/1365–1375
Tutu	St. Thomas	23B	Female	36–45	ECA	cal. A.D. 2σ 665–770
Tutu	St. Thomas	26	Female	18–25	LCA	cal. A.D. 2σ 1280–1400
Tutu	St. Thomas	29	Female	46+	LCA	cal. A.D. 2σ 1200–1320/1350–1390
Tutu	St. Thomas	30	Male	36–45	LCA	cal. A.D. 2σ 1300–1425
Tutu	St. Thomas	31	Female	36–45	LCA	cal. A.D. 2σ 1395–1435
Tutu	St. Thomas	32A	Child	5	?	
Tutu	St. Thomas	33	Male	36–45	LCA	cal. A.D. 2σ 1300–1425
Tutu	St. Thomas	36	Unknown	46+	ECA	cal. A.D. 2σ 450–615
Tutu	St. Thomas	38	Male	46+	LCA	cal. A.D. 2σ 1170–1400
Tutu	St. Thomas	39	Child	8	LCA	cal. A.D. 2σ 1660–1700/1720–1820/1855–1860/1920–1950
Wemyss Bight cave	Bahamas	4685	Male	26–35	LCA	
Yauco 1	Puerto Rico	173	Unknown	adult	LCA	

APPENDIX B – AGE DISTRIBUTION

Anse à la Gourde

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	1	1.45
1-4 yrs	3	4.35
5-9 yrs	2	2.90
10-14 yrs	2	2.90
15-17 yrs	0	0.00
Juvenile < 18 yrs	1	1.45
18-25 yrs (Young Adult)	10	14.49
26-35 yrs (Young Middle Adult)	20	28.99
36-45 yrs (Old Middle Adult)	6	8.70
46+ yrs (Mature Adult)	7	10.14
Adult ≥ 18yrs	17	24.64
Total	69	100.00

Canashito

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	0	0.00
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	0	0.00
26-35 yrs (Young Middle Adult)	1	25.00
36-45 yrs (Old Middle Adult)	1	25.00
46+ yrs (Mature Adult)	0	0.00
Adult ≥ 18yrs	2	50.00
Total	4	100.00

Chorro de Maíta

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	4	5.50
5-9 yrs	8	10.96
10-14 yrs	6	8.22
15-17 yrs	6	8.22
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	15	20.55
26-35 yrs (Young Middle Adult)	17	23.29

Age	n	% of Total
36-45 yrs (Old Middle Adult)	5	6.85
46+ yrs (Mature Adult)	9	12.33
Adult ≥ 18yrs	3	4.11
Total	73	100.00

Diale 1

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	1	14.29
5-9 yrs	1	14.29
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	4	57.14
26-35 yrs (Young Middle Adult)	0	0.00
36-45 yrs (Old Middle Adult)	0	0.00
46+ yrs (Mature Adult)	0	0.00
Adult ≥ 18yrs	1	14.29
Total	7	100.00

Escape

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	1	4.00
10-14 yrs	0	0.00
15-17 yrs	1	4.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	6	24.00
26-35 yrs (Young Middle Adult)	6	24.00
36-45 yrs (Old Middle Adult)	4	16.00
46+ yrs (Mature Adult)	3	12.00
Adult ≥ 18yrs	4	16.00
Total	25	100.00

Juan Dolio

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	0	0.00
10-14 yrs	0	0.00

Age	n	% of Total
15-17 yrs	1	14.29
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	3	42.86
26-35 yrs (Young Middle Adult)	1	14.29
36-45 yrs (Old Middle Adult)	0	0.00
46+ yrs (Mature Adult)	0	0.00
Adult ≥ 18yrs	2	28.57
Total	7	100.00

Kelbey's Ridge 2

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	1	16.67
5-9 yrs	0	0.00
10-14 yrs	2	33.33
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	0	0.00
26-35 yrs (Young Middle Adult)	0	0.00
36-45 yrs (Old Middle Adult)	1	16.67
46+ yrs (Mature Adult)	1	16.67
Adult ≥ 18yrs	1	16.67
Total	6	100.00

Lavoutte

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	2	6.45
5-9 yrs	0	0.00
10-14 yrs	1	3.23
15-17 yrs	2	6.45
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	1	3.23
26-35 yrs (Young Middle Adult)	6	19.35
36-45 yrs (Old Middle Adult)	8	25.81
46+ yrs (Mature Adult)	3	9.68
Adult ≥ 18yrs	8	25.81
Total	31	100.00

Maisabel

Age	n	% of Total
<0 (foetus)	0	0.00

Age	n	% of Total
<1 yr	0	0.00
1-4 yrs	6	18.75
5-9 yrs	0	0.00
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	4	12.50
26-35 yrs (Young Middle Adult)	4	12.50
36-45 yrs (Old Middle Adult)	3	9.38
46+ yrs (Mature Adult)	11	34.38
Adult ≥ 18yrs	4	12.50
Total	32	100.00

Malmok

Age	N	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	0	0.00
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	0	0.00
26-35 yrs (Young Middle Adult)	2	50.00
36-45 yrs (Old Middle Adult)	2	50.00
46+ yrs (Mature Adult)	0	0.00
Adult ≥ 18yrs	0	0.00
Total	4	0.00

Mamora Bay

Age	N	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	0	0.00
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	0	0.00
26-35 yrs (Young Middle Adult)	0	0.00
36-45 yrs (Old Middle Adult)	0	0.00
46+ yrs (Mature Adult)	0	0.00
Adult ≥ 18yrs	4	100.00
Total	4	100.00

Manzanilla

Age	N	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	1	5.56
10-14 yrs	2	11.11
15-17 yrs	1	5.56
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	5	27.78
26-35 yrs (Young Middle Adult)	3	16.67
36-45 yrs (Old Middle Adult)	1	5.56
46+ yrs (Mature Adult)	4	22.22
Adult ≥ 18yrs	1	5.56
Total	18	100.00

Point de Caille

Age	N	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	0	0.00
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	2	50.00
26-35 yrs (Young Middle Adult)	0	0.00
36-45 yrs (Old Middle Adult)	0	0.00
46+ yrs (Mature Adult)	2	50.00
Adult ≥ 18yrs	0	0.00
Total	4	100.00

Punta Candelero

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	3	5.36
5-9 yrs	3	5.36
10-14 yrs	0	0.00
15-17 yrs	2	3.57
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	7	12.50
26-35 yrs (Young Middle Adult)	11	19.64
36-45 yrs (Old Middle Adult)	5	8.93
46+ yrs (Mature Adult)	7	12.50

Age	n	% of Total
Adult ≥ 18yrs	18	32.14
Total	56	100.00

Punta Macao

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	1	5.26
1-4 yrs	3	15.79
5-9 yrs	0	0.00
10-14 yrs	0	0.00
15-17 yrs	1	5.26
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	3	15.79
26-35 yrs (Young Middle Adult)	5	26.32
36-45 yrs (Old Middle Adult)	2	10.53
46+ yrs (Mature Adult)	3	15.79
Adult ≥ 18yrs	1	5.26
Total	19	100.00

Santa Cruz

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	1	16.67
5-9 yrs	0	0.00
10-14 yrs	1	16.67
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	2	33.33
26-35 yrs (Young Middle Adult)	1	16.67
36-45 yrs (Old Middle Adult)	1	16.67
46+ yrs (Mature Adult)	0	0.00
Adult ≥ 18yrs	0	0.00
Total	6	100.00

Savaneta

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	1	14.29
10-14 yrs	1	14.29
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00

Age	n	% of Total
18-25 yrs (Young Adult)	2	28.57
26-35 yrs (Young Middle Adult)	2	28.57
36-45 yrs (Old Middle Adult)	0	0.00
46+ yrs (Mature Adult)	1	14.29
Adult ≥ 18yrs	0	0.00
Total	7	100.00

Savanne Suazey

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	1	20.00
5-9 yrs	0	0.00
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	1	20.00
26-35 yrs (Young Middle Adult)	0	0.00
36-45 yrs (Old Middle Adult)	0	0.00
46+ yrs (Mature Adult)	0	0.00
Adult ≥ 18yrs	3	60.00
Total	5	100.00

Tocorón

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	0	0.00
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	0	0.00
26-35 yrs (Young Middle Adult)	0	0.00
36-45 yrs (Old Middle Adult)	0	0.00
46+ yrs (Mature Adult)	0	0.00
Adult ≥ 18yrs	6	100.00
Total	6	100.00

Tutu

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00

Age	**n**	**% of Total**
5-9 yrs	5	19.23
10-14 yrs	0	0.00
15-17 yrs	0	0.00
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	2	7.69
26-35 yrs (Young Middle Adult)	0	0.00
36-45 yrs (Old Middle Adult)	6	23.08
46+ yrs (Mature Adult)	13	50.00
Adult ≥ 18yrs	0	0.00
Total	26	100.00

Early Ceramic Age

Age	**n**	**% of Total**
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	3	4.22
5-9 yrs	1	1.41
10-14 yrs	0	0.00
15-17 yrs	2	2.82
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	11	15.49
26-35 yrs (Young Middle Adult)	12	16.90
36-45 yrs (Old Middle Adult)	13	18.31
46+ yrs (Mature Adult)	13	18.31
Adult ≥ 18yrs	16	22.54
Total	71	100.00

Late Ceramic Age

Age	**n**	**% of Total**
<0 (foetus)	0	0.00
<1 yr	2	0.65
1-4 yrs	23	7.42
5-9 yrs	16	5.16
10-14 yrs	14	4.52
15-17 yrs	11	3.55
Juvenile < 18 yrs	1	0.32
18-25 yrs (Young Adult)	53	17.10
26-35 yrs (Young Middle Adult)	63	20.32
36-45 yrs (Old Middle Adult)	32	10.32
46+ yrs (Mature Adult)	44	14.19
Adult ≥ 18yrs	51	16.45
Total	310	100.00

Early Ceramic Age – Lesser and Southern Antilles

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	0	0.00
1-4 yrs	0	0.00
5-9 yrs	1	2.50
10-14 yrs	0	0.00
15-17 yrs	1	2.50
Juvenile < 18 yrs	0	0.00
18-25 yrs (Young Adult)	8	20.00
26-35 yrs (Young Middle Adult)	10	25.00
36-45 yrs (Old Middle Adult)	8	20.00
46+ yrs (Mature Adult)	4	10.00
Adult ≥ 18yrs	8	20.00
Total	40	100.00

Late Ceramic Age – Lesser and Southern Antilles

Age	n	% of Total
<0 (foetus)	0	0.00
<1 yr	1	0.68
1-4 yrs	9	6.16
5-9 yrs	5	3.42
10-14 yrs	7	4.79
15-17 yrs	3	2.05
Juvenile < 18 yrs	1	0.68
18-25 yrs (Young Adult)	23	15.75
26-35 yrs (Young Middle Adult)	31	21.23
36-45 yrs (Old Middle Adult)	17	11.64
46+ yrs (Mature Adult)	15	10.27
Adult ≥ 18yrs	34	23.29
Total	146	100.00

LSAMAT

Age	n	% of Total
18-25 yrs (Young Adult)	32	17.49
26-35 yrs (Young Middle Adult)	51	27.87
36-45 yrs (Old Middle Adult)	31	16.94
46+ yrs (Mature Adult)	35	19.13
Adult ≥ 18yrs	34	18.58
Total	183	100.00

Non-LSAMAT

Age	n	% of Total
15-17 yrs	17	8.25
18-25 yrs (Young Adult)	41	19.90

Age	**n**	**% of Total**
26-35 yrs (Young Middle Adult)	37	17.96
36-45 yrs (Old Middle Adult)	19	9.22
46+ yrs (Mature Adult)	29	14.08
Adult ≥ 18yrs	63	30.58
Total	206	100.00

SUMMARY

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 focusses 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 ass 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 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.

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 intensified agriculture traditionally associated with Late Ceramic Age chiefdom societies of the Greater Antilles, evidence from the dentitions of its inhabitants demonstrates 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 intensified 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 sociopolitical 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 unpredictable 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/horticultural 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 significantly 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 inflammation, 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 proliferous. 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, 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.

SAMENVATTING

Dit onderzoek heeft als doel te ontdekken hoe de analyse van menselijke gebitten bijdraagt aan de kennis van de leefwijze en culturele praktijken van de pre-Columbiaanse Amerindianen van het Caribisch gebied. De analyses richten zich op de sporen van het dagelijkse leven die zijn achtergebleven op het menselijke gebit in de vorm van slijtagepatronen en pathologie, en de temporele en regionale variatie daarin. Het onderzoek is verdeeld in drie belangrijke componenten van het dagelijkse leven en culturele praktijken: voedselpraktijken, gezondheid en ziekte, en bepaalde ambachtelijke activiteiten. Deze drie aspecten worden onderzocht door informatie uit gebitsslijtage en pathologie te integreren onze huidige kennis van studies van paleodieet, paleopathologie, en ambachtelijke activiteiten. Aan de basis van dit werk staat een multidisciplinaire aanpak: een combinatie van archeologisch, bioarcheologisch, etnohistorische en etnografische gegevens, samen met informatie uit de moderne tandheelkunde, wordt gebruikt om de dentaal antropologische gegevens van dit onderzoek te contextualiseren.

Tijdens de jaren '60 werd de dentale antorpologie opgericht en wornde een belangrijke subdiscipline van de fysische antropologie en osteologie. In grote lijnen kan dentale antropologie worden gedefinieerd als 'de studie van het gebit om de biologie en het gedrag van vroegere mensen en mensachtigen beter te begrijpen'.

De associatie tussen dentale pathologie en dieet is en blijft een belangrijk onderwerp in de dentale antropologie. De wereldwijde toename van cariës door de tijd wordt toegeschreven aan een verschuiving naar een koolhydraatrijk(er) dieet. In de meeste gebieden valt deze verschuiving samen met belangrijke sociaal-politieke en culturele ontwikkelingen, vaak geassocieerd met de ontwikkeling van de landbouw. Onderzoek heeft echter aangetoond dat ook minder ingrijpende veranderingen in het dieet kunnen leiden tot verschillen in cariës percentages. De wijze van voorbereiden van het voedsel is ook van grote invloed op de ontwikkeling van cariës. Zacht , gekookt voedsel met een kleverige consistentie bevordert de groei van bacteriën in de delen van de mond waar voedselresten gemakkelijk kunnen achterblijven. Onderzoek naar sekseverschillen in het voorkomen van cariës heeft aangetoond dat in verschillende culturen en voedselsystemen de vrouwen vaker worden getroffen door cariës dan de mannen. Deze verschillen worden vaak uitgelegd als het gevolg van seksegebonden taakverdeling, waarbij de vrouwen verantwoordelijk zijn voor de voedselproductie. Studies naar sociale status in verschillende samenlevingen hebben aangetoond dat individuen met een hoge status vaak ook afwijkende cariës waarden hebben dan individuen van lagere klassen.

Andere tandpathologieën zoals tandsteen en premortem tandverlies kunnen ook een indicatie zijn van het type dieet dat werd gegeten. Vaak zijn dentale pathologieën nauw met elkaar verbonden, en om een complete beeld van de dental pathologie in een groep te krijgen, dient rekening te worden gehouden met de samenhangende etiologie van veel ziekten van het gebit.

Gebitsslijtage bij mensen is voor een groot deel gerelateerd aan leeftijd, hoe ouder een individu wordt, hoe langer de tanden zijn gebruikt, met meer slijtage als gevolg. Naast leeftijd, is de mate van tandslijtage ook het gevolg van de fysieke eigenschappen van de voeding en de voedsel voorbereidingstechnieken, en het inclusie van zand en grind in de voeding, bijvoorbeeld in maritieme of woestijnachtige omgevingen.

Door de tijs heen is er een gemiddelde daling van de mate van slijtage waargenomen, die wordt toegeschreven aan de overgang van een jagers-verzamelaars dieet naar een agrarische bestaan. Zowel de fysieke eigenschappen als de voorbereidingstechnieken zullen in een dergelijk process veranderen. De verandering van de consumptie van verschuiven van harde, schurende voeding naar zachte, verfijnde, en plakkerige voeding heeft direct gevold voor het gebit. Onderzoek heeft aangetoond dat een hoge mate van slijtage vaak geassocieerd is met de consumptie van mariene voedsel.

Ontwikkelingsstoornissen van het gebit bestaan meestal uit defecten in het glazuur. Glazuurdefecten die macroscopisch waarneembaar zijn onderverdeeld in hypoplasieën, *opacities*, en verkleuringen. Hypoplasieën zijn verschillen in de dikte van het glazuur op de kroon.

Naast ‘natuurlijke' modificaties van de tanden als gevolg van het kauwen van voedsel of ziektes, zijn modificaties als gevolg van culturele praktijken een belangrijk onderdeel van de dentale antropologie. Deze soorten modificaties, soms aangeduid als "kunstmatige modificatie " of "*non-alimentary wear*" kunnen het uiterlijk drastisch veranderen. Kunstmatige modificaties kunnen het resultaat zijn van het gebruik van de tanden als een ‘derde hand’ of als gereedschap, of van opzettelijke modificatie. In het laatste geval worden de tanden gemodificeerd door vijlen, chippen, inleggen met steen of metaal, of zelfs complete verwijdering om esthetische redenen. Het gebruik van de tanden als gereedschap was een veelvoorkomende activiteit in veel prehistorische populaties.

De dentale antropologie is een gevestigde subdiscipline van bioarcheologie en osteologie en wordt erkend als een waardevolle bijdrage aan de archeologie. De toepassing van dentaal antropologisch onderzoek in de archeologie kan echter nog verder worden uitgebreid. Het benutten van gegevens over begravingspraktijken, de omgevens van de vindplaats, fauna en botanische resten die zijn aangetroffen, en archeometrische analyses maakt het mogelijk om een de dentala gegevens te contextualiseren en interpreteren. Dentale antropologische studies zijn vrij zeldzaam in het Caribisch gebied, hoewel enkele onderzoekers gebitsanalyses hebben verricht. .

Een totaal van 458 gebitten uit 49 verschillende vindplaatsen uit de hele Caribische archipel zijn bestudeerd. De meerderheid van het materiaal dateert tot de Laat Ceramische Periode (600/800-1500 n.Chr.), hoewel een groot deel dateert tot de Vroeg Ceramische Periode(400 v.Chr. - 600/800 n.Chr.). De skeletresten die zijn onderzocht in deze studie variëren met betrekking tot de omvang van het assemblage en de hoeveelheid beschikbare contextuele informatie. Sommige materialen zijn gedateerd d.m.v. C14 analyse, maar anderen kunnen alleen met behulp van algemene vindplaats datering en geassocieerde materiële cultuur worden gedateerd. Om deze reden, en vanwege het gebrek aan Archaisch gebitsmateriaal, is er bij het verdelen van het materiaal om temporele vergelijkingen te maken een grove indeling in twee groepen aangehouden. De eerste groep vertegenwoordigt de Vroege Ceramische Periode en bevat vindplaatsen die op basis van de absolute en/of relatieve datering kunnen worden toegewezen aan de periode tussen 400 v.Chr. en 600/800 n.Chr. De tweedee groep vertegenwoordigt de Laat Ceramische Periode, bevat vindplaatsen die op basis van de absolute en/of relatieve datering kunnen worden toegewezen aan de periode tussen 600/800 en 1500/1600 n.Chr.

De resultaten van het onderzoek naar gebitsslijtage en pathologie in deze studie geven aan dat dentale pathologie zeer veelvoorkomend was onder de pre- Columbiaanse inwoners van het Caribisch gebied. Een vergelijking van de cariës waarden die wijn waargneomen in deze studie met eerder onderzoek over de hele wereld toont aan dat het merendeel van de gemeenschappen in dit onderzoek kan worden gekarakteriseerd als grote koolhydraat consumenten.

Er werden verschillen gevonden in de voedselpraktijken tussen mannen en vrouwens van enkele vindplaatsen, en voor de totale groep. De verschillen zijn echter relatief klein en subtiel, en zijn hoogstwaarschijnlijk het gevolg van minieme verschillen de hoeveelheid koolhydraten die werd gegeten. Vrouwen hebben over het algemeen hogere deltale pathologie waarden dan mannen. De cariës waarden van de vrouwen is soms aanzienlijk hoger. Het is mogelijk dat de enigszins lagere slijtage bij vrouwen verband houdt met een iets grotere component van zeer verfijnde, zachte, kleverige, en zetmeelrijke voeding in hun dieet. Mannen daarentegen hebben hogere chippingswaarden, dat wellicht verband houdt met het eten van hardere, grovere voedsel met mogelijkerwijs meer inclusies zoals zand of stof. Het is ook mogelijk dat mannen meer eiwitrijke voeding aten, wellicht marienevoeding, die het gebit sneller doet afslijten. De vrouwen zullen grotendeels verfijndere, koolhydraatrijke, kleverige, gekookte voedsel hebben gegeten, en misschien wel meer fruit. Mogelijkerwijs aten de vaker op een dag mannen. De verschillen zijn echter vrij subtiel, vooral vergeleken met studies over de hele wereld , waar de verschillen tussen de seksen vaak relatief groot zijn.

Er zijn in deze studie geen andere aanwijzingen gevonden voor het bestaan van statusverschillen in de voedselconsumptie. Het blijft echter mogelijk dat status differentiatie in de voedselconsumptie alleen werd beoefend in rituele en ceremoniële contexten, zoals voorgesteld in eerdere studies in de regio.

De temporele vergelijkingen van gebitsslijtage en pathologie van de vindplaatsen heeft geen significante verschillenaangetoond . Echter, bij de vergelijkingen tussen de Vroeg Ceramische en Laat Ceramische Periode zijn er grote verschillen tussen de twee groepen geconstateerd, zowel in de patronen van gebitsslijtage als pathologie . De duidelijk lagere mate van slijtage in de Laat Ceramische groep is mogelijk het gevolg een lagere mate van slijtende inclusies in de voeding van deze groep in vergelijking met de Vroeg Ceramische groep. De slijtende werking van het dieet is grotendeels het gevolg van voedsel bereidingstechnieken, dat wil zeggen, hoe verfijdn het eten is, in combinatie met de inherente fysieke kwaliteiten van de voeding. Dit suggereert dat voedsel in de Laat Ceramische Periode het algemeen verfijnder was, en het minder slijtende inclusies zoals zand en grit bevatte. Het statistisch significanet verschil in cariës percentage tussen de twee groepen is aanzienlijk: het cariës percentage Laat Ceramische groep is bijna het dubbele van dat van de Vroege Ceramische groep. Dit suggereert op zijn minst een duidelijk verschil in bereidingstechnieken tussen de twee groepen , maar veel waarschijnlijker een duidelijk verschil in de proportie van koolhydraten in het dieet in combinatie met uiterst verfijnde voedsel bereidingstechnieken. Het hogere cariës percentage in de Laat Ceramische groep gaat gepaard met significant hogere premortem tandverlies, wat ook suggereert dat een veel koolhydraatrijker en verfijnder dieet werd gegeten.

Dit onderzoek ondersteunt de bevindingen van eerder onderzoek, datheeft aangetoond dat de Laat Ceramische Periode een duidelijke toename en intensivisering van de landbouw met zich meebracht in de Grote Antillen. Bovendien geven de resultaten van deze studie aan dat er een verschuiving van gelijke, zo niet grotere, omvang plaatsvond in de Kleine Antillen tijdens de Laat Ceramische Periode. In een regio waar van oudsher werd aangenomen dat er niet een soortgelijke intensieve landbouw is ontwikkeld toont bewijs van gebitsslijtage en pathologie aan dat de inwoners van de Kleine Antillen een zeer verfijnd, zetmeelrijke en suikerhoudende dieet hadden.

De redenen voor deze verschuiving in voedselpraktijken is niet duidelijk. In de Grote Antillen is de intensivisering van de landbouw in verband gebracht met de opkomst van *chiefdom* samenlevingen in de Laat Ceramische Periode. Maar de soortgelijke verschuiving in voedselpraktijken in de Kleine Antillen, waar traditioneel wordt aangenomen dat deze vorm van sociale complexiteit zich niet heeft ontwikkeld, geeft aan dat de relatie tussen sociaal-politieke organisatie en voedselpraktijken in het Caribisch gebied niet eenvoudig is. Het is mogelijk dat klimaatverandering een rol speelde in deze verschuiving. Wellicht hebben gemeenschappen na de overexploitatie en de resulterende uitputting van bepaalde middelen, in combinatie met lange perioden van droogte na de Vroeg Ceramische Periode geprobeerd oplossingen te zoeken voor de onvoorspelbare toegankelijkheid tot voedingsbronnen door hun voedseleconomieën aan te passen. Ook zou de verhoogde neerslag na de droge periode bevorderlijk kunnen zijn geweest voor de landbouw / tuinbouw praktijken. Wat ook de redenen voor de veranderingen in voedselpraktijken door de tijd heen zijn geweest, de voedseleconomieën in de gehele regio in de Laat Ceramische Periode maakten het mogelijk om een groeiende bevolking te ondersteunen.

Orale gezondheid en hygiëne in de pre-Columbiaanse Caraïben was over het algemeen slecht. In alle grotere assemblages in deze studie werden hoge waarden van dentale pathologie waargenomen, voornamelijk onder de volwassenen maar ook onder een aanzienlijk deel van de kinderen. Hoewel orale gezondheid en hygiëne zelden genoemd worden in de etnohistorische bronnen, geven ook deze aan dat orale gezondheid en hygiëne zeer slecht waren. De meeste mensen hadden dentale pathologieën zoals cariës en de daarmee geassocieerde ontstekingen, en de meeste volwassenen zouden hebben geleden aan tandvleesontsteking, premortem tandverlies, en soms van abcessen.

Tandslijtage begon om jonge leeftijd, vanaf de leeftijd van 1-2 jaar. Vrouwen hebben over het algemeen hogere pathologiewaarden dan mannen.

De toename in dental pathologieën en het veranderende patroon van tandslijtage door de tijd heen tijd is aanzienlijk, en geeft aan dat orale gezondheid met de tijd verslechterde. Gebreken, zoals glazuur hypoplasie tamen ook met de tijd toe. De belangrijkste factor in de afname van orale gezondheid door de tijd heen in de regio is de veranderende voedselpraktijken. Naarmate het dieet steeds meer koolhydraten bevatte, en voedsel aanzienlijk verfijnder werd, werden dentale pathologieën steeds veelvoorkomender. De mogelijke oorzaken van deze zeer duidelijke verschillen in voedselpraktijken zouden onder meer veranderingen in sociaal-politieke organisatie, klimaatverandering en bevolkingsgroei kunnen zijn, of een combinatie van deze potentieel samenhangende factoren. De bevolkingsgroei ging gepaard met een grotere druk op voedingsbronnen, en steeds slechtere hygiënische omstandigheden die leidden tot de verspreiding van besmettelijke ziekten.

Een totaal van 66 individuen (14,41%) tonen bewijs van slijtage die niet van de voeding afkomstig is, maar van het gebruik van de tanden als gereedschap.

Vijf dergelijke varianten van slijtage worden indeze studie onderscheiden. Elk is gerelateerd aan verschillende gebruiken van de tanden als gereedschap, hoewel het mogelijk is dat Type 1 het resultaat is van tanderosie in tegenstelling tot het gebruik van het gebit als gereedschap. Type 2, het meest voorkomende type, is een non-specifiek type, waarbij de voor- en achtertanden in verschillende mate gesleten zijn. Etnohistorische bronnen en eerdere studies van ambachtelijke activiteiten in de regio wijzen erop dat taken zoals het maken van kralen tot de verschillende activiteiten zouden kunnen behoren. Type 3, die bestaat uit groeven in het kauwvlak van de voortanden, is waarschijnlijk gerelateerd aan de vervaardiging van touw, naaien of vlechtwerk. Het aantal individuen met deze vorm van slijtage is klein. Interessant is dat in deze groep is er enige aanwijzingen zijn voor taakverdelingen onder mannen en vrouwen. De groeven varieren in grootte, vorm, en oriëntatie, echter, vijf van de vrouwelijke individuen tonen een duidelijk gelijke patroon van groeven in de voortanden, die het gevolg kan zijn van spinnen of weven, of van mandenmakerij . Verdere analyse met SEM is nodig om de exacte etiologie van dit slijtagepatroon te begrijpen. Type 4 zou mogelijkerwijs het resultaat kunnen zijn van het dragen van lipornamenten. Type 5 is een set unieke patronen van duidelijk, die waarschijnlijk het gevolg zijn van individuele gewoonten.

Het is waarschijnlijk dat alle individuen hun tanden gebruikten als gereedschap in het dagelijkse leven, zoals tegenwoordig bij het openen van plastic verpakkingen of het afscheuren van plakband. Een klein, maar toch substantieel deel van de bevolking gebruikte de tanden in specifieke ambachtelijke activiteiten. Dit fenomeen is sterker geassocieerd met mannen dan met vrouwe , wat wellicht aangeeft dat er een bepaalde taakverdeling was tussen de geslachten. Het is ook mogelijk dat mannen en vrouwen dezelfde of soortgelijke werkzaamheden op een andere wijze uitvoerden (met of zonder tanden).

Hoewel erg moeilijk is om specifieke ambachtelijke activiteiten aan te duiden, zijn er aanwijzingen gevonden voor zeer specifieke activiteiten, zoals mandenmakerij, het maken van touw (bijvoorbeeld voor visnetten), en het gebruik boog boren (bijvoorbeeld om stenen en schelpen kralen en hangers te maken). Deze ambachtelijke activiteiten zouden een grote mate van kennis, opleiding en deskundigheid hebben vereïst.

Een groot aantal individuen toonde een slijtagepatroon dat LSAMAT genoemd wordt. Deze studie heeft aangetoond deze vorm van linguale slijtage verder onderzoek benodigd, omdateen verscheidenheid aan activiteiten de oorzaak voor dit patroon zouden kunnen zijn. Het is waarschijnlijk dat een aanzienlijk deel van de individuen met LSAMAT zure voedsel at, of last had van maagzuur oprispingen, waardoor het lingual glazuur erodeerde (Type 1 LSAMAT). Type 2 LSAMAT komt duidelijker overeen met de bewerking plantenmateriaal met de tanden .

Individu 72B van de site van Chorro de Maíta, een jonge vrouw van 18-25 jaar, vertoont Intentional Dental Modification (IDM) van de bovenste snijtanden en hoektanden. De tanden zijn gevijld met een mate van precisie en symmetrie die suggereert dat een specialist met speciaal gereedschap de modificatie moet hebben uitgevoerd. De IDM is typerend voor mesoamerikaanse varianten, met name die gedocumenteerd is onder postklassieke individuen van de site van Lamanai, Belize. Dit type modificatie is uniek in de Caribische regio. In combinatie met een aantal andere aanwijzingen lijkt de IDM van deze persoon aan te tonen dat het gaat om een migrant die van het vaste land naar Cuba migreerde.

De analyses van gebitten in deze studie heeft nieuwe inzichten in de leefwijze en culturele praktijken van de pre -Columbiaanse Caraïbische Amerindianen gegeven. Individuen, gemeenschappen en regionale bevolkingen in het Caribisch gebied werden fysiek beïnvloed door hun voedselpraktijken en culturele praktijken. De sporen daarvan zijn op het gebit achtergebleven. Verschillen tussen de vindplaatsen , geven aan dat de voedselpraktijken varieerden per gemeenschap, waarschijnlijk als het gevolg van lokale omstandigheden en sociaal-culturele voorkeuren. De meeste gemeenschappen consumeerden grote hoeveelheden plantaardig voedsel. Taakverdeling tussen mannen en vrouwen, en de rol van vrouwen in de voedselproductie, zouden de oorzaak kunnen zijn geweest voor verschillende voedselpraktijken tussen mannen en vrouwen. Ondanks deze kleine verschillen, werd er verder geen bewijs gevonden voor statusverschillen in voedselpraktijken.

Gemeenschappen pasten hun voedselpraktijken in de loop van de tijd aan, en richtten zich in toenemende mate op de productie van meer verfijnde plantaardige voedingsmiddelen en de consumptie van meer agrarische voeding. Dit resulteerde in een drastische contrasterende slijtage- en pathologie profiel tussen de Vroeg Ceramische Periode en de Laat Cermische Periode, die samenviel met sociale en ecologische veranderingen op brede schaal tijdens de overgang tussen deze twee perioden. Hoewel het mogelijk is dat sociale complexiteit, bevolkingsgroei en/of klimaatverandering de oorzaak waren van veranderende voedselpraktijken, is enige voorzichtigheid geboden bij het aannemen van directe oorzaak-gevolg relaties. De mogelijkheden voor toekomstige uitbreiding van dit onderzoek liggen onder meer in de integratie van Archaïsch gebitsmateriaal en het secuur dateren van gebitten in het huidige databestand om vat te krijgen op de belangrijke temporele verschuivingen die in deze studie zijn aangetoond.

AFTERWORD

"*The only thing that archaeology can tell us for certain about ancient civilizations is that they were all skeletons who lived underground... the rest is speculation*" Chris Addison – stand-up comedian, writer and actor. 15th August 2010.

It can be hard enough to explain to friends, family, or any other non-archaeologist, what it is precisely that archaeologists do. The quote above humorously shows how we archaeologists often fail in explaining to others why what we do is in any way important. But as I have often experienced throughout the course of my research, the same applies to archaeologists among each other. My assumption that like-minded dirt-lovers would automatically find the study of the teeth of ancient dead people extremely exciting, turned out to be wrong. Therefore, this dissertation is an attempt to explain why boring old teeth are in actual fact incredibly interesting, to both the layman and the trained archaeologist.

But this highlights a deeper issue at the core of our field. Archaeology is one of the most diverse fields of research today, with an incredible variety of research questions, pertaining to a huge array of regions, time periods, societies, cultures, and communities, and perhaps an even greater set of multi-disciplinary tools to answer these questions. This multi-disciplinarity is essential to our scientific endeavours, yet sometimes leaves us less interconnected as a group of researchers working together with one common cause: learning about the history and development of the human race. The enormous number of specializations within archaeology, regarding both material and theoretical approaches, means that archaeologists among each other sometimes have less in common than archaeologists and the general public. In taking a dental anthropological approach, as a trained archaeologist, in an attempt to better understand foodways, health and disease, and crafting activities in the pre-Columbian Caribbean, I have constantly been aware of the fact that those of us who specialize ourselves in highly specific subfields of research, must continually reflect on our contribution to science and society as a whole. Having spent a total of eight years, from my Bachelor research onward, specializing myself in Caribbean archaeology and dental anthropology, I feel I may – in part at least – be able to explain to laymen and archaeologists alike why dental wear and pathology of pre-Columbian Caribbean Amerindians is fascinating and important. I now intend to broaden my scope, and who knows, one day I may be able to explain why ancient civilizations were not simply a bunch of dead people who lived underground. For now though, the rest is just speculation.