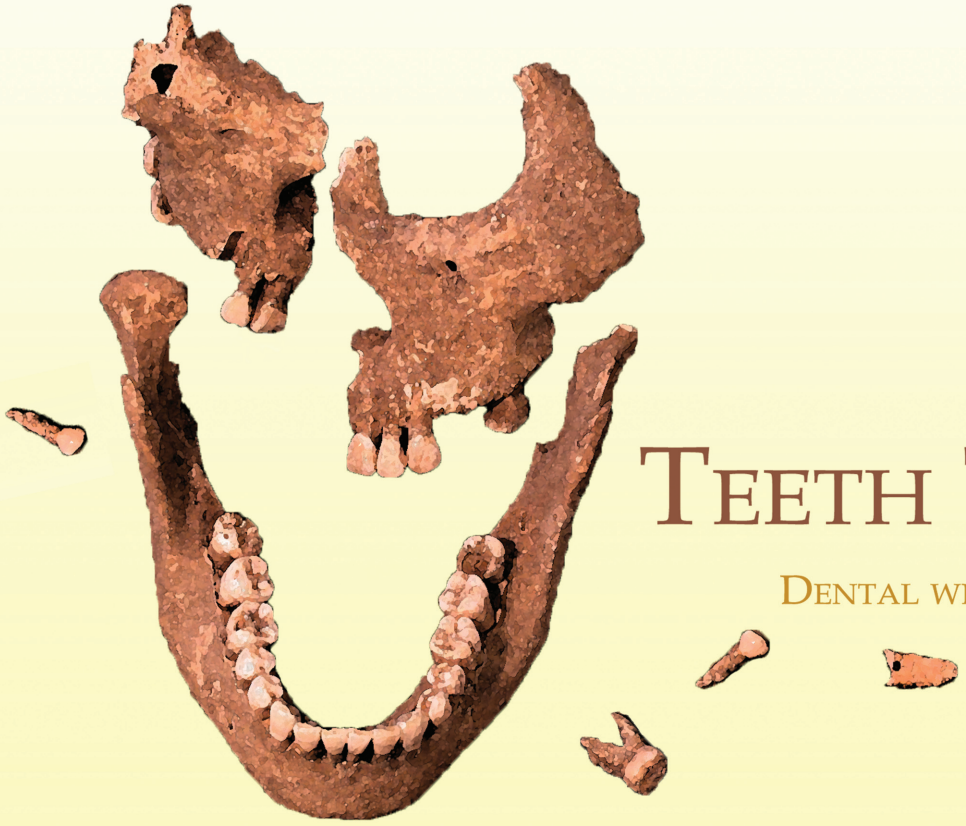

Teeth Tell Tales

Dental wear as evidence for cultural practices at Anse a la Gourde and Tutu

Hayley L. Mickleburgh

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MPhil thesis

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For Marley and Lily

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Contents

List of Tables and Figures

Tables

Figures

Chapter 1: Introduction

1.1 Human dental wear and its study

In its most simple sense, human dental wear is the wear and loss of the occlusal (or chewing) surfaces of the tooth crowns. Tooth wear is a normal process, resulting from a number of factors, which affects an individual progressively during his/her lifetime. In the discipline of dental anthropology, which studies all aspects of primate, fossil hominid, and modern human teeth, dental wear is often categorized in *masticatory* and *non-masticatory* (or *extra-masticatory*) wear.[1] Masticatory wear refers to the wear which occurs during normal tooth use for the mastication of food. Non-masticatory wear comprises all other forms of wear, which are not the result of food mastication. Modifications of the teeth due to occupational use, often termed 'teeth as tools' use, are an important example of non-masticatory wear (Alt & Pichler 1998).

Traditionally, dental anthropology also categorizes dental wear according to the agent causing the wear. Attrition and abrasion are identified as the two main components in dental wear. The former is caused by tooth-on-tooth contact, whereas the latter is the result of contact with foreign materials (e.g. food, abrasives in food, other objects held in the mouth). More recently, dental anthropology has come to consider a third agent in dental wear, due to influences from the discipline of modern dentistry: erosion. Erosion is the result of chemical dissolution of hard tissues due to the introduction of acidic chemicals into the mouth.

Making a distinction between the three components of dental wear is often very difficult in skeletal material. In modern dentistry, this aspect of dental analysis is paramount, as it is necessary for therapeutic reasons.[2] In skeletal material, however, distinguishing between these three components is usually impossible – and unnecessary for therapeutic reasons – since in these cases different processes tend to have overlapped and cannot be distinguished (Alt & Pichler 1998).

Once a human tooth has become worn, it does not remodel or repair itself. Tooth wear, therefore, is the cumulative result of all abrasive factors on the teeth during an individual's lifetime. In this way, it is possible that certain forms of dental wear become erased by later wear. On the other hand, it can be possible to distinguish multiple types of wear on individual teeth, often resulting from wear at different stages during lifetime. These characteristics make human teeth and their wear at the same time a snapshot of a person's lifetime, and a longer term picture. In archaeological terms, the human teeth and their wear could be considered a 'palimpsest'. Like a palimpsest, the human teeth can contain an enormous amount of information on an individual's life and lifestyle, however the different agents causing the patterns observed are often difficult to distinguish. In order to make sense of the complicated dental wear patterns, detailed statistical analyses must be done, and interpreted using a multidisciplinary approach.

[1] A distinction based on the categorization of the *act* which causes a particular form of dental wear, as opposed to a distinction on the basis on the *type of physical agent* which produced the wear.

[2] Once the agent causing the dental wear has been identified, appropriate measures can be taken in order to prevent further damage to the teeth.

1.2 Research Aims and Objectives

This study aims at recording and understanding the dental wear patterns in human dentitions from two archaeological sites in the Caribbean. The sites concerned are Anse à la Gourde, located on most eastern point of Guadeloupe, and Tutu, located on the small island of St. Thomas, U.S. Virgin Islands. The premise of this research is the assumption that dental wear patterns are informative of a great many aspects of human lifestyle and health. The use of the mouth and teeth in both masticatory and non-masticatory activities is assumed to leave traces which can be studied post mortem to infer the lifestyle linked to such activities.

In order to build a complete picture of these activities and the lifestyle linked to the dental wear patterns, other lines of evidence are also followed here, such as ethnohistoric and ethnographic accounts, and evidence from modern dentistry.

Drawing on multiple lines of evidence is imperative to understanding the complicated patterns of human dental wear. In recording and statistically analyzing the dental wear forms, and comparing the results with previous archaeological dental wear studies, modern dentistry studies, ethnohistoric and ethnographic accounts, and the archaeological site context, this research aims to answer a number of questions:

1. How is the dental wear at Anse à la Gourde and Tutu characterized?
2. Which causes and consequences can be linked to the dental wear patterns?
   - Is there evidence for the use of teeth as tools?
3. What were the implications of the dental wear for the oral and general health of the individuals?
4. What are the differences and similarities between the sites; how can these be explained?
5. What are the differences and similarities between the different age and sex categories; how can these be explained?
6. What can the patterns of dental wear tell us about general health and lifestyle of these Amerindians?

In answering the aforementioned questions, this study also aims to emphasize the importance and value of studying human dental wear in archaeology. Like the study of the human skeleton by osteoarchaeologists, or the study of any category of material culture by archaeologists, the study of human dental wear proves itself to be an extremely useful source of information on past peoples' lives.

1.3 Previous research in the field

1.3.1 History of the field

The study of dental wear patterns in prehistoric populations is part of a larger subject of research, namely the study of teeth as a key to the biology and behaviour of past and living populations. This area of research was established in the early sixties, though important work on the subject was done much earlier. Now widely known as dental anthropology, this multi-disciplined field of research has proved itself valuable to researchers in human biology, anatomy, biological anthropology, forensic odontology, osteology, (palaeo)pathology, evolutional biology, bioarchaeology, and a range of other disciplines.

With the work of the likes of Lyell and Darwin in the second half of the nineteenth century, and the new and exciting ideas they produced, many

scientists worldwide were inspired to concentrate on the study of the human dentition. The number of studies and papers on the subject of the dentition of prehistoric and 'primitive' populations increased greatly in the 1920s. In this period and the years after there were great advances in the knowledge about dental structures, hominid dental evolution, dental morphology, dental pathology, and dental wear (both abrasion and attrition). A.A. Dahlberg is most often considered to be the 'father of dental anthropology' as it was his early work in the 1930's and 1940's which laid the very important foundations for further research in the field. A Ciba foundation meeting in September 1957 included a colloquium on dental anthropology, where among others A.A. Dahlberg spoke on "The American Indian Dentition" and various other subjects in dental anthropology. The results of this colloquium were later published in Brothwell's 1963 volume "Dental Anthropology" (Brothwell 1963; Kelley & Larsen 1991).

The field of dental anthropology had now well and truly taken flight, which resulted in an explosion of research into the anatomy, growth, physiology and pathology of teeth during the twentieth century. This opened up avenues for the application of this research in archaeology (Hillson 2005).

From the mid-sixties on, interest in the study of teeth increased. A sub-area of dental anthropology, forensic odontology, developed in the early seventies. It proved to be extremely valuable for modern investigations into homicide and accidental deaths. Victims of such accidents as the collapse of buildings could be identified by their dental records. Thanks to the rapid development of forensic odontology, much research was done that was also of value to other sub-disciplines of dental anthropology (Kelley & Larsen 1991).

Another great expansion of research in dental anthropology in the eighties, 25 years after the publication of Brothwell's classic volume "Dental Anthropology", finally resulted in a symposium in 1988 at the annual meetings of the Dental Anthropological Association and the American Association of Physical Anthropologists, named "Horizons of Dental Anthropology". In 1991 a new volume on dental anthropology was published, edited by Kelley and Larsen, that included revised versions of the papers presented at the symposium in 1988. By now different perspectives and approaches to the study of teeth had been brought together, and yet more innovative research was done (Kelley & Larsen 1991).

The extremely broad and multi-disciplined character of the field of dental anthropology, means that a great number of researchers now consider it to be an important part of their work. Research categories in dental anthropology include primate and fossil hominid dental studies, modern human dental studies, metrics, morphology, (oral) health, evolution, growth, genetics, usage (dental wear), forensics, and ethnographic treatment (Scott & Turner 1988). The range of research which can be classified as dental anthropology is increasing rapidly, not the least in the field of archaeology, where researchers are becoming increasingly aware of the value of dental anthropological research (Mayhall 2000).

1.3.2 Research related to the present study

Dental wear is one of the most important subjects of research in dental anthropology, and has received much attention from the establishment of the discipline onward. Some of the most influential studies in this field, and those

of importance to the present study are discussed here.

1.3.2.1 Diet and subsistence

An influential work concerning the use of dental anthropology in archaeology was J.E. Anderson's study of molar tooth wear in pre-agricultural Mexican Amerindians. Anderson studied pre-agricultural Mexican Amerindian dental wear and compared it to later agricultural Mexican Amerindian dental wear. The first group exhibited molar wear which was characterized by crescents of enamel on the occlusal surfaces, whereas the second group did not. Anderson's observations triggered excitement, as it seemed that dental wear types could be the key to information on the economy and diet of ancient peoples (Anderson 1965; Turner & Machado 1983). In the years following Anderson's work, several different patterns of wear were reported for prehistoric dentitions, which could be linked to certain diets or subsistence forms (e.g. Fine & Craig; Puech 1979; Smith 1982).

Another important study concerning dental wear which could be linked to the subsistence and diet of prehistoric populations was done by B.H. Smith. Smith proved that there are *systematic* differences in patterns of tooth wear related to major differences in subsistence and food preparation. In an article published in 1984 she presents evidence for flatter molar wear in hunter-gatherers, due to the mastication of tough and fibrous foods, and oblique molar wear in agriculturalists, due to the higher proportion of ground and prepared food in the diet. Smith also briefly touches on the topic of the occlusal surface shape of molars in her article. It has been proven that agriculturalists often develop a cupped occlusal surface shape whereas hunter-gatherers do not develop cupping in such a way. The most likely cause of this difference in wear patterns is the fine particles of grit that are present in the processed foods eaten by agriculturalists. It is known that food that has been ground in preparation for consumption often contains tiny particles of stone which come loose from the grind during the processing of the food (Costa & Greaves 1981; Larsen et al. 2002; Smith 1984).

1.3.2.2 Systems for recording dental wear

Concerning the systems used for recording masticatory dental wear, a number of researchers have made significant advances in dental anthropology.

Traditionally, the dental wear evaluation systems developed by Brothwell and Murphy have been used by dental anthropologists and physical anthropologists alike. Both of these dental wear evaluation systems are based on a grading system where numerals represent differing degrees of dentine exposure and loss of crown height. Often the difficulty of these types of evaluation systems is the fact that they either pertain only to the molars or they make little or no differentiation between the different types of teeth (incisors and canines, premolars, molars). In reaction to this problem, Stephen Molnar developed a more detailed dental wear evaluation system in 1971.

Molnar published an influential article on the subject of recording dental wear, in which he presents the data he acquired while studying dental wear among the skeletal remains of North American Indians from three areas: California, the Southwest and the Valley of Mexico. To determine the degree of tooth wear Molnar uses 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. Molnar increased the accuracy of this scoring system by providing different criteria of wear degree for each element type. Incisors and canines, for example, are subject to different types of wear than premolars and molars. Therefore, a score of 4 for the level of dentine exposure, given to an incisor or canine, would indicate the presence of a small dentine patch and the loss of less than one-fifth of the crown, whereas the same score of 4 given to a molar would indicate the presence of three or more small dentine patches (Molnar 1971).

Using this scoring system Molnar was able to prove a positive correlation between tooth wear and cultural factors, as the types and degrees of wear in the different groups he studied showed significant differences. He also found differences between the sexes within each population. By studying the correlations between tooth wear and cultural factors, Molnar argues, valuable information about human-environmental relationships can be gained (Molnar 1971).

Systems for recording non-masticatory or special dental wear are a more recent development, and are by far outnumbered by masticatory dental wear evaluation systems. Nonetheless, two very important grading systems for *dental chipping* and *dental notching* should be mentioned here for their relation to the present study.

An Italian team of scientists from the Department for Evolutionary Biology of the University of Bologna have recently done research into masticatory and non-masticatory dental modifications in the Epipalaeolithic necropolis of Taforalt, Morocco. The sample exhibited a large number of chips in the enamel of the teeth, and some teeth also showed notches or grooves in the occlusal and interproximal surfaces. Bonfiglioli et al. conclude that the chipping observed in the Taforalt dentitions is caused by increased stress on the posterior teeth due to avulsion of the maxillary central incisors. Food processing activities and non-masticatory activities would have shifted to the posterior teeth, causing them extra strain. The chips observed in the sample differed in their severity, which prompted Bonfiglioli et al. to develop a grading system to classify the severity of the chips. Chips are thus given a numerical grade, from 1 to 3, according to the size and depth of the chip and the amount of dentine involved. The dental notches were graded in the same manner, with a scale from 1 to 3 to indicate the size and depth of the notch. In the case of dental notching it was concluded that the notches were caused by repeated contact with wooden or bone needles, sinew, or plant fibre threads (Bonfiglioli et al. 2004).

1.3.2.3 Non-masticatory dental wear

In his influential overview of the field of dental anthropology, A.A. Dahlberg discussed the use of teeth as tools, suggesting "*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 were put to (Dahlberg 1963:237).

Stephen Molnar also contributed to the study of non-masticatory dental wear; dental wear which is the result of the use of the teeth as tools in certain tasks or for the manufacture of certain objects. His complete and comprehensive overview of the non-masticatory uses of teeth sparked excitement and interest for this subfield of dental anthropology (Molnar 1972).

More recently, another influential researcher in the field of both masticatory and non-masticatory dental wear is Clark Spencer Larsen. The main focus of Larsen's work in dental anthropology has been on the biocultural adaptation of Amerindian populations. He has made

significant contributions to our knowledge of the use of teeth as tools, including his research into tool use in the western Great Basin (Larsen 1985).

Of importance to the present study is Larsen's recent work together with Teaford and Sandford, on the dentition of 35 individuals excavated at the site of Tutu, St. Thomas, U.S. Virgin Islands. In this study the Tutu teeth were assessed for pathological conditions, as well as masticatory and non-masticatory wear. Evidence was found for the importance of teeth in the technology of the Tutu population, along with evidence for exposure to abrasives in the diet, such as sand and grit (Larsen et al. 2002).

A particular form of dental wear was observed in the Tutu teeth, whereby the lingual surfaces of the maxillary incisors (and sometimes also the maxillary canines and first premolars) display a characteristic type of wear which results in the eventual loss of enamel along the entire lingual surface of the tooth without any corresponding wear on the mandibular teeth. This type of tooth wear was first elaborated on by Turner and Machado in an article published in 1983, although it has been observed and reported by other researchers such as Linda Budinoff (Budinoff 1987; Larsen et al. 2002; Turner & Machado 1983).

1.3.2.4 Dental wear studies in the Caribbean region

The importance of comparison of the sample under study with dental material from the same natural and cultural environment has been emphasized by among others D.R. Brothwell (Brothwell 1981). However, for the Caribbean region this is a somewhat difficult task, due to the lack of dental anthropological work done here. Apart from Larsen et al.'s dental wear study mentioned above, little dental anthropological work has been done on Caribbean skeletal assemblages. Listed here are some of the studies which mention or include dental analysis.

Linda Budinoff made a number of observations that are important in relation to the present study. She did an osteological analysis of 34 skeletons that were excavated at the Saladoid/Ostionoid site of Maisabel on the north coast of Puerto Rico. She observed *"frequent ante mortem chipping"* in many of the site's adult dentitions, which she suggests is caused by crushing hard substances such as bone or the shells of crabs and shellfish. Budinoff noticed that the pattern of chipping she observed, resembled a pattern described by Turner and Cadien, which they named 'pressure-chipping' due to the resemblance to flake scars on chipped stone artefacts (Budinoff 1987; Turner & Cadien 1969).

Turner and Cadien analyzed 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"* (Turner & Cadien 1969:303). They strongly associate 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.

Apart from the above mentioned research into dental chipping, there are numerous studies focused on burial practices or general physical anthropological aspects of skeletal material in the Caribbean and

neighbouring regions. Many of them hardly touch on the subject of dental anthropology, and when they do it is mostly to document pathological conditions such as abscesses and caries. I have come across some descriptions of severe dental wear which may warrant further attention in the light of the present study.

Dental remains found at the site of Hope Estate (St. Martin) have been described as generally very heavily worn, and one of the burials in particular displays apparent 'heavy wear of the incisors', however the description of dental wear patterns is limited to these minimal comments (Bonnissent & Richier 1995).

The dentition of a burial found at the site of Puerto Ferro (Puerto Rico) displays severe dental wear, according to the authors caused by the use of the teeth as tools. There also seems to be severe wear and trauma on the right side of the mandible. The sparse comments on the state of the teeth leave us only to speculate whether the authors are possibly describing dental chipping or merely heavy dental wear (Chanlatte Baik & Narganes Storde 1991).

M.R. Khudabux mentions an "*inconsistent tendency of increasing attrition with age*" for the dental wear pattern of 8 of the 36 skeletons from the site of Tingi Holo Ridge (Suriname), however no further description is given of the dental wear, nor are suggestions given for the cause of this heavy wear (Khudabux 1991:816).

F. Luna Calderón mentions a difference in severity of dental wear in dental material from the site of Boca del Soco (Dominican Republic) between males and females, which he attributes to a difference in diet between the sexes. What the exact differences are in dental wear patterns is not described, nor does the author give any suggestion for what the dietary differences may be (Luna Calderón 1983).

1.3.3 Author's previous research

The present work is the result of an ongoing study into the dental wear of the prehistoric inhabitants of the Caribbean region. This research started in the context of the author's Bachelor thesis at Leiden University (Mickleburgh 2005). This work focused on developing an appropriate system for recording and analyzing human dental wear in detail, using 10 dentitions from the Anse à la Gourde skeletal assemblage in a pilot study.

The dental wear evaluation system developed during this study has been used in the present study, and further elaborated upon with a database to store and analyze the increasing amounts of information. The results of the pilot study have been used as the point of departure for the present study, in which a much larger sample is analyzed and interpreted using multi-disciplined insights.

In the pilot study in 2005 a number of (possibly) non-masticatory forms of dental wear were identified in the 10 Anse à la Gourde dentitions, which alluded to the intensive use of the teeth as tools in certain activities. These forms of dental wear were dental chipping, dental notching, and what was identified as LSAMAT.[3] Next to these special forms of dental wear, the degree and shape of occlusal surface wear was recorded. The results of the latter analysis pointed towards an important agricultural component in the diet of the inhabitants of Anse à la Gourde, as a large portion of the molars were worn either obliquely or cupped. The Anse à la Gourde dentitions were compared to the published results of the study of the Tutu teeth by Larsen et al., as at this point in time I had not yet studied these teeth myself (Larsen et al. 2002). Many similarities were found

[3] Lingual Surface attrition of the Maxillary Anterior Teeth (Turner & Machado 1983).

between the Anse à la Gourde teeth and what was known of the Tutu teeth. Both assemblages were affected by a high degree of dental wear and a reasonably high rate of caries, both apparently had LSAMAT, and both had dental notches.

Using what was known of dental chipping, dental notching, and LSAMAT from dental anthropological literature, it was concluded that all three could have been caused by non-masticatory activities. Dental chipping, however, was most likely the result of the combination of masticatory and non-masticatory activities.

The cracking of shellfish and crabs, together with grit adhering to foods was suggested as the cause of the chipping. Dental notching was not discussed in detail, but was assumed to be the result of non-masticatory activities such as basketry or sewing, as there is a general consensus on its cause in the literature. LSAMAT was interpreted to be a non-masticatory dental wear, moreover Turner and Machado's suggestion that it may have been caused by the sucking of raw cassava peel was rejected on the basis that raw cassava is known to be toxic.

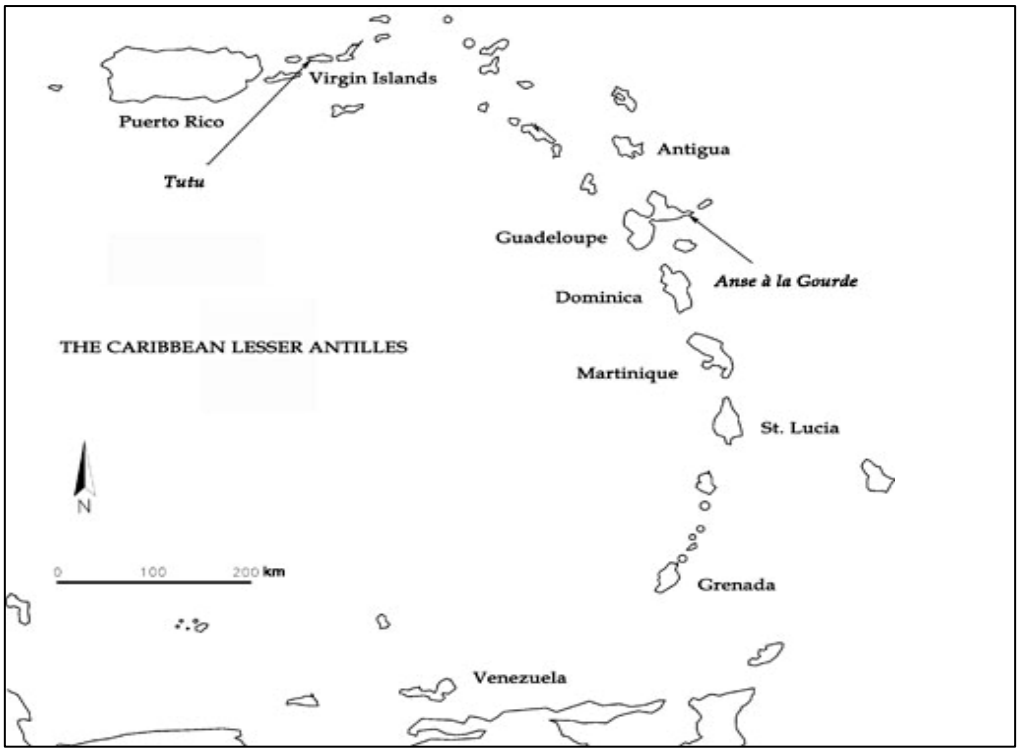
Statistical analysis, for example of age and/or sex differences, was not viable using such a small sample. Further research using a much larger sample was therefore argued for.

The pilot study concluded that the Anse à la Gourde dentitions had been exposed to many different factors which produced the dental wear patterns that were observed during the study. The large number of factors at work in producing the dental wear patterns was confusing, however, as it made it very difficult to distinguish between the different causes and consequences of the dental wear. The study of a larger sample, and the direct comparison with other assemblages was suggested to solve this issue.

Chapter 2: Natural and Cultural setting

2.1 Introduction

The dentitions used in this study have been selected from skeletal assemblages which were excavated at two sites in the Lesser Antilles. The largest assemblage comes from the site of Anse à la Gourde, on the east side of Grand-Terre, the limestone part of the island of Guadeloupe, which is located at the southern end of the Leeward Islands.
The other skeletal assemblage originates from the site of Tutu, located on the eastern end of the volcanic island of St. Thomas, U.S. Virgin Islands. The latter are located to the east of Puerto Rico, joining the Lesser Antillean arc with the Greater Antilles towards the west.
The group of islands which form the Lesser Antilles stretch from Trinidad and Tobago north to the Virgin Islands; a distance of about 850 km (Maury et al. 1990). The Lesser Antilles comprise a mix of (mostly) volcanic islands and low-lying limestone islands which formed due to tectonic movements of the Caribbean plate towards the Atlantic plate around 45 million years ago. During this process, the Atlantic plate was pushed under the Caribbean plate, causing radial cracks through which the plastic interior escaped and subsequently formed the volcanic islands of the inner arc of the Lesser Antilles. 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. From Guadeloupe northward the Lesser Antillean arc splits, with volcanic islands in the western arc and limestone plateau islands in the eastern arc (Fox & Heezen 1975).
The fact that the Lesser Antillean islands have not been attached to the mainland at any point in time is reflected in the fauna which could be found there in the time of Amerindian settlement. No mammals larger than small rodents such as *hutia* and *rice rats* could be found naturally, although the Amerindians did introduce some animals to the islands, such as small



dogs[4] and the *agouti* from the South American mainland (Rouse 1992; Wilson 1997).

The different islands in the Lesser Antilles vary considerably in their ecological conditions, with islands like Dominica and Trinidad being covered with dense forest, while other islands like Antigua are more arid. The forests would have provided the Amerindians with an abundance of wild fruits and vegetables such as palms and guave berries, whereas fish, shellfish and waterfowl would have been available along the shores and in reefs and mangrove swamps. The variety in food resources from island to island would have invited the development of trading networks between them (Rouse 1992).

Culturally the Lesser Antilles were initially assigned to the domain of the Island Caribs, whereas the Greater Antilles were supposed to have been inhabited by the Taíno. This assumption was based on the poorly understood accounts of other islands and their inhabitants given by the Taíno in their initial meetings with the Europeans. It is now understood however, that the Caribbean region contained numerous different ethnic groups, who remained culturally diverse while maintaining continuous trade relations and interacting with other groups (Wilson 1997).

With regards to the two sites which have provided the dental material for this study, Tutu falls within the Taíno cultural influence sphere of the Greater Antilles, as the Virgin Islands are archaeologically and historically known to have been inhabited by the Taíno (Righter 2002; Rouse 1992).

Anse à la Gourde on the other hand, is characterized by a Cedrosan Saladoid component and subsequently a Troumassoid component. The latter period was the focus of investigation at the site, and the skeletal assemblage studied here relates to that period. Troumassoid ceramics are not considered to be Taíno assemblages but are a more regional development in the Lesser Antilles (Allaire 1997; Hofman 1993; Hofman et al. 1999; Rouse 1992). Nonetheless this region has been shown to have been strongly influenced by Taíno chiefdom society and ideology, most likely due to its position along the Lesser Antillean route of trade and interaction which connected the Greater Antilles with the South American mainland (Hoogland & Hofman 1999).

2.2 Anse à la Gourde

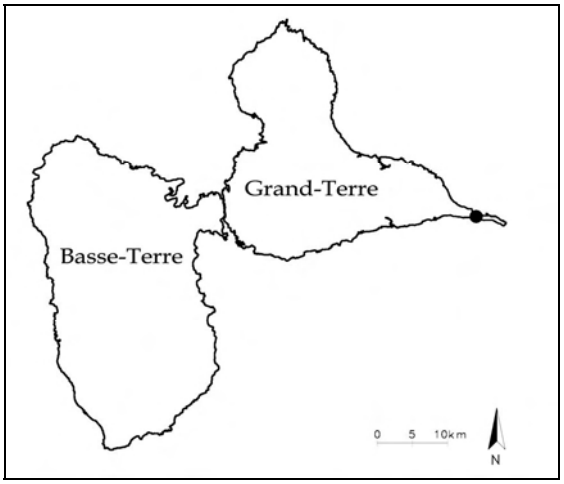


Figure 2: Anse à la Gourde, located on the island of Guadeloupe, courtesy of Dr. M.L.P. Hoogland

2.2.1 The natural setting

Anse à la Gourde is situated on the east side of the limestone island of Grand-Terre, Guadeloupe. The site, which is located on the lower coastal limestone terrace, is situated in a large bay facing north into the Atlantic Ocean, which is protected from the sea by a reef barrier.

[4] The ancestor of the modern *chihuahua*, which was small and edible (Griffin 2004).

The eastern part of Grand-Terre, consists of a narrow strip of land, just 0,5-1 km wide, which ends at Pointe des Châteaux. The site is 4,5 ha. in size, extending 300 m along the coast and 150 m inland. The location of the site ensures easy access to the north of Grande-Terre and to the east towards the islands of La Désirade and Petite-Terre. Access to the south and southern islands is also possible. It seems that the location of the site would have been strategic for maritime activities such as travel to other locations and fishing (Delpuech et al. 1999).

Bordering the sand beach there is a 3-4 m high coastal dune, behind which there is a shallow depression filled with a clayish sandy sediment, which is now covered with vegetation. Behind the depression, the rest of the terrace consists of bedrock covered by a shallow sandy sediment. Originally, before A.D. 600, the bay in which Anse à la Gourde is now situated was enclosed by a sandy bar, and was saline. The sea level was approximately 1-2 m lower then; when it rose in the period between A.D. 600 and A.D. 1000 the salt pond was opened to the sea and the sandy bar gradually eroded. A mangrove formed in the western part of the former salt pond. After A.D. 1000 the sandy bar was completely eroded, and a new sandy beach appeared on the southern side of the former salt pond. The dunes that are now present started to form and the bay was from then on only protected by a reef barrier (Delpuech et al. 1999; Hofman et al. 1999).

The climate in this region is one of the most arid in the Guadeloupian archipelago, with less than 1000 mm of precipitation per year (Hofman et al. 2002).

2.2.2 The cultural setting

Three occupation phases can be distinguished at Anse à la Gourde using (mainly ceramic) artefact analysis, between approximately A.D. 400 and A.D. 1400. The first period of occupation dates roughly from A.D. 400-600/800, and is represented by a Cedrosan Saladoid assemblage with diverse vessel and rim shapes and decorative modes such as white-on-red painting, polychrome painting, zoned-incised-crosshatching and incising, and modelled-incised adornos with anthropomorphic and zoomorphic representations. The apparent abandonment of the site after this phase coincides with the changing of the coastal environment as described in 2.2.1.

The second occupation phase is early-Troumassoid, dating from A.D. 800-1200, and includes simpler and less diverse ceramic shapes. Griddles with legs are found, along with many zoomorphic adornos and a variety of funerary vessels. Decoration is mainly red monochrome with fine-line and broad-line incisions.

The last of the three occupation phases is late-Troumassoid, A.D. 1200-1400, and is characterized by vessels with simple contours with rounded or flat rims, often with punctuations. Decorative modes include incisions on a red-slipped surface, but are mainly not painted but modelled into figurines, adornos and notched fillets (Hofman et al. 1999).

The occupation of Anse à la Gourde was characterized by the construction of many round or oval house structures which seem to have been adapted to endure tropical storms and hurricanes. Evidence of these structures was found in the great number of postholes which were carved into the underlying bedrock. The house plans were large, varying from 8-13m in diameter, and 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 burials excavated at Anse à la Gourde were located within the

habitation area, and for the largest part were associated with the house structures identified there. The deceased were probably interred in their houses, in the living quarters of their family. Although all burials are located in the habitation area, they occur in clusters comprising of 3 to 10 burials (Hofman et al. 2001b).

The burial practices observed at Anse à la Gourde along with the strong association of burials with house structures indicate a close affinity with the dead and ancestors. In most cases the dead seem to have been wrapped in some kind of container (most likely a hammock) after having been desiccated over a fire. After interment in a shallow, open pit while decomposition of the soft tissues took place, certain bones were selected and removed or reburied (Hofman et al. 2001a; Hoogland et al. 1999).

Stable isotope analysis of bones collagen samples from 21 individuals[5] at Anse à la Gourde found indications of a particularly heavy reliance on marine protein, although in general the Anse à la Gourde inhabitants consumed a varied diet, with the use of C3 and C4/CAM plants and some terrestrial protein as well (Stokes 1998).

2.3 Tutu

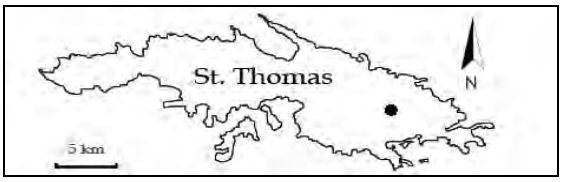


Figure 3: Tutu, located on the island of St. Thomas, U.S. Virgin Islands

2.3.1 The natural setting

The site of Tutu was located in the inland valley of Turpentine Run, about 1,75 km from the coast on the eastern side of St. Thomas, U.S. Virgin Islands.[6] The site, which comprised about 2.2 ha. of pasture land, was situated in one of the few areas of flat land on the volcanic island of St. Thomas, which consists mainly of gently sloping land with summit areas of over 300 m above sea level and a highest point of about 500 m above sea level. Although the soils of the small island of St. Thomas are mostly thin and rocky, the site of Tutu has access to fertile soil. Together with its flat ground and fertile soil, Tutu also enjoyed immediate access to fresh water (the Terpentine Run River), a continuously blowing trade wind, a protected defensible position, access to large trees for house and canoe building, and access to the coast via a major stream (Righter 2002).

The climate of St. Thomas is maritime tropical, with temperatures never dropping below 19 °C during winter and rarely rising above 32 °C on the hottest days in summer. Trade winds blow throughout the year from the northeast, east and southeast, making it necessary to construct windbreaks to protect crops in open flat areas like Tutu; something which was apparently done by Tutu's prehistoric inhabitants (Righter 2002).

The most extensive rainy season is in the month of November, although there is another in May and June. Hurricanes and tropical storms are experienced irregularly, although most often they occur during the months between June and November (Righter 2002).

[5] Individuals: F304, F311, F288, F195, F342, F212, F332, F335, F171, F199, F138, F196, F108, F202, F350, F378, F207, F339, F050, F339, and F139 (Stokes 1998).

[6] The site no longer exists, as the excavation was a rescue operation pending the construction of a large shopping centre, which now occupies the terrain (Righter 2002).

Today, the vegetation of St. Thomas is very different from that of the prehistoric period, as the forests were cut during the colonial period in order to make way for plantations. The site itself was only marginally affected by farming practices and seems to have not been used for residential purposes since the end of the prehistoric occupation at around AD 1500 (Righter 2002).

2.3.2 The cultural setting

The site of Tutu was inhabited during two major occupation phases: one between cal. AD 65 and cal. AD 900 and the next between cal. AD 1150 and cal. AD 1500. In both phases of occupation the village consisted of a central plaza/burial precinct with structures dispersed around it, and the refuse areas behind the houses. Burial patterns at Tutu suggest that kinship formed the basis of social order in the early (Saladoid) phase, most likely with a dominant unilinear descent group in the village. In the later phase (Chican Ostionoid), the burials seem to reflect the higher level of social complexity which was a trend throughout the northern Antillean region due to social and political change. The individual household seems to become more important at Tutu, with only a select number of burials occurring with ceramic goods, and burials being clustered in specific areas near houses as opposed to being located in a central cemetery (Righter 2002).

Although there seems to have been a shift towards a greater difference in status of individuals in the later occupation phase, the overall dietary pattern demonstrated through stable isotope analysis suggests that in both phases individuals had equal access to the range of available foods (Righter 2002).

Even so, it is clear that life at Tutu was not particularly easy, as there is evidence of stress in the skeletal remains found there. The people of Tutu likely suffered from on-going iron deficiency and endured hard physical work; as a consequence, there would have been long-term stress on bones and articular surfaces. Also, they played host to treponemal diseases which resulted in lesions and diffuse pitting (Righter 2002).

Root crops were used as subsistence foods, along with a wide array of tree fruits and wild plants. In addition people relied on marine animals; mostly (reef) fishes along with molluscs and crustaceans. Furthermore, terrestrial animals such as small mammals, reptiles, and birds would have made up a part of the diet at Tutu (Righter 2002).

The results from stable isotope analysis of 24 bone collagen samples from Tutu have shown the Tutu diet to have been intermediate between marine protein sources and terrestrial protein sources and C3 plants (Norr 2002).

For the preparation and storage of the food, ceramics were fabricated from predominantly local clay types. Other artefacts were manufactured from *Strombus gigas* shells, such as beads, inlays, celts, scrapers, zemis, and pendants. On-site manufacturing of small lapidary ceremonial and ornamental objects took place in the early occupation phase, while in the later occupation phase massive stone ceremonial objects and semi-precious, exotic stone objects were procured and/or exchanged from neighbouring islands (Righter 2002).

During it's long occupation Tutu developed into a typical "classic Taíno" village, most likely overseen by a "*minor chief in a system of hierarchical villages organized under a paramount chief whose headquarters were elsewhere*" (Righter 2002:353).

Chapter 3: Materials and Methods

3.1 Introduction

The dental materials chosen for this study represent individuals from two sites in the Lesser Antilles which can be said to fall within the same cultural contact sphere, while still representing a geographical and cultural spread which makes comparison of the material very interesting. The Anse à la Gourde burials represent the Troumassoid period inhabitants of eastern Guadeloupe, whereas Tutu represents both a Saladoid and a Chican Ostionoid phase of occupation in eastern St. Thomas.
The methods of documentation used in this study are based on previous work I have done on human dental wear patterns in the form of a Bachelor thesis study (Mickleburgh 2005). This study was focused on devising a dental wear evaluation method which would clearly and accurately describe the observed wear patterns in great detail. The method proved to be very suitable for the detailed study of dental remains in its trial on 10 dentitions from Anse à la Gourde, and has therefore been used in the present study of a much larger sample.
The methods of interpretation used in this study are based on the comparison between results from statistical analysis of the data with multidisciplinary lines of evidence. In the discipline of dental anthropology statistical analysis of large amounts of data is deemed appropriate in order to interpret the data in a correct manner. However, statistical analysis is merely a tool to recognize certain patterns in the data, and cannot afford direct insights into the cultural specifics behind these patterns. This is where different disciplines can shed light on the matter. Ethnography, ethnohistory, and modern dentistry all have incredible 'archives of information' which can be of use in dental anthropology.

3.2 Sample material

The dental material selected for this sample consists of the dentitions of 66 individuals from Anse à la Gourde, and 26 individuals from Tutu. In total 1320 teeth have been analyzed.
The number of males, females, individuals of unknown sex, and children in the Anse à la Gourde and Tutu samples are presented in Table 1, while Table 2 gives additional individual information on age and number of teeth present per individual.[7]

3.2.1 Anse à la Gourde

Of the over 90 individuals excavated at Anse à la Gourde only 66 individuals still possessed (a part of) their dentition. The other individuals had lost these post mortem due to burial practices or taphonomical processes (Hoogland et al. 1999).[8]
The skeletal remains were generally poorly preserved. In most cases the maxilla and mandible were fragmented, which allowed the loose teeth to be studied easily under the microscope.

[7] For Anse à la Gourde this information was acquired from the unpublished results of the physical anthropological study by M.L.P. Hoogland and R.G.A.M. Panhuysen. In the case of Tutu this information was gathered from the report of investigation submitted to the Department of Planning and Natural resources, Government of the Virgin Islands of the United States (Sandford et al. 1997).

[8] At Anse à la Gourde burials were often disturbed after decomposition of the soft tissue in order to remove parts of the skeleton, such as the long bones or the cranium (Hoogland et al. 1999).

However, this fragmentation also made it impossible or extremely difficult to observe the teeth in occlusion; the latter allows much greater insight into wear patterns caused by occlusal contact of the teeth (attrition), which in turn is important to be able to distinguish between different causes of dental wear.
In some cases the poor condition of the skeletal remains has made it impossible to determine age or sex (M.L.P. Hoogland pers. comm. 2007; R.G.A.M. Panhuysen pers. comm. 2007).

3.2.2 Tutu
Of the 42 individuals excavated at the site of Tutu, 26 individuals were included in the present study. The remaining 16 individuals represent those who lost their dentition due to burial practices or taphonomical processes, or infants who were too young to exhibit dental wear. In the case of individuals 8A, 8B, and 34, the location of (a part of) the remains was unclear, which led to them being excluded from the sample.[9]
As with the case of Anse à la Gourde, the Tutu material is often fragmented, although generally it is in a better condition than the Anse à la Gourde material.[10] Inspection of the teeth in their maxillary and mandibular positions, and in occlusion, was more often possible in this assemblage. The slightly better condition of the Tutu material has allowed aging and sexing of almost all individuals (Larsen et al. 2002; Sandford et al. 2002).

3.3 Method of documentation

3.3.1 Method of dental wear evaluation
The evaluation of dental wear in osteoarchaeological research usually entails establishing how large a portion of the crown of the tooth has been worn away (whether due to attrition, abrasion or erosion), and thus to what extent the dentine of the tooth has been exposed. Often the degree of dental wear observed in such a manner, is used together with other skeletal traits, to estimate an individual's age.
As mentioned at the beginning of this chapter, the methods of evaluating and recording the dental wear patterns observed in the sample are the result of a previous study in which a suitable method was sought. In the fields of osteoarchaeology and dental anthropology numerous systems for evaluating dental wear have been used. As not all of these systems are compatible or record dental wear in equal detail, studying and comparing patterns of dental wear from different assemblages can be challenging. Therefore a system of dental wear evaluation which is compatible with the most commonly used systems, and which also records a high degree of detail, is desirable.
It is of great importance that such a system also records other aspects of dental wear than the degree of crown loss and dentine exposure alone, as other aspects such as the direction of wear of the occlusal surface, and occlusal surface shape, are equally important factors in dental wear, which may reflect diet and subsistence forms.

[9] Parts of the skeletal remains of 8A and 8B were present at the Department of Anthropology at UNCG, in a separate location from the rest of the skeletal remains, pending further study of pathology. However the dentitions of these individuals could not be located in the 4 weeks I spent in Greensboro.
[10] Much of the fragmentation of the Tutu material was not the result of taphonomic processes, but was caused by construction work in the site prior to excavation (for the building of a shopping centre), and the heavy machinery used during excavation (Righter 2002; Sandford 1997).

A tooth wear evaluation method was devised by Stephen Molnar, which not only takes into account all of the above, but also recognizes the difficulty in applying one wear-evaluation to all types of teeth. The different types of teeth, i.e. incisors, canines, premolars, and molars, are subject to different kinds of wear, and this should be taken into account when evaluating their wear. The degree of crown loss and dentine exposure therefore is evaluated using a different scale for each of the three different types of teeth.[11]
The complete description of dental wear for each tooth is expressed with a three digit value. The first digit describes the level of crown loss and dentine exposure - or degree of wear - with the numbers 1 to 8. Number 1 is the value given to unworn teeth, whereas number 8 is the score for 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 direction of surface wear can offer valuable information on the subsistence and food preparation methods of prehistoric populations (Molnar 1971; Smith 1984).[12]
The last digit of Molnar's scoring method describes the occlusal surface shape of the individual teeth. According to Molnar this is very informative of certain *"special tooth functions"* (Molnar 1971:179). Molnar recognizes 6 different categories of occlusal surface form, however I have added two categories (*one half of surface rounded* and *other*) as not all the teeth in the present sample could be categorized using the six categories given by Molnar.
The first digit in Molnar's dental wear evaluation method, which refers to the degree of crown loss and dentine exposure, corresponds broadly to other evaluation methods which have commonly been used. In most cases, crown loss and dentine exposure are the only aspects of the dental wear which are recorded. Molnar's grading of crown loss and dentine exposure is based on Brothwell's and Murphy's methods (Brothwell 1981; Murphy 1959).
The different scores and their corresponding wear patterns of Molnar's dental wear evaluation method are presented in Table 3 (Molnar 1971).

3.3.2 Other forms of dental wear

The presence and severity of dental chipping was also documented according to a grading system. This system was developed by a group of Italian scientists, who have recently studied dental chipping in teeth from the Epipalaeolithic necropolis of Taforalt (Morocco). 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).
Bonfiglioli et al. have devised a grading system for the different levels of chipping which they classify on a three-grade scale by evaluation of its size and depth. 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*

[11] In this method incisors and canines are grouped together.
[12] As has previously been mentioned in section 1.3.2.1, an influential study by B. H. Smith has proved the existence of a link between different patterns of molar tooth wear between hunter-gatherers and agriculturalists. Hunter-gatherers develop flatter molar wear, due to the mastication of tough and fibrous foods, whereas agriculturalists develop oblique molar wear due to the higher proportion of ground and prepared food they consume (Smith 1984).

destroy the tooth" (Bonfiglioli et al. 2004:449).

Bonfiglioli et al. also devised a grading system for dental notching during the same study of the dentitions of the necropolis of Taforalt. Although the presence of a dental notch is recorded by Molnar's scoring system, the severity of the notch is not. To distinguish between heavy and light notching, any notches observed were also 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, Bonfiglioli et al. grade notching with a three-way grading 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 presence of LSAMAT[13] was recorded for the different dental elements, although this form of wear was not evaluated for its severity. This form of dental wear entails the abrasion of the entire lingual surfaces of the maxillary anterior teeth. The enamel is often worn away, and the remaining structure often has a polished appearance. As yet, no grading system has been developed for LSAMAT, and I have not introduced one myself for three reasons. The first is the fact that as the activity (or activities) which caused LSAMAT is as yet unknown, the severity of LSAMAT cannot be linked to duration or intensity of the activity. Secondly, if LSAMAT is presumed to be the result of a non-masticatory activity, then for the purpose of this study it suffices to know that LSAMAT is present, or in other words: a non-masticatory activity has been engaged in. Thirdly, the development of a grading system ought to be based upon the systematic study of far more teeth displaying LSAMAT from a far greater geographical and temporal area than is the case in the present study.

The presence and location of dental caries was recorded, although caries are not a form of dental wear but a dental pathology. The reason for recording dental caries is threefold. Just as dental wear is linked to certain diets and/or subsistence patterns, the frequency of dental caries can also offer information concerning the types of food consumed. Furthermore, the presence of dental caries, and the loss of teeth due to caries, can make evaluation of dental wear in the affected elements very difficult or impossible. Finally, teeth affected by caries are often weakened and therefore subjected to different or more rapid forms of dental wear. For these reasons it is important to record the presence *and* location of caries in order to be able to correctly interpret the patterns of dental wear observed.

3.3.3 The standard form

The patterns of dental wear observed in the sample were documented on a standard form. This standard form, which was developed during the trial study of 10 dentitions from Anse à la Gourde, was designed to capacitate a lot of information while remaining clear and simple to use.

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

[13] Lingual Surface Attrition of the Maxillary Anterior Teeth

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 result of this manner of recording is a very clear representation of the dental wear patterns in a manner which maintains the visual impact associated with these patterns of dental wear. Visual identification and assessment of dental wear forms is the basis of dental anthropology, and the interpretation of dental wear patterns is based on the visual analysis of individual dental elements in relation to the rest of the dentition. The standard form accurately represents individual elements in relation to the rest of the dentition, while remaining much simpler and more schematic than photographic representations would be.

The scores or grades given to dental wear, dental notching, and dental chipping of each individual tooth are scored in a table at the bottom of the sheet. The individual dental elements are numbered according to normal practice in modern dentistry. The mouth is thus divided into four quadrants, which are numbered from 1 to 4. The first quadrant contains all the teeth on the right side of the maxilla. The second quadrant contains the teeth on the left side of the maxilla. Quadrant three is comprised of the teeth on the left side of the mandible. The fourth quadrant contains the teeth on the right side of the mandible. The teeth within each quadrant are numbered from 1 to 8 in mesial-distal direction. Thus, according to this method, the first left maxillary molar would be numbered 2.6. The second right mandibular premolar would be numbered 4.5. The numbering of the dental elements is represented in Figure 4.

The age and sex of the individual (where known), is recorded in the top left hand corner of the form.

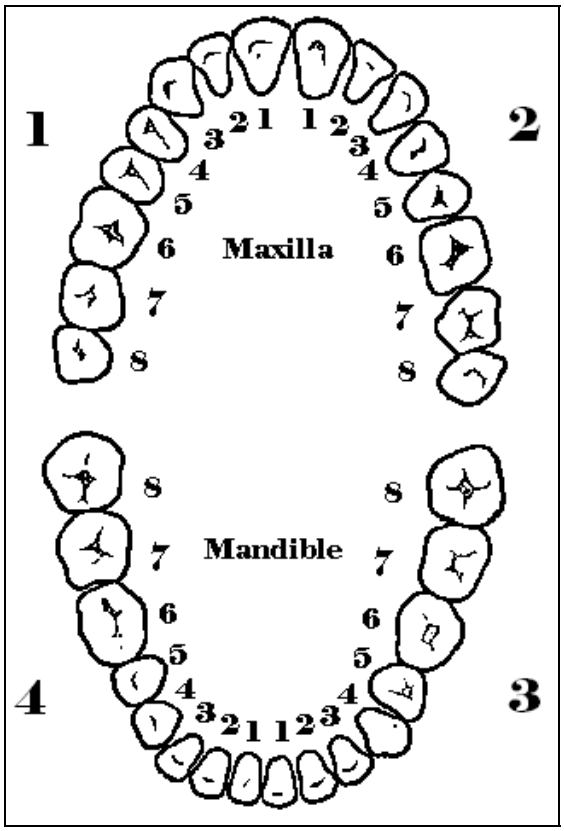


Figure 4: The numbering of the dental elements according to normal practice in modern dentistry

Between the depictions of the dental elements and the scoring table, there is room for remarks and additional observations. Figure 9 and 10 represent an empty and a filled-in example of the standard form (see appendix).

3.3.4 The database

A Microsoft Access database was maintained, alongside the standard form, in order to keep control of the large amounts of data being generated. The database records the exact same information as the dental wear form, although it of course does not retain the same visual aspects as the latter. It does, however, allow the all important statistical analysis of the data, which in many cases has provided answers to the questions asked in this study.

The database consists of two linked tables, each containing a different 'layer' 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 separate individual 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[14], 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 kept separate or combined with relative ease.

3.3.5 Photographs
High quality photographs were taken of certain dental elements chosen for their typical or exceptional dental wear. These photographs were taken at a resolution of at least 300 x 300 DPI. The photographs were taken purely for illustrative purposes, which is why only a small number of elements were photographed. The photographs were taken using a microscope with a digital Leica camera and software. In some cases the digital photos were altered using the Leica software, in order to make the wear patterns clearer. In all cases the alterations only concerned increasing/decreasing the contrast, or increasing/decreasing the brightness of the pictures.

3.4 Method of interpretation

As is mentioned in the introduction to this chapter, the use of multidisciplinary lines of evidence is an approach which is not only extremely useful in interpreting dental anthropological data, but it is also *necessary* in order to obtain the most complete possible picture of the cultural specifics of dental wear patterns.
Statistical analysis of the data may demonstrate that a certain portion of the population engaged in a non-masticatory practice which chipped the buccal surfaces of the anterior teeth, however, it is ethnography which tells us that the activity in question could be the pressure flaking of chert artefacts with the front teeth.
In the same way, archaeological investigations, ethnographical studies, ethnohistoric documents, and the field of modern dentistry can all offer insights for interpreting the statistical data from dental anthropological analyses. It is not, however, the intention of this work to apply the aforementioned disciplines as a 'cultural veneer' on to these statistical data in order to make them appealing to archaeology. Rather, it is my intention to use the insights provided by these disciplines in a combined effort to produce data which is not only relevant to archaeologists, but also to researchers from the other disciplines concerned.

[14] This refers to the resin casts taken of some teeth which were destroyed during Strontium isotope analysis.

Chapter 4: Results

4.1 Introduction

The results of the study of the dental remains from Anse à la Gourde and Tutu are presented here in an array of statistical analyses. In the discipline of dental anthropology many different statistical approaches are used, depending on the condition of the remains and the completeness of the data on them.[15] I have attempted to use as many of these as possible concerning the material I have studied. The reason for this approach is simple: just as using multidisciplinary lines of evidence greatly increases our knowledge of the use of the human teeth, so does the use of multiple methods for analyzing the data. Therefore, the approaches used are not mutually exclusive, but on the contrary their combined use improves our understanding of the dynamics of human dental wear.

The different aspects of dental wear have been divided into those concerning diet and subsistence, health and lifestyle, and special (non-masticatory) uses of the teeth. This is an artificial categorization, which does not fully reflect the great amount of interplay between the different factors involved in dental wear; however, as a unit of analysis this approach is the most appropriate for presenting the data at hand.

4.2 General statistical data

The general data on each individual from both sites is presented in Table 2. This table represents what is known of the age, sex, and number of dental elements per individual. For the site of Anse à la Gourde some age and sex estimations could not be made, due to the poor quality of the skeletal material.

4.3 Diet and subsistence

Relating to diet and subsistence strategies, the degree, rate and type of (molar) wear have proven to be extremely valuable indicators. In this context, the type of (molar) wear mostly refers to the angle of wear of the occlusal surface and the occlusal surface shape. The relationships between wear and subsistence, age, sex, and inter-group differences have become the most important factors in studies of diet and subsistence in dental anthropology.

4.3.1 Degree of wear

Concerning the comparison of the degrees of wear for different groups, it is important to remember that such groups usually differ considerably in their age profiles. Because the degree of dental wear is linked to age,[16] comparison of groups with different age profiles becomes impossible. The same problem applies to assemblages which are in such poor condition that estimates of skeletal

[15] For example, how much is known about age and sex of the individuals under study.

[16] The relation between age and dental wear is neither linear, nor predictable. In the past the degree of dental wear was often used as an indicator of age, however, nowadays researchers have increasingly become aware of the different influences upon dental wear, such as diet and subsistence strategies. It is now understood that young individuals may exhibit extreme dental wear, or indeed the opposite may be true; older individuals may exhibit very slight dental wear. In most cases nowadays dental wear is only used as a final tool in confirming the deduced skeletal age of an individual.

age can not be made; this was sometimes the case for the Anse à la Gourde material. To solve this issue, it is possible to use intra-individual *rates of wear*, as opposed to group averages of *degrees of wear*. In this case, 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. These comparisons are thus based on mean *rate* of wear as opposed to mean *degree* of wear (Scott & Turner 1988; Smith 1972).

Using non-parametric statistics, the difference or relation between two sample groups can be calculated. In other words, we can work out whether there is a significant difference between the rates of wear for the two groups, Anse à la Gourde and Tutu. For this analysis, the *Spearman's rank correlation coefficient* has been used. In this test, a coefficient is calculated which expresses the correlation or relatedness between two variables (the wear of the molar teeth).

The correlation coefficients presented in Table 4 represent the relation between the degree of wear for M1-M2, M2-M3, and M1-M3 respectively.

4.3.1.1 Anse à la Gourde

The correlation coefficient combined with the number of samples in the test is used to look up the significance of the correlation in *Spearman's rank critical values table*. For Anse à la Gourde, for example, we can say that there is a significantly positive relation between the degree of wear on the first molars and the degree of wear on the second molars, because for n=31 and correlation coefficient 0.75 the critical values are 0.356 ($P < 0.05$) and 0.459 ($P < 0.01$). As the correlation coefficient 0.75 is higher than both these critical values, we can say that the positive relation is significant at $P < 0.01$.

The relation between second and third molars is not (quite) significantly positive ($P < 0.05$). The same is true for the relation between first and third molars ($P < 0.05$).

4.3.1.2 Tutu

For Tutu we can say that there is a significantly positive relation between the degree of wear on the first molars and the degree of wear on the second molars ($P < 0.01$). Also, the relation between second and third molars was significantly positive ($P < 0.05$). The same is true for the relation between first and third molars ($P < 0.01$).

4.3.1.3 In comparison

In comparison, the rates of wear for both sites for M1-M2 are practically the same, with no significant difference between them. However, for the rates of wear between M2-M3, there is a significant difference between Anse à la Gourde and Tutu. The same is true for the rates of wear for M1-M3 ($P < 0.05$). This means that whereas the rate of wear at Tutu was quite constant during life, with a strong positive correlation between the degrees of wear for the different molars, the rate of wear at Anse à la Gourde was not constant. The positive relation between the degrees of wear for the different molars at Anse à la Gourde becomes much less positive after the eruption of the third molars. In other words, the rate of wear at Anse à la Gourde reduced after the eruption of the third molars. The mean degree of wear can therefore be deduced to have been lower at Anse à la Gourde than at Tutu. This difference is not to be explained by age differences in the samples, as this method of analysis allows for comparison of populations with different age profiles. Any differences, therefore, are to be

attributed to differences in diet and food preparing techniques.

4.3.2 Direction of wear

An influential work on dental wear, by B.H. Smith, proved that there is a correlation between subsistence and the angle of molar wear. Agricultural subsistence strategies tend to produce oblique molar wear, whereas hunter-gatherer subsistence strategies produce flatter molar wear. These differences are related to the presence of refined or tough foods in the diet, and the presence of fine particles of grit in processed foods. Table 5 shows the divisions across the different directions of molar wear for Anse à la Gourde and Tutu. These directions of wear are classified according to Molnar's grading system (Molnar 1971; Smith 1984).

4.3.2.1 Anse à la Gourde

Clearly, for the case of Anse à la Gourde the category *natural form* is far greater than the other categories. In this case however, it is important to keep in mind that this category only exists when dental wear is still at a minimum. In order to get a picture of the directions of occlusal surface wear present in the sample, we must look at the more severely worn teeth. Therefore, the category natural form can be excluded from this analysis. When we leave out this category, there is no clear majority among the remaining categories. However, in this case we can group the different categories of oblique wear together, as all of these indicate angularly worn molars, which in turn can indicate a large proportion of refined foods in the diet. When the oblique categories are grouped, the number of obliquely worn molars is significantly greater than the remaining category of *horizontal*.

4.3.2.2 Tutu

If we exclude the category *natural form* from the calculations, then it seems that the category *horizontal* is by far the largest for Tutu. A test for significance proved that this category indeed significantly outnumbers the others ($P < 0.01$). However, if we group the categories of oblique wear together, to represent all molars which are worn obliquely, this category also seems to be considerably larger than the others ($P < 0.01$). Comparison between the grouped obliquely worn categories and the category horizontal, shows that there is no significant difference between the two at $P < 0.01$ or $P < 0.05$. However, we can say that it is 92% certain that the category of obliquely worn molars is significantly greater than that of horizontally worn molars.

4.3.2.3 In comparison

In the comparison between the groups, once again the category of natural form has been excluded. When the different groups of oblique molar wear are grouped, there is a significant difference between the number of oblique molars from Tutu and the number of oblique molars from Anse à la Gourde; Tutu has significantly more oblique molars ($P < 0.05$).

4.3.3 Occlusal surface shape

Past studies have proven a relation between cupped molar surfaces and agricutural subsistence strategies. It is known that agriculturalists develop cupped molar surfaces (the dentine becomes hollowed out, but remains surrounded by a wall of enamel), whereas hunter-gatherers do not develop cupping to such a degree. This difference in molar wear pattern has been attributed to the fine particles of stone which are often

introduced into processed agricultural foods.
Molnar's three-grade dental wear scoring system grades two forms of cupped surface shape: *one-half of surface cupped* and *entire surface cupped*. The divisions of the different occlusal surface shape forms graded in Molnar's system are presented in Table 6.

4.3.3.1 Anse à la Gourde
It is clear from the data presented in Table 6 that once again the category *natural form* by far outnumbers the other categories of occlusal surface shape. This difference is statistically significant ($P < 0.05$). However, in this case this category can again be excluded from the calculations, as it only occurs in unworn or very slightly worn teeth. Among the remaining categories, the category *one-half of surface cupped* then seems to be the largest, however this difference is not statistically significant.
The categories of *one-half of surface cupped* and *entire surface cupped* both represent cupping, most likely as the result of a diet based on refined agricultural foods. For this reason these categories can be grouped together. When the cupped categories are grouped, there is a significant difference between the number of cupped molars and the remaining categories *flat* and *other* ($P < 0.05$).

4.3.3.2 Tutu
Again we may exclude *natural form* from the calculations, as this category only exists when there is little or no wear. It is apparent that the two categories concerning cupped molar wear together outnumber the other categories. This difference is statistically significant at $P < 0.01$. However, the category of flatly worn molar surfaces is still substantial. One explanation for this is that the occlusal surface shape *flat* precedes *cupped* as a tooth increasingly becomes worn. Once the tooth surface is worn flat, dentine becomes exposed and eventually becomes hollowed out.

4.3.3.3 In comparison
Comparison between the percentage of cupped (and half-cupped) molars from both sites revealed a significantly larger proportion of cupping at Tutu ($P < 0.05$). However, when the category *natural form* is excluded, as these teeth tend to be less worn, there is practically no difference between the two samples.

4.3.4 Caries
The presence of dental caries in the human dentition informs us about oral health and hygiene, and the amount of carbohydrates in the diet. In the latter case, the percentage of carious teeth in a population sample is indicative of different subsistence strategies. An agricultural existence is paired with a large proportion of carbohydrates in the diet, and subsequently a high percentage of dental caries. The hunter-gatherer subsistence involves a much smaller carbohydrate consumption, which is reflected in the much lower percentage of carious teeth in hunter-gatherer populations.
Worldwide reviews of caries frequencies in hunters and gatherers, 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 (Powell 1985; Scott & Turner 1988; Turner 1979) .

4.3.4.1 Anse à la Gourde
The percentages of dental caries per sex for both sites can be found in Table 7. For Anse à la Gourde the percentages seem to fall generally between a mixed economy and an agricultural economy. There are no statistically significant differences

between males, females, and individuals of unknown sex, although females and individuals of unknown sex seem to be slightly more frequently affected than males. However, there are significant differences between all three aforementioned groups and the children ($P < 0.05$). The percentage of caries in the Anse à la Gourde children is extremely high. For the greater part this is due to the exceptionally high number of carious teeth in individual F377. This child, estimated at 3 to 5 years of age, counted 15 carious teeth in a total of 17. As this seems to be a unique case, it is fair to exclude this individual from the calculations in order to get a more balanced picture of juvenile caries rate. Once individual F377 is excluded, the percentage of dental caries in the Anse à la Gourde children drops from 42.6% to 15.6%. With this percentage of dental caries, there are no longer any statistically significant differences between any of the groups at Anse à la Gourde.

4.3.4.2 Tutu

For Tutu, the percentages are clearly very high, and fall well within the range of an agricultural economy, suggesting there was a large amount of sticky refined carbohydrates in the Tutu diet. In the Tutu sample, females have slightly less carious teeth than males; however this difference is not statistically significant. The difference between both males and children, and females and children seems to be considerable; however, again this difference is not statistically significant.

4.3.4.3 In comparison

In comparison the percentages of carious teeth for the complete adult populations of Anse à la Gourde and Tutu show a significant difference ($P < 0.05$). Therefore it is clear from these data that the Tutu adults were more severely affected by dental caries than the Anse à la Gourde adults. Comparisons between the separate adult groups (male, female, unknown) from both sites were not statistically significant; however this may be due to the smaller sample sizes.

When we compare the juvenile population for both sites - when individual F377 is excluded - there is no significant difference. However, it is clear from these data that Anse à la Gourde children were more frequently affected by dental caries than Tutu children. Once again, if we include individual F 377 this difference *is* significant, with Anse à la Gourde children being more severely affected by caries than Tutu children ($P < 0.05$). The posterior teeth (in particular the molars) are often most severely affected by dental caries, due to their complicated cusp patterns and intense utilization in grinding foodstuffs. In Figures 11 and 12 the percentages of carious teeth per type of element and jaw are presented for Anse à la Gourde and Tutu respectively. It is clear from these figures that the posterior teeth are more frequently affected by caries than the anterior teeth. The latter is statistically significant for both sites at $P < 0.05$.

What also becomes clear from these figures is the fact that in both samples the maxillary dentition is more frequently affected by caries than the mandibular dentition. For Anse à la Gourde this difference is not statistically significant, however, for Tutu it is significant at $P < 0.05$.

It is important when we compare the percentages of caries from two populations to keep in mind that a large amount of the absent teeth may have been lost to dental caries. Although it is often not possible to say how absent teeth were lost, it is possible to take note of the proportion of absent teeth. Figures 13 and 14 show the percentage of teeth present

per element type for Anse à la Gourde and Tutu respectively, reasoning that each adult individual had a complete dentition of 32 elements to start with. Here, absent teeth comprise both ante mortem and post mortem losses. For both Anse à la Gourde and Tutu there are less molar teeth present than premolars (and incisors). When we compare these two figures to Figure 11 and Figure 12, which depict the percentages of carious teeth for each site, it is clear that molars are the most frequently affected by carious lesions. This suggests that at least a substantial part of the absent molar teeth were lost to caries.

Figures 13 and 14 also seem to indicate that there are less maxillary teeth still present in comparison with the number of mandibular teeth present. For both sites, these differences were tested per category of male, female, unknown, child, and adults combined. Only the Tutu females have significantly more mandibular teeth than maxillary teeth still present ($P < 0.025$). Although this difference is not significant for all groups, it may still indicate that the maxillary teeth, which are affected by caries more frequently than mandibular teeth (Fig. 11 and 12), are less numerous than the mandibular teeth for this very reason.

4.4 Health and lifestyle

4.4.1 Severe dental wear

In our early hominid ancestors - and many mammals today - severe wear and eventual loss of the teeth was a serious condition which often would have led to death. Due to changes in food preparation techniques and diet, it became increasingly easy for individuals with damaged or severely worn teeth to survive. Even complete loss of the teeth became easier to live with thanks to these cultural changes (Scott & Turner 1988).

It is important to keep in mind, however, that the severe wear or loss of the teeth still poses significant problems to an individual's general health. The poor condition or absence of the teeth makes food mastication a difficult task. Certain foodstuffs prove too hard to consume, which restricts the variety in a person's diet. The latter can lead to malnutrition which in turn leads to weakening of the immune system.

It has been explained in section 4.3.1 that inter-group comparisons between mean degrees of wear are not possible for groups with differing age profiles. Intra-group comparisons of mean degrees of wear can be done however, when enough information is available on age and sex of the individuals. In this case differing age profiles are not a problem, as the group's age profile is not compared to a different profile, but is examined for internal patterns.

4.4.1.1 Anse à la Gourde

At Anse à la Gourde the dentitions have been categorized into males, females, and children. Furthermore, these groups have been divided according to the following age groups: 0-10 years, 10-20 years, 20-40 years, 30-60 years, >40 years, >50 years (Fig. 15).

A number of individuals were excluded from these calculations, as their age was unknown (or too broadly estimated) or their sex could not be determined. Even though these individuals were excluded, the remaining sample is large enough to give an impression of the differences in mean degrees of wear for the different age and sex groups within the Anse à la Gourde sample.

Figure 16 clearly shows that males in all age categories have a higher mean degree of dental wear than females. The mean degree of wear seems to increase with age. Furthermore, the mean degree of wear is

quite high for all age groups. The latter suggests that the foods consumed were abrasive in nature, with males possibly consuming more abrasive foods than females.

4.4.1.2 Tutu

At Tutu the dentitions have equally been categorized into males, females and children. The same age categories have been used: 0-10 years, 10-20 years, 20-40 years, 30-60 years, >40 years, >50 years (Fig. 17).

Only one individual was excluded from these calculations, as the sex of this individual was unknown. The remaining 25 individuals were included in the calculations, which therefore give a good impression of the differences in mean degrees of wear for the different age and sex groups within the Tutu sample.

As can be seen in Figure 18, comparison between males and females is difficult in this sample, as there is little overlap between the two sexes and the age categories. In the most general category - 30-60 years – however, the males have a higher mean degree of wear than the females, as is the case for Anse à la Gourde.

4.4.2 Caries

4.4.2.1 Location of caries

The location of dental caries is an important indicator of dental health. In general, all dental caries are formed due to carbohydrate consumption and poor oral hygiene. However, the location of carious lesions is informative of particular oral diseases which in turn can inform us about oral hygiene practices.

Cavities which are located on the occlusal surface of the teeth are the most frequently occurring type of dental caries. Often the molars are affected most severely, due to the intricate cusp patterns on the occlusal molar surfaces. These patterns which consist of small grooves and pits can harbor food remains and cariogenic bacteria. Interproximal caries also occur frequently, as the area between two adjacent teeth is also a perfect location for food remains and cariogenic bacteria. Smooth surface caries, on the other hand, usually occur only when the amount of carbohydrates in the diet is extremely high, and there a great degree of dental plaque. Cervical caries occur when the gingiva are unhealthy or receding. The latter most often happens as the result of periodontal disease or *periodontitis*. Periodontitis is caused by bacteria adhering to the tooth surface, which thrive in dental plaque. Inflammation of the gingiva leads to their recession, and gives cariogenic bacteria access to the roots of the teeth and their supporting bone structure. These tissues are particularly susceptible to carious lesions, as they dissolve at a higher pH level than tooth enamel (6.7 as opposed to 5.2).

Tables 8 and 9 present the percentages of each aforementioned type of caries in the Anse à la Gourde and Tutu samples. The presence of a high degree of occlusal and cervical caries in both samples suggests that oral hygiene was poor; the teeth would not have been cleaned regularly or properly. The high degree of cervical caries in both samples suggests that periodontitis was widespread.

Tutu shows a greater percentage of smooth surface caries, which is significantly higher than the percentage for Anse à la Gourde ($P < 0.05$). The latter suggests that the Tutu individuals consumed a larger proportion of carbohydrates than the Anse à la Gourde individuals. The difference is not likely to be the result of larger amounts of dental plaque in Tutu people, as the Anse à la Gourde sample shows a higher percentage of cervical caries; these are most likely

associated with periodontitis and thus also with dental plaque.

4.4.2.2 Fluoride

An important factor to keep in mind when assessing caries frequency in human populations, is the intake of fluoride through the diet. Fluorides are naturally present in the environment in rocks, soil, plants, animals, and groundwater. The consumption of optimal amounts of fluoride is known to protect the teeth against the development of dental caries. If large amounts of fluorides are consumed during childhood, when the adult teeth are still in development, *fluorosis* can occur. Fluorosis is the process of damage which is done to the teeth when excessive amounts of fluoride are consumed during their developmental stage. The teeth are generally composed of hydroxyapatite and carbonated hydroxyapatite; however, when an excessive amount of fluoride is present, fluorapatite is created. This can cause white spots on the teeth in a mottled effect. In a more advanced stage of fluorosis, the teeth can become stained (yellow or brown), pitted, and sometimes even chipped (W. Kuiters, pers. comm. 2007).

Groundwater is generally higher in fluoride content than surface water. Seawater is slightly higher in fluoride content than groundwater, and therefore the fluoride content of the diet rises when seafood is consumed. The latter would suggest that the inhabitants of Anse à la Gourde and Tutu were consuming enough fluoride to protect their teeth from dental caries. This is corroborated by the fact that some elements from both samples were observed to have the slight greyish-white mottling characteristic of fluorosis.

Despite this extra protection of the teeth against dental caries, the caries frequency for both populations is rather high. This suggests that the carbohydrate consumption was either extremely high or dental hygiene extremely poor. A combination of both seems most likely. As mentioned above, it is unlikely that the teeth were properly cleaned on a regular basis; in some individuals there are extremely large amounts of calculus present, particularly on the lingual surface of the mandibular anterior teeth (these elements are generally most severely affected in cases of calculus).

4.5 Special uses of the teeth (non-masticatory)

4.5.1 Dental Chipping

One of the most important aspects in the analysis of dental chipping is the possibility of differences between the anterior and posterior teeth. Broadly speaking, chipping in the anterior teeth could be interpreted as the result of non-masticatory 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 sexes and/or the mandible and the maxilla could be indicative of the cause(s) of the chipping.

Some researchers suggest that there is a relation between heavy dental wear and chipping (Bonfiglioli et al. 2004, Budinoff 1987). This relation could be the result of the weakening of the tooth by severe wear, which would make the tooth more susceptible to chipping[17], or conversely it is possible that severely chipped teeth wear faster than unchipped teeth. The

[17] 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 more easily.

latter is interesting, as it may offer more insights into the consequences of certain uses of the teeth.

4.5.1.1 Anse à la Gourde

On examination of the percentage of chipping for the complete dentition (Table 10), it becomes clear that there is a significant difference between the percentage of teeth with chipping in males and the percentage of teeth with chipping in females ($P < 0.05$). Males have a significantly larger percentage of chipped teeth than females. Furthermore, males also have a significantly larger percentage of chipped teeth than individuals of unknown sex and children ($P < 0.05$).

The percentages of anterior and posterior chipped teeth for the different sexes at Anse à la Gourde can also be found in Table 10. When we take a close look at the differences between the anterior and posterior teeth, we find that there is no significant difference between male anterior and posterior chipping. For females, on the other hand, the anterior teeth are chipped significantly more frequently than posterior teeth ($P < 0.05$). For both children and individuals of unknown sex there is no significant difference between the percentage of anterior and posterior chipping.

Females, in turn have a significantly larger percentage of chipped teeth than children ($P < 0.05$), but do not significantly differ from individuals of unknown sex. Individuals of unknown sex do not differ significantly from children.

Figures 19 and 20 give a graphic representation of the percentages of chipped teeth per element type and the mean degree of chipping per element type for the Anse à la Gourde adults. When the males and females are grouped together, there are no significant differences between the percentages of chipping for the different elements or jaws. There is no significant difference between the *mean degrees* of chipping per element type for the adults. The overall impression given here is that the anterior teeth were less severely chipped than the posterior teeth; the average chipping degree was lower. These differences were not statistically significant, however. Although not represented graphically here, the Anse à la Gourde children had a significantly lower mean degree of chipping than the adults.

When we divide the data into the different sexes, the picture remains pretty much the same (Fig. 21 and 22). There are two significant differences however: the females have a larger percentage of chipped mandibular molars than maxillary molars. They also significantly differ from the males in this respect.

With regards to the mean degree of chipping per element type at Anse à la Gourde, there seems to be a higher average chipping degree for mandibular molars in females than in males (Fig. 23 and 24).

Concerning the relation between dental chipping and degree of wear, there seems to be a larger percentage of chipped teeth with a high degree of wear (Fig. 25). The relation grows in a linear fashion, and declines after degree of wear 6. This is to be expected, as from this degree of wear onward, there is little or no enamel still present which can then obviously not be assessed for dental chipping.

4.5.1.2 Tutu

For Tutu (Table 11), there is a significant difference between the percentage of teeth with chipping in males and the percentage of teeth with chipping in females ($P < 0.05$); the males have a larger percentage of chipped teeth than the females. The percentage of teeth in children with chipping is significantly lower than both males and females ($P < 0.05$).

The percentages of chipped anterior and posterior teeth for males, females and children can be found in Table 10. Here we can see that for the males and children there is a large difference in the percentage of anterior and posterior teeth which are chipped; the posterior teeth are affected more often. In both cases these differences are significant at $P < 0.05$. For the females, however, the percentages of anterior and posterior teeth with chipping are very similar.

Both males and females have significantly more anterior chipping than children, although only males have significantly more posterior chipping than children ($P < 0.05$).

Figures 26 and 27 give a graphic representation of the percentages of chipped teeth per element type and the mean degree of chipping per element type for the Tutu adults. When the males and females are grouped together, there is a significant differences between the *percentage* of chipped first molars and the *percentage* of chipped third molars (both maxillary and mandibular) at $P < 0.05$. There is no significant difference between the *mean degrees* of chipping per element type, although the third molars seem to be affected more severely than the other elements. The overall impression these figures give is that the first molars were chipped most frequently, and quite severely. Although not graphically represented here, the Tutu children had a significantly lower mean degree of chipping than the adults.

When we divide the data into the different sexes, the picture remains pretty much the same (Fig. 28 and 29). There are two differences however; the Tutu males have no chipping in the first incisors whereas the females have significantly more chipping in these elements, and the males have a very large percentage of chipped mandibular canines, although the latter is most likely due to the small size of the sample of these elements.

With regards to the mean degree of chipping per element type at Tutu, there is one significant difference between males and females: in males the first incisors are not chipped at all, which gives them an average chipping degree of 0. In females, the degree of chipping in first incisors is significantly higher (Fig. 30 and 31).

Concerning the relation between dental chipping and degree of wear, at Tutu there also seems to be a larger percentage of chipped teeth with a high degree of wear (Fig. 25). The relation grows in a linear fashion, and declines sharply at degree of wear 7.

In sum it is clear that in both samples, the males have a larger proportion of chipped teeth than the females. On the other hand, while Tutu females do not display any significant difference between the anterior and posterior dentition, the Anse à la Gourde females do, with a larger proportion of chipped anterior teeth. Conversely, the Tutu males and children display a greater percentage of posterior chipping, while the Anse à la Gourde males, children and individuals of unknown sex do not display any such significant differences.

4.5.1.3 In comparison

Comparison between percentages of adult chipped teeth (anterior *and* posterior) from both sites has revealed that the Tutu teeth are chipped significantly more frequently than the Anse à la Gourde teeth. Furthermore, Tutu males have a significantly greater proportion of chipped teeth than Anse à la Gourde males ($P < 0.05$). The same is true for Tutu females, who have significantly more chipped teeth than Anse à la Gourde females ($P < 0.05$). The Tutu children also have significantly more chipped teeth

than the Anse à la Gourde children ($P < 0.05$).

There don't seem to be many conspicuous differences between the mean degrees of chipping per element type for the different sites, although Tutu females don't have any chipped first and second maxillary molars. The reason for the latter, however, could be the fact that only a small number of these elements are present in the sample, paired with the fact that one third of these have dental caries, which has made assessment for chipping impossible. Furthermore, as already mentioned above, the Anse à la Gourde females have more frequently and more severely chipped mandibular molars than maxillary molars.

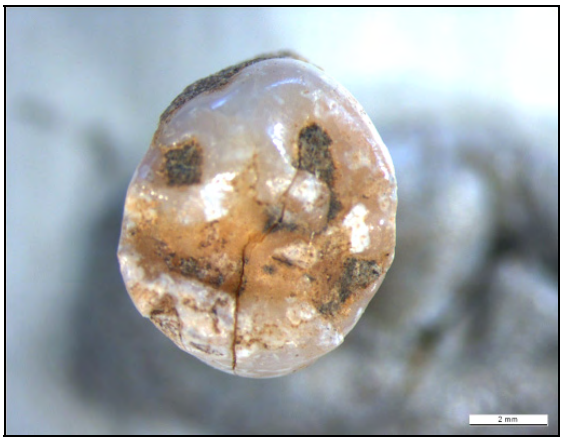


Figure 5: A dental notch in occlusal view in the second left lower premolar (3.5) of F430

4.5.2 Dental Notching

In order for a dental notch or groove to be a clearly non-masticatory form of dental wear, there are a number of characteristics which it must possess. The notch or groove must be clearly defined, usually uniform in shape and size across its entire length, and display polishing or striations along its worn surface. To reiterate, the characteristics of a dental notch - as defined by Bonfiglioli et al. - are the following: "*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). Figure 5 is an example of a dental notch or groove.

During the course of this study, it has become clear that certain types of notching, as defined by Molnar in his three-digit grading system, do not conform to these characteristics. This discrepancy is due to the different qualities these different researchers have attributed to dental notches.

It is the author's opinion that some of the forms of notching identified by Molnar, are most likely not the cause of non-masticatory practices, and therefore must be excluded from this analysis as 'notches'. The notched occlusal surface shapes in question do not possess all or any of the characteristics described by Bonfiglioli et al., and could just as easily have been formed 'by accident'. Modern dentistry supports this conclusion, as the notched appearance of - in particular - anterior teeth as described by Molnar, is a frequently occurring form of occlusal surface shape which is not caused by non-masticatory activities. For this reason I have re-evaluated many of the notched teeth in this sample, and have found a substantial number of them to be 'notch-free' or inconclusive. These teeth have been left out of the calculations which follow. Here, only teeth which can be said with great certainty to be notched, are discussed. Tables 12 and 13 illustrate the occurrence of dental notching at Anse à la Gourde and Tutu by sex, element and jaw.

4.5.2.1 Anse à la Gourde

The immediate observation here is the fact that only females - and one individual of

unknown sex[18] - are affected by dental notching at Anse à la Gourde.
All notches observed in this sample are occlusal surface notches as opposed to interproximal notches. The latter are often inferred to be the result of tooth-picking in order to relieve oneself from pain from infectious teeth and gums, or to remove food remains from between the teeth. The fact that all notches are occlusal suggests that these notches are the result of another non-masticatory activity.
The next immediate observation would be the fact that none of the molars are notched; only incisors, canines, and premolars are affected.
It is clear from the data presented in Table 12, that the number of teeth affected by dental notching at Anse à la Gourde is still very small. Table 14 presents the numbers of individuals affected by dental notching by sex for both sites. This table illustrates the fact that the number of individuals (10) with dental notching is a substantial part of the total population at Anse à la Gourde (15.1%). Almost one third (29%) of the females at Anse à la Gourde display dental notching (9 individuals).
When we take a closer look at the ages of the individuals involved in dental notching at Anse à la Gourde, there doesn't seem to be a clearly defined age group for this form of dental wear, with the ages ranging between 20 and 80 years old. However, the mean age estimates for all individuals concerned seem to fall in the 30-40 years age range.

4.5.2.2 Tutu

At Tutu, both males and females are affected by dental notching. No significant differences can be found between the number or type of elements affected in males and females.

[18] This concerns individual F450.

As is the case for Anse à la Gourde, all notches observed in the sample are occlusal surface notches as opposed to interproximal notches. Again we see that the notches are confined to the anterior teeth, with only incisors, canines, and one premolar affected. Table 13 shows that for Tutu, the number of teeth affected by dental notching is also very small. Table 14 illustrates that the number of individuals affected by dental notching at Tutu is quite substantial. A total of 5 individuals are affected for the entire sample (19.2%). Three of the females at Tutu are affected (21.4%), and 2 of the males (33.3%).
The individuals affected by notching at Tutu fall in a mature age range, between 35 and 55 years old. The mean age estimates for all individuals with dental notching fall in the 40-50 age range, with no significant age differences between the males and the females.
There do not seem to be any conspicuous differences in the shape and size of the male and female notches, which means a different aetiology can not be established.

4.5.2.3 In comparison

For both sites, the dental notching has a similar appearance, which suggests a similar aetiology. However, at Anse à la Gourde only females are affected by these notches, whereas at Tutu both males and females are affected.
In comparing the number of individuals affected by dental notching at both sites we see that a larger percentage of the Tutu population is affected than the Anse à la Gourde population.

4.5.3 LSAMAT

During the course of this study, numerous forms of lingual wear of the maxillary anterior teeth have been recorded, including some incidents of lingual wear of the mandibular anterior teeth. All of

these were recorded as LSAMAT, or Lingual Surface Attrition of the Maxillary Anterior Teeth. In a strict sense, all forms of lingual wear which have been recorded as LSAMAT, do in fact comply with the description above.[19] However, Turner and Machado, who first documented and described LSAMAT, list more specific qualities which characterize LSAMAT. They emphasize the fact that LSAMAT is strongly associated with a high degree of caries (Turner & Machado 1983). Furthermore, they state that the form of wear they identify as LSAMAT is *"flattened at all stages and angled appropriately for some sort of material having been drawn across the lingual tooth surfaces"* (Turner et al. 1991). They strongly reject the suggestion that LSAMAT could be associated with habitual regurgitation of stomach acids, mainly because they do not believe that very high percentages of populations could take part in such activities - voluntary or involuntary – but also because the LSAMAT they recorded did not display the characteristic cupping that erosion does.

The different forms of anterior lingual surface attrition in the sample under study here warranted further attention, and therefore have been categorized into those which can be characterized as LSAMAT - in the sense that Turner and Machado have defined it - and those which do not fall under this form of wear.

The forms of lingual surface wear which have been classified as not being LSAMAT, were either inconclusive with respect to their aetiology, or displayed different characteristics than LSAMAT. Many of the forms of wear in question could have been the very first stages of LSAMAT, where the lingual enamel is polished, but not worn away. In other cases the cause of the wear could have been erosion, which is indicated by the loss of lingual enamel and the cupped appearance of the lingual surface. It is not ruled out that a combination of factors could have caused both LSAMAT and other forms of lingual surface wear, however for the purpose of this analysis LSAMAT is the only form of lingual wear which has been statistically recorded, as it indicates a non-masticatory activity using the teeth.

The typical manifestation of LSAMAT at both sites is a severely worn lingual surface missing most or all of its lingual enamel. Tiny striations are present on the worn surface, which are scattered in many different directions, but generally follow a labiolingual direction. In some cases there is lingual polishing or shininess.

4.5.3.1 Anse à la Gourde

At Anse à la Gourde no significant difference could be found between the percentage of males, females and individuals of unknown sex affected by LSAMAT (Fig. 32). The percentage of children affected by LSAMAT seems lower, however this difference is also not statistically significant.[20]

[19] It is worthy to note here that the term 'attrition' actually refers to the wear of the teeth as a consequence of contact with the opposing teeth. As this is not the case in LSAMAT and its associated aetiology, the term is somewhat misplaced, and may be replaced by 'wear' or 'abrasion' to avoid confusion. Turner and Machado themselves have the following to say on the matter: *"In common usage today,* abrasion *usually means scraping or finely cutting, whereas* attrition *has more of a sense of removing. We feel that common usage and readily available dictionary definitions support our usage of the word* attrition *when communicating to a larger audience than clinical dentists or dental anthropologists"* (Turner & Machado 1991).

[20] At Anse à la Gourde only one deciduous tooth is affected by LSAMAT, which is why the category 'Child' is not present in Table 25.

As there doesn't seem to be any gender-based differentiation for LSAMAT at Anse à la Gourde, it appears that all sexes engaged in the activity which caused it.

Figure 6: LSAMAT in the first upper left incisor (2.2) of F89

The aetiology for LSAMAT in all sexes appears to be the same, however there are some differences between the number and type of elements affected. The females show a larger percentage of first incisors with LSAMAT than the males (Fig. 33 and 34) although this difference is not statistically significant. For both males and females there is a small percentage of mandibular anterior teeth which is affected by lingual surface attrition strongly resembling LSAMAT. For the individuals of unknown sex, the number of mandibular first incisors affected in this way is substantial, and even slightly larger than the number of maxillary teeth affected by LSAMAT (Fig. 35). The aetiology of the mandibular lingual surface wear is consistent with Turner and Machado's description of LSAMAT in maxillary teeth (Turner and Machado 1983).

Concerning the association of LSAMAT with a high degree of dental caries, it is clear that this is the case for Anse à la Gourde, although the relation between LSAMAT and caries in this sample is not clear. The other forms of lingual surface wear mentioned in the section above, were numerous for Anse à la Gourde. In most cases these appear to be early stages of LSAMAT, however their assessment as such proved inconclusive. Some cases of cupped lingual surface wear were found; the female individual F2215 was affected particularly severely by lingual cupping in all four maxillary anterior incisors.

4.5.3.2 Tutu

In the case of Tutu the percentage of males who display LSAMAT is clearly greater than the percentage of females and children with LSAMAT, although this difference is not statistically significant (Fig. 32). The single individual of unknown sex does not have LSAMAT. Even though the males are affected by LSAMAT more often than the females, there doesn't seem to be any gender-based differentiation in the sample. The aetiology for LSAMAT in all sexes is the same; the differences that exist at Tutu are to be found between the numbers of elements affected for the different sex groups.

Figure 7: LSAMAT in the upper right canine (1.3) of T30

The males show a larger percentage of first incisors with LSAMAT than the females (Fig. 36 and 37). For females there

is a small percentage of mandibular anterior teeth which is affected by lingual surface attrition strongly resembling LSAMAT. The aetiology of the mandibular lingual surface wear is consistent with Turner and Machado's description of LSAMAT in maxillary teeth (Turner and Machado 1983).

Concerning the other forms of lingual surface wear at Tutu; some (probable) early stages of LSAMAT were found. There was some evidence for cupped lingual wear (Fig. 7).

Concerning the association of LSAMAT with a high degree of dental caries, it is clear that this is the case for Tutu, although the relation between LSAMAT and caries in this sample is not clear.

4.5.3.3 In comparison

In comparing the two sites it becomes clear that Tutu has a significantly larger percentage of individuals with LSAMAT than Anse à la Gourde ($P < 0.05$). The appearance and apparent aetiology of LSAMAT for both sites is the same (compare Fig. 6 and 7). The same is true for the appearance of the teeth which displayed lingual wear other than LSAMAT. The latter may reinforce the suggestion that some of these forms of lingual wear are early stages of LSAMAT.

Chapter 5: The lines of evidence

5.1 Introduction

Archaeologists working in the Caribbean are blessed with a wealth of ethnohistoric documents from the early contact period to late in the Colonial period, which may be the envy of many a European prehistorian. These documents, however, must be treated with due care when using them to clarify or explain archaeological data, as they were written for very specific political, economic, or religious reasons which strongly affected what was recorded and how it was recorded. The personal motives and ideologies of the authors, along with the social and political context of colonization and domination, are important factors which helped form the documents which have survived until today.

Information supplied by ethnohistoric accounts, must where possible be backed up with other lines of evidence, such as other ethnohistoric accounts, archaeological data, and/or ethnographic evidence.

The latter is a problematic field for the Caribbean region, as practically all of the region's original inhabitants were wiped out during the early Colonial period. A group of approximately 3,000 mixed descendants of the last Island Caribs live on the island of Dominica today, in a 3,700 acre area in the northeast of the island named *Carib Territory*.

Contrary to what many tourists are led to believe, the Karifuna (or Kalinago) people of Dominica do not live in the same way the Island Caribs did over 500 years ago. As is the case for all cultures, change has affected this community over time. The Colonial history of the region has meant the ruthless treatment of the surviving Island Carib descendants, along with extermination of many of their cultural practices. Today, the Karifuna live in conditions of extreme poverty, with poor amenities and education, much like many Native North Americans who live on reservations. The biological and cultural connection of the Karifuna with the Island Caribs is undeniable, however the use of ethnographic information from these people for the purpose of understanding archaeological data would be extremely difficult (Joseph 1997).

The same cautionary tale applies to possible ethnographic analogies with the Garifuna of Central America and St. Vincent. The Island Caribs who inhabited St. Vincent fought off the European colonizers well into the 18th century. The island had become a refuge for escaped African slaves who intermarried with the local Carib population, which led to a racial mix which the British termed *Black Caribs*. During the latter part of the 18th century, the British and French struggle over the island of St. Vincent the islands exposed the Caribs to a range of diseases for which they had little natural immunity. Their forces weakened and eventually they were forced to surrender to the British, who proceeded to separate them on the basis of the darkness of their skin colour. The darker skinned people were considered to be a threat and were swiftly deported to Balliceaux, and eventually to the Caribbean coast of Central America, where they still live today. A small group of lighter skinned individuals, who the British called *Yellow Caribs* were allowed to stay on St. Vincent, which explains the small numbers of Carib descendants on St. Vincent today (Gonzales 1997; Rogozinski 1992).

Traditionally the use of ethnography in Caribbean archaeology has focused on groups of people who inhabit the Orinoco delta in northern South America. Cultural similarities are presumed between the

people who inhabit this region and pre-contact groups in the Caribbean, as the latter are believed to have migrated to the Caribbean islands from this region. Comparisons are often made between kinship systems, housing, food types and production, and cosmology and religious beliefs of contemporary mainland peoples and prehistoric Caribbean inhabitants. Most researchers do not attempt direct analogies between these two, but use ethnographic information as an aid in understanding patterns in the archaeological record.

Ethnohistoric and ethnographic evidence will be presented in this chapter, in an attempt to place our understanding of dental wear and the use of the human dentition within a cultural context. Next to the above, another line of evidence will be used here to broaden our scientific understanding of the factors which produce human dental wear: modern day dentistry.

In the field of dentistry, human dental wear was long considered to be a remnant of the prehistoric past, which had no relation to the present day practice of dentistry. However, dental wear still exists in modern populations, despite the increasing consumption of soft, processed foods, and the (presumed) general absence of any non-masticatory practices involving the teeth.

Specific forms of dental wear can still be seen today, which may have some relation to the forms of dental wear witnessed in prehistoric populations. Using insights offered by modern dentistry, it is argued here that a better understanding of the causes and consequences of prehistoric dental wear can be accomplished. A number of the dentitions used for this study were examined by dentist Dr. Willem Kuiters, and his interpretation of the dental wear is presented here along with insights afforded by recent dentistry literature.

5.2 Ethnohistoric accounts

The use of ethnohistoric accounts in this study has been restricted to those pertaining to the native inhabitants of the Caribbean, as related by some of the earliest European visitors to the region. It is important to keep in mind that observations on the state of the dentition or oral health of the natives would not have been high up on the list of priorities of the Europeans who wrote about them. Most written evidence of native inhabitant's lives was documented as the result of very specific assignments on the part of the European party. For example, Fray Ramón Pané, who wrote extensive accounts on the cosmology and beliefs of the Taíno, was appointed specifically to research the native inhabitant's religion and beliefs by Christopher Columbus. Bartolomé de las Casas' accounts of the natives, on the other hand, relate mainly to his attempts to bring a halt to their mistreatment by the European colonizers. Las Casas did however spend a considerable amount of time documenting the lifestyle of the Taíno Indians he lived with for some years in Hispaniola. His account of Taíno lifestyle is extensive, although fraught with arguments for the innocence and inherent goodness of these people, and comparisons with Greek and Roman antiquity.

In the following, some excerpts from Las Casas' *Apologética Historia* will be analyzed for their usefulness in the present study.

As mentioned in the introductory chapter to this work, dental wear may be the result of attrition, abrasion, erosion, pathological conditions, or a combination

of these. Erosion is often not considered in interpreting prehistoric dentitions, mainly due to the difficulty in identifying it in non-living tissue. The following two excerpts may be of importance in interpreting possible erosion in prehistoric dentitions as the result of erosive acids, as they afford insights which could not be derived from the dental material alone.

> *"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."* (Las Casas:Capítulo XII).

> *"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, e idos al río, que siempre lo tenían cerca, les provocaba echar lo que habían cenado, y después de lavados volvíanse y tornaban 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. No lo hacían así algunos, al menos uno conocí yo, de los nuestros españoles, y aun era harto persona honrada, del cual se decía que tomaba las mismas yerbas y hacía el efecto de los indios, por tornar otra vez a cenar. Destos eran los que por hartar su gula dividieron la tragantonería en cuatro meimbros: en almuerzo, yantar, cena y comensación o colación, segun decimos."* (Las Casas: Capítulo CCIV).

In these two excerpts it is suggested that partaking in regular purging activities, brought on by the use of certain herbs which have an emetic effect, was not uncommon in this culture. In the first excerpt, it is suggested that such herbs were used as a medicine in order to cleanse a sick individual of slime or gal by self-induced vomiting. In the second excerpt, we see that self-induced vomiting is a daily activity, which was apparently participated in by all members of the community. Las Casas argues here that the Indians purged their stomach contents to maintain good health. He goes on to say that the small amounts of food they consumed together with their purging activities prove that they were not greedy or gluttonous people, in contrast to the Spaniards. It is important to understand that Las Casas is using this example of purging behaviour to argue for the Indians' good virtues and cleanliness. Instead of this being a vulgar habit, he reasons, it is actually very healthy and clean.[21]

However it seems more likely that these activities may be related to concepts of purity and contamination with regards to certain foods, or as a result of certain ailments or illnesses. Within the Caribbean context it is known that self-induced vomiting was carried out in preparation for ritual activities and/or shamanistic activities. The act of purification through sneezing, fasting and vomiting was an important preparation for communication with zemis and spirits during trances. Vomiting could be

[21] Thereby alluding to the notion that cleanliness is close to godliness.

induced by an emetic[22] or by the use of an oblong object thrust down the throat.[23]
Either of the above forms of self-induced vomiting, if performed on a regular basis, can be expected to cause considerable erosive effects on the dentition. The presence of acids in the mouth causes the enamel to be broken down; a process which starts as soon as the pH level in the mouth drops below 5.2. As we will see below, modern dentistry provides a more detailed description of the process and resulting damage of erosion by vomiting on the human dentition.
Involuntary regurgitations of stomach acids could also be suggested as a cause for erosion; however it is unlikely that such a high percentage of the population suffered from this condition. Furthermore, as the excerpts from ethnohistoric documents describe above, the act of vomiting seems to be a very conscious and deliberate choice.
Another possibility is the presence of *dietary* acids in the mouth, which can have the same erosive affect on the teeth as non-dietary acids from purging. Nowadays this form of erosion is often experienced by people who consume large amounts of sugary soft drinks, however the consumption of large amounts of fruit (juices) has also been identified as a cause. It is known that the native inhabitants on the Caribbean region had access to a great amount of different fruits, and their diet seems to have consisted of large amounts of fruit according to descriptions by Columbus, Las Casas, and Oviedo. Bartolomé de las Casas, for example, describes the wealth of fruits and fruit trees on the island of Hispaniola in Capítulo XII of *Apologética Historia* (Vol. III). Oviedo describes numerous fruits in *Historia General y Natural de Indias*, many of them from the Caribbean islands.
Whether the consumption of fruits and fruit juices was substantial enough to cause erosion depends very much on the strength of the individual dentitions and oral healthcare. It is also important to consider that different fruits produce different pH levels in the mouth during consumption. Assuming that oral health and cleanliness was poor, we can speculate that consumption of fruit and fruit juices may have been a factor in producing erosive dental wear.

5.3 Ethnographic accounts

Ethnographic studies of the use of the human teeth and dental wear are not nearly as plentiful as the studies of skeletal dental wear in dental anthropology. Outside the disciplines of dental anthropology and dentistry, there is extremely little interest in dental wear in contemporary populations; anthropologists and ethnographers tend to be more interested in other practices and aspects of human culture. That is not to say there are no ethnographic case studies which may be of help in the interpretation of the data of the present study. Here follows a selection of

[22] In his observations of the Island Caribs during fasting and ritual purification in the 17th century, Father Raymond Breton describes the use of tobacco juice as a drastic emetic (Taylor 1950).
Fray Ramón Pané describes the snuffing of the hallucinogenic drug *cohoba* and the use of certain herbs to induce vomiting (Pané XV and XVI).
[23] Elaborate 'vomiting sticks' have been found in the Caribbean region, which apparently served for the purpose of self-induced vomiting. The very elaborately decorated vomiting sticks which are known are considered to have been the property of shamans, while regular people may have used far simpler instruments for this purpose (Roe 1997).

ethnographic case studies which may be able to shed some light on these data.

5.3.1 Dental notching/grooving

With regards to dental notching or grooving, some substantial ethnographic research has been done. In a study on linear grooves on anterior teeth from British Colombia, Cybulski found that comparison of pre-contact dentitions with ethnographic accounts of Northwest coast groups revealed a similar aetiology of the dental wear for both groups. This led him to conclude that the grooves, which occurred only in females, were associated with root fibres used in constructing baskets. The fibres were held in the mouth during the manufacture of the items (Cybulski 1974).

The association of notches or grooves with one of the sexes has often been the concluding factor in determining the aetiology of the wear. However, Larsen's study of prehistoric Great Basin hunter-gatherer dentitions revealed grooves in anterior teeth in male dentitions, whereas in comparing his data with photographs from an ethnographical study of Paiute lifestyle, he found that only females had been documented to engage in basketry. Examination of the photographs which depict a Paiute woman engaged in basket-making using her teeth, led Larsen to conclude that the aetiology of the historic and prehistoric grooves were the same. The discrepancy between prehistoric and historic data was interpreted to be either a sampling bias or the result of a different activity practiced by males altogether: the preparation of sinew for bows (Larsen 1985; Wheat 1967). The preparation of sinew using the anterior dentition was recorded for contemporary Inuit populations from Greenland. This activity resulted in grooving of the occlusal surfaces of the anterior teeth (Pedersen 1947).

As we have seen above, the ethnographical studies which have documented special uses of the human teeth resulting in notches or grooves, have focused mainly on describing the particular activity which is suggested to have caused this type of dental wear. In most cases no actual dental analysis has been performed, which has resulted in a lack of data to compare with the vast amounts of detailed information on skeletal dentitions. Comparisons often run along the lines that 'the direction of the grooves on the prehistoric sample seem similar to the manner in which historic people are said to have clamped the fibres/sinews between their teeth'.

Presumably the reason for this lack of detailed analysis is again due to the disinterest of anthropologists and ethnographers in dental anthropology, possibly coupled with the fact that detailed analysis of a person's teeth is quite an invasive procedure.

5.3.2 Dental Chipping

In the case of dental chipping there have been numerous studies of prehistoric dentitions, which have in most cases been compared to ethnographic accounts on the use of the teeth. These ethnographic accounts of Inuit, Aleuts, and North American Indians, have been of great use in interpreting dental chipping in prehistoric teeth, due to their very detailed descriptions of tooth use. Again these descriptions pertain mainly to the activity which is supposed to have caused the chipping, instead of the physical condition of the teeth; nevertheless most often they have led to the establishment of a direct link between activities observed by ethnographers and prehistoric dental chipping. For example, Turner and Cadien studied 324 prehistoric Inuit, Aleut, and Northern Indian dentitions, and observed that all three groups were affected by

considerable dental chipping, although the Inuit dentitions were affected most severely. Through statistical analysis of their data they were able to establish that the Inuit dentitions displayed more severe chipping due to their diet, which was comprised mainly of meat from large land and sea mammals. Through the use of ethnographic data on the Inuit, they were able to establish a link between the consumption of large amounts of (frozen) meats - and the use of teeth as tools for processing seal skin - and dental chipping (Turner & Cadien 1969).

In their interpretation of the dental chipping in their prehistoric sample, Turner and Cadien take note of the account by Gontran de Poncins, a French adventurer who spent 15 months with the Inuit of the Canadian arctic in 1938-1939. The following account from De Poncins' book *Kabloona* sheds some light on the Inuit's attitude towards and use of their teeth.

> *"They ground their teeth and their jaws cracked as they ate…They had long since stopped cutting the meat with their circular knives; their teeth sufficed, and the very bones of the seal crackled and splintered in their faces. What those teeth could do, I already knew. When the cover of a gasoline drum could not be pried off with the fingers, an Eskimo would take it between his teeth and it would come easily away. When a strap made of seal skin freezes hard - and I know nothing tougher than seal skin - and Eskimo will put it in his mouth and chew it soft again. And those teeth were hardly to be called teeth. Worn down to the gums, they were sunken and unbreakable stumps of bone. If I were to fight with an Eskimo, my greatest fear would be lest he crack my skull with his teeth."* (De Poncins 1941:72).

The use of the teeth in such a way would clearly be disastrous for their condition. However, for people like the Inuit it seems to have been a survival strategy; Turner and Cadien suggest that they needed to extract the maximum amount of nutrition from the meat they had hunted, and therefore ate the crushed bones and marrow as well as the meat.

Whatever the reason, it is clear from the ethnographical studies of the Inuit and other arctic and Northern American groups that the chewing of bone from fish, birds, sea and land mammals could have caused dental chipping. Furthermore, the use of the teeth as tools in certain non-masticatory activities could have been an important factor.

A non-masticatory activity which could have caused damage to the dentition was recorded in Robert J. Flaherty's 1922 silent film *Nanook of the North*. This early ethnographic documentary depicts an Inuit family during daily activities such as hunting and igloo building. During a fishing expedition, the father Nanook catches a number of fish of different sizes. To kill the larger fish, he delivers a crushing bite to the dorsal area above the gills. This non-masticatory activity illustrates the manner in which teeth were used as tools, but in collaboration with the other examples given above it also shows the variety of tasks the teeth were put to.

In an example closer to the Caribbean region, it is clear that extraction of nutrition from tough foodstuffs and the use of the teeth as tools for certain tasks, plays an important role in the use of the teeth. In the context of enthoarchaeological fieldwork, Jimmy Mans visited some indigenous groups in Suriname during the spring months of 2007. During his stay in Amotopo, a village located near the conjunction of rivers which form the Corantyne, he

witnessed individuals belonging to the Trio ethnic group using their teeth as tools in cracking nuts to extract the inner fruit. These nuts, which are called *Kaura* (Fig. 8) by the Trio and *Hymenaea courbaril* by botanists, have a thick, hard shell which would seemingly make them difficult to open; they can be cracked using a hammer or a machete. Nonetheless, the individuals concerned managed to crack them using only their teeth and jaw muscles. Furthermore, on a trip into the surrounding forest near the village, an Amotopo villager used his teeth to cut entangled lianas - notoriously tough and woody vines - which were hampering the progress of the trip (J.L.J.A. Mans; pers. comm.. 2007). Such examples serve not only to illustrate the attitude many people have towards (the use of) their teeth, but they also offer us insights into the *exact* activities which may have caused certain forms of dental wear.

Figure 8: The *Kaura* or *Hymenaea courbaril*. Photo courtesy of J.L.J.A. Mans

5.4 Modern dentistry

As argued in the introduction to this chapter, modern dentistry is one of the lines of evidence which is imperative to understanding the complicated patterns of human dental wear. To understand more about how these patterns arose, a number of insights from modern dentistry are discussed here, which have some bearing on the forms of dental wear observed in this study's sample.

5.4.1 Bruxism

Bruxism is the habit of clenching and/or grinding the teeth together when not eating. It is a major cause of abrasion to the human dentition. Estimates from clinical studies of how many people brux, range from 6% to 88% of the population (Ahlberg 2002). The range of causes suggested for bruxing is almost equally as great, with explanations varying from stress to temporomandibular disorder. Another favorite cause often opted for bruxism is the activation of reflex chewing activity during sleep; reflex nerve pathways which control chewing activities remain active, while brain control is inactive. The result is an abnormal chewing action (Abrahamsen 2005; Ahlberg 2002; Watts et al 1999).

The damage to the dentition caused by bruxing can be considerable. Bruxing can cause chips and fractures in the tooth enamel and underlying dentine, and wear of the occlusal, lingual, and buccal surfaces of the teeth. The latter scenario is usually only the case for severe or prolonged sleep bruxing, or bruxing which goes undiagnosed or untreated by a dentist for a long period of time. Dental chipping and fracturing should be considered as one of the most important destructive effects on the teeth. Professor of dentistry, Ben W. Pavone has the following to say on this matter: "*The relationship between clenching and bruxing and cusp or tooth fracture can be understood more easily when the focus is placed on the excessive forces that can be exerted on opposing teeth. The average force generated by opposing teeth has been estimated at 175 to 250 psi. I have measured forces as high as 250*

to 350 psi. Arnold states that "since the cusps of teeth usually present an area that is about 0.001 inch square, it can be seen that given the average force (of 175 psi) it would not be unusual for the stress to reach 175,000 psi." (Arnold 1981:395; Pavone 1985:693).

Apart from the wear to the teeth, bruxing can lead to tooth sensitivity, headaches, jaw pain or tightness in the jaw muscles, dislocation of the jaw, damage to the tongue and insides of the cheeks, earache, chronic facial pain, and 'popping' or 'clicking' of the temporomandibular joint (Pavone 1985).

5.4.2 Erosion: dietary and non-dietary

Erosion of the teeth is the process of chemical dissolution of hard dental tissues due to the presence of acids in the mouth. Once the pH level in the mouth has dropped below 5.2 the enamel of the teeth starts to dissolve (W. Kuiters, pers. comm. 2007). The acids which cause this dropping of the pH level can be intrinsic or extrinsic acids. Intrinsic acids are those which come from within the body; gastric acids.[24] Extrinsic acids are usually introduced as foodstuffs (e.g. citric fruits or sugary drinks), although chemists exposed to dangerous chemicals and acids have been known to suffer from dental erosion through inhalation of the acidic fumes (Abrahamsen 2005; Alt & Pichler 1998; Bartlett 2005; Valena & Young 2002).

The process of demineralization is counteracted somewhat, especially during its initial stages, by the remineralizing effects of saliva in the mouth. Saliva contains calcium and phosphate which can replace the lost minerals. In severe cases of 'acid attack' however, the remineralizing ability of the saliva is overcome, which leads to swift erosion of dental tissues. Due to differences in the saliva flow within the oral cavity, some teeth are less protected than others from the destructive effects of acids. The least well protected teeth are the maxillary incisors and canines (Amaechi & Higham 2001).

The appearance of tooth wear due to erosion can be very characteristic. As the enamel surfaces of the teeth are worn away, the underlying dentine is exposed. The dentine is subject to more rapid wear due to the fact that it is softer than enamel. The erosion of the dentine proceeds in a 'hollowing' fashion; the teeth become cupped on the affected surfaces. In the maxillary anterior teeth, this usually occurs on the lingual surface, giving these teeth a 'scooped-out' look. On the molar surfaces, the cusp patterns disappear and are replaced with a number of small cups. In further erosive damage, the molar surfaces become one large hollow of exposed dentine (Abrahamsen 2005; Bartlett 2005).

The most commonly known cause of intrinsic acid erosion is the psychosomatic disorder *bulimia nervosa*. Up to 90% of patients suffering from this condition are said to suffer from dental erosion. The periods of purging indulged in by bulimic patients cause rapid and severe erosion of the teeth, in particular the maxillary incisors and canines. The other dental elements are protected from the acids by the tongue and the remineralizing effects of saliva (Valena & Young 2002). In many cases of intrinsic acid erosion, however, the introduction of gastric acids into the mouth is an involuntary process. Well-documented examples are conditions such as *gastro-oesophageal reflux disease* (GORD) and *chronic gastritis* as a result of alcoholism. GORD is the most common gastrointestinal disorder, which affects about 40% of the general population at some point in time. The gastric contents reflux into the oesophagus, and then into

[24] Gastric acid erosion is also known as *Perimolysis*.

the oral cavity. In contrast to vomiting there is a relatively small amount of fluids ejected. The condition is often associated with heart burn (Valena & Young 2002).

Chronic gastritis is the chronic vomiting and/or gastro-oesophageal reflux as the result of prolonged alcohol abuse. This condition similarly leads to dental erosion, like that experienced by GORD patients. Again the maxillary anterior teeth are affected most severely (Valena & Young 2002).

Extrinsic acid erosion is usually caused by the consumption of acidic foods and/or drinks. In this case the frequency of consumption and how the foods are consumed is of great influence on the pattern of erosion. In modern dentistry, the most common causes of extrinsic acid erosion, or dietary erosion, is the consumption of excessive amounts of carbonated soft drinks or acidic fruits. Certain consumption habits also play a great role in these cases; the most common phenomena are described as *coke-swishing* and *fruit-mulling*. Coke-swishing is the habit of swishing the soft drink around the oral cavity for some time before swallowing, to remove the bubbles. This bathes the teeth in the acidic drink, and exposes them to far greater erosive factors. Coke-swishers often take a great amount of time to consume one drink, which in fact makes matters worse for the teeth, as they are repeatedly exposed to acids over a long time. Fruit mulling is a habit often observed in health-conscious patients, who consume fruit during the day. They delay the actual swallowing of the fruit pulp in order to be able to mull it between the teeth. This act of mulling the fruit exposes the maxillary and mandibular teeth to the acidic pulp for prolonged periods of time during the day. In both coke-swishing and fruit-mulling, the posterior teeth are affected more severely than the anterior teeth, as opposed to gastric acid erosion where the anterior teeth are affected more severely (Abrahamsen 2005; Bartlett 2005).

It is important to remember in all cases of dental erosion that this form of dental wear never occurs on its own; it is always accompanied by abrasion and/or attrition. These combined factors can make it very difficult to distinguish the different factors causing dental wear. The aetiology of combined erosion, abrasion, and attrition is very complex, and can often prove problematic in modern dentistry; in skeletal material the matter is even more complex (Alt & Pichler 1998; Bartlett 2005).

5.4.3 Caries

Dental caries are lesions in the tooth crown or root which develop due to site-specific demineralization of the tooth enamel, dentine, and/or cementum as a result of organic acids produced by bacteria which permanently inhabit dental plaque. Certain bacteria in dental plaque, known as *acidogenic bacteria*, produce organic acids under influence of fermentable carbohydrates in the diet. High concentrations of these acids eventually lead to lesions which can be severe enough to destroy the whole tooth. Once enamel has been penetrated, the bacteria gain access to the dentine, which is for the greater part an organic material. The bacteria proceed to consume the organic dentine, often causing severe infection in and around the tooth. As with dental erosion, the saliva plays an important role in remineralizing enamel which has been affected by organic acids. For this reason both the diet and the chemical make up of an individual's saliva is of great importance in their susceptibility to dental caries (van Houte 1994). The presence of fluoride in a person's diet is especially important for the ability of their teeth to withstand

carious demineralization. Fluoride is present in drinking water and nowadays is supplemented in tooth paste. Fluoride in saliva protects teeth from demineralization, and also helps remineralize eroded areas (Featherstone 1999).

If left untreated, dental caries can lead to pain and infection, tooth loss, and edentulism (complete tooth loss). As teeth are lost, more pressure is put on the remaining teeth to masticate food. Further tooth loss is often a consequence. Pain and tooth loss in turn lead to (extreme) difficulty in eating, which eventually can lead to malnutrition. The dire consequences to a person's health as the result of dental caries and tooth loss are not to be underestimated. Many studies have shown that dental caries and the loss of the teeth have led to premature death in the past. Simon Mays remarks the following on the matter: *"[U]ntreated caries can give rise to potentially lethal complications. Advanced caries of a maxillary tooth can lead to infection within the cranial cavity, such a meningitis or cavernous sinus thrombosis. […] Advanced caries of the mandibular dentition may give rise to an infection in the lower jaw and throat, called Ludwig's angina. […] In antiquity, then, dental caries may have been anything but a trivial disease."* (Mays 1998:148-149).

5.5 Examination by a modern dentist

A small number of the dentitions from Anse à la Gourde were examined by a modern dentist, Willem Kuiters, who gave his professional opinion on the dental wear present in this sample. A total of 10 dentitions were examined by Mr. Kuiters, in two separate sessions. The dentitions chosen for his analysis exhibited some of the most severe or characteristic forms of dental wear found in this sample. A brief characterization of these dentitions is given in Table 15.

In Kuiters' opinion, at least a portion of the wear in this sample seems to have been caused by bruxing. His analysis of the lingual surface wear of the maxillary anterior teeth proved inconclusive; in most cases this wear did not resemble erosion, which is characterized by cupping of the affected area. Furthermore, he could not conclusively declare that this wear was caused by the processing of plant materials. However he did state that the severity of the wear in many cases illustrated the repeated and frequent practice of a certain *non-masticatory* activity.

His examination led him to conclude that the carious lesions and subsequent infections in these dentitions must have led to extreme pain and discomfort to their owners. These conditions would significantly weaken the individuals affected, as they would be severely impeded from eating.

Chapter 6: Discussion of the results

6.1 Introduction

In Chapter 4 the results of a very broad range of dental wear analyses were presented for the sites of Anse à la Gourde and Tutu. In the present chapter, these results will be discussed in the light of previous research in dental anthropology and archaeology, and the 'other lines of evidence' presented in Chapter 5. The combination of these approaches in the discussion here will lead us to the conclusions of this research, which are presented more concisely in Chapter 7.

6.2 Diet and Subsistence

6.2.1 Degree of wear

The strong positive correlation between the degrees of wear for the different molars at Tutu indicates that the degree of wear of the molar teeth was quite constant during life at this site. The latter suggests an equally abrasive diet during the course of the Tutu inhabitant's lifetimes. At Anse à la Gourde, however, the degree of wear reduced after the eruption of the third molars. The latter can be interpreted as a natural reaction to the presence of the new teeth; the stress on the first and second molars reduces as the third molars take on some of the work. In this case the constant degree of wear at Tutu would imply that the Tutu individuals endured increased stress upon the teeth after the eruption of the third molars, which counteracted the relief of strain which the third molars would otherwise have given. On the other hand in cases of severely abrasive diets (which is most likely the case in both groups), the counteractive role the third molars can play is often short-lived, because once the cusp patterns of the molars are worn away, swift dental wear is sure to follow. If the latter is the case, then we can only conclude that the Anse à la Gourde adult diet was less abrasive than the Tutu adult diet. The less positive relations between the degrees of wear of the first/second molars and the third molars at Anse à la Gourde then indicate that after eruption of the third molars the rate of dental wear slowed down. At Tutu it remained pretty much the same.

When these findings are placed within what is known of the cultural context of habitation at both sites, it becomes clear that the differences between the rates of wear for both sites are most likely the result of a difference in the composition of the diet. As was mentioned in sections 2.2.2 and 2.3.2, the analysis of stable isotopes in bone collagen showed the Tutu diet to be intermediate between marine protein, terrestrial protein, and C3 plants, while the Anse à la Gourde diet relied heavily on marine resources (despite being quite varied overall). The latter, together with the strategic location of the site of Anse à la Gourde on the small strip of land on the very eastern coast of Guadeloupe, suggests that the marine component in the diet at Anse à la Gourde was substantially larger than at Tutu. It is known that agricultural diets (or in this case horticultural diets) often contain small particles of grit and sand which enter the food during its preparation; e.g. during grinding on a grindstone. These small particles are extremely abrasive to the teeth, and are the main reason for the association between agricultural diets and severe dental wear. It is most likely the larger component of horticulturally produced foods in the Tutu adult diet, in comparison with the Anse à la Gourde diet, which caused the higher rate of wear observed in the sample. The greater focus on marine resources at Anse à la Gourde

would have spared the teeth slightly from this abrasive factor.

6.2.2 Direction of wear

In section 4.3.2 we have seen that the categories of oblique wear outnumber the other directions of surface wear at both sites. However, at Tutu the frequency of obliquely worn molar teeth is significantly greater than at Anse à la Gourde. The latter suggests that the amount of refined foods consumed at Tutu was greater than at Anse à la Gourde, as oblique molar wear has been proved to be the result of the presence of a large amount of (agriculturally produced) refined foods in the diet. This ties in well with the fact that the Tutu teeth had a higher rate of wear in adult life than the Anse à la Gourde teeth due to the more prominent presence of horticultural products.

6.2.3 Occlusal surface shape

In section 4.3.3 the occlusal surface shapes of the molar teeth were examined, in order to establish how great a proportion of these were cupped. Molar cupping indicates the consumption of refined agricultural foods; the cupping is attributed to the presence of small particles of stone and grit in agriculturally produced foods.

As molar cupping has been linked to the small particles of grit from food preparation in the diet, one would expect from the conclusion drawn in section 6.2.1 that molar cupping would be more frequent in the Tutu sample than the Anse à la Gourde sample. This is indeed the case; the difference is statistically significant.

Again the molar wear seems to indicate that Tutu people consumed greater amounts of refined foods than Anse à la Gourde people. However, there is another factor which could have been of influence on the cupped appearance of the molar teeth: erosion. In section 5.4.2 we have seen that the characteristic shape of an eroded molar is cupped; once the enamel has been eroded, the dentine becomes hollowed out, as it is much more susceptible to acids than enamel is. Furthermore, in section 5.2 we have seen that ethnohistoric accounts describe self-induced vomiting and the consumption of large amounts of fruits, both of which would introduce acids into the mouth which are capable of causing dental erosion.

In a skeletal sample it is not possible to distinguish between cupping produced by erosion or cupping produced by small particles of stone and grit in refined foods. Considering the evidence from ethnohistoric accounts, though, it is fair to say that there must have been numerous dietary (and gastric) acids present in the mouth of these people, which would no doubt have had an erosive effect on the teeth. A combination of both subsistence strategy and acid erosion therefore seems to be the most plausible explanation for the dental cupping witnessed in the assemblages.

6.2.4 Caries

In section 4.3.4 the frequency of caries at the sites was discussed as an indicator of the proportion of carbohydrates in the diet. Not surprisingly, the percentage of carious teeth in the Tutu sample was very high; typical for a diet based on high carbohydrate consumption from an agricultural staple food. The percentage of carious teeth in the Anse à la Gourde sample was significantly lower than in the Tutu sample, falling within the range between a mixed economy and an agricultural economy. Again this difference seems to indicate the greater reliance on horticulture at Tutu, and the substantial component of marine foods in the diet at Anse à la Gourde.

It is very likely that the frequency of dental caries was in actual fact much higher at both sites, as many of the missing teeth must have succumbed to dental caries.

6.3 Health and Lifestyle

6.3.1 Severe dental wear

In section 4.4.1 we have seen that the mean degrees of wear at both sites were very high. The latter would have been problematic, especially for older individuals with more severe dental wear, as it would increasingly become an impediment to the normal consumption of different foods. In this section we have also seen that the Anse à la Gourde males had a higher mean degree of wear in all age categories than the Anse à la Gourde females. The latter could have been the result of the consumption of more abrasive foods by males. Another possible explanation for the difference between males and females is the fact that males generally have heavier set jaws and larger jaw muscles, which exert more pressure on the teeth resulting in more rapid dental wear. At Tutu this difference in mean degrees of wear is present for the age category 30-60 years, however the absence of any clear overlap between the age categories of the two sexes makes comparison impossible and any difference therefore difficult to interpret.

It is to be expected that the mean degree of dental wear is lower in children - as is the case for both groups - because their teeth have not been exposed to abrasives for a long period of time, and generally children consume softer, less abrasive foods as their jaws are not strong enough to masticate tougher foods.

6.3.2 Caries

Due to the larger proportion of marine foods in the Anse à la Gourde diet, it is possible that the inhabitants of this site consumed more fluorides, and were therefore better protected against caries than the Tutu inhabitants. Therefore, not only the consumption of fewer carbohydrates could have been the reason for the considerably lower caries frequency at Anse à la Gourde, but also the consumption of more marine foods. This illustrates very well how important the diet is for oral health.

An important consequence of the high degree of caries in both populations would have been the large amount of pain suffered by these people as a result of the rampant infections in their teeth. The severity and frequency of dental caries in these populations must have been a great impediment to food consumption, and as a consequence would have further affected the general health of the individuals concerned. Tooth loss as a result of dental caries would also have posed a problem to these people, as the remaining dentition would be put under greater strain as a consequence.

6.4 Special uses of the teeth

6.4.1 Dental Chipping

In section 4.5.1 we have seen that frequency of dental chipping differs significantly when we compare the Anse à la Gourde sample and the Tutu sample. The Tutu population is affected more frequently by dental chipping than the Anse à la Gourde population.

Interesting in the light of the above, is the fact that Tutu individuals seem to have less teeth present than Anse à la Gourde individuals (Fig. 9 and 10).

When we compare the total number of teeth present for each site to the number

of teeth which could be expected if each individual had a complete dentition, it is clear that the Tutu adults have a significantly smaller percentage of teeth still present than Anse à la Gourde adults (30.3% and 53.7% respectively). This difference may provide some clue to why the Tutu people were more strongly affected by dental chipping than the Anse à la Gourde people; once teeth are lost, more stress is put on the remaining elements, which could cause them to be chipped more frequently than would otherwise be the case. The latter is assuming that the difference in percentages of teeth present is the result of ante mortem tooth loss as opposed to post mortem tooth loss. It is quite likely that a very large number of the missing elements were lost ante mortem, considering the high degree of caries and dental wear. The percentages indicating the proportion of surviving teeth for the children of both sites are practically the same (Tutu: 30.6% and Anse à la Gourde: 30.9%).

On the other hand, if dental chipping is considered to be the result of small particles of stone and grit in foods, a larger proportion of chipped teeth for Tutu may be expected. Viewed in this manner, the significant difference between the two samples would be indicative of a masticatory cause for dental chipping; damaging particles causing chipping during normal mastication of food.

The previous does not explain the large number of chipped anterior teeth in both groups, however. These teeth are not intensively used during food mastication (grinding), but are generally used for cutting and tearing portions of food for further mastication. It is for this reason that they are generally less affected by chipping due to particles of stone and grit in food, as the food is masticated by the posterior teeth. A large (or larger) proportion of chipped anterior teeth can therefore be indicative of non-masticatory causes for dental chipping. In Anse à la Gourde this seems to have been the case, as the females at this site had a significantly larger proportion of chipped anterior teeth than chipped posterior teeth. The Tutu females do not show such a significant difference between the anterior and posterior dentition, however, their posterior chipping is also not significantly more frequent than the anterior chipping. For the Tutu males and children this *is* the case. This may be interpreted in the following way: the Tutu posterior teeth were chipped frequently as a result of small particles of stone and grit in the diet; this resulted in a larger proportion of chipped posterior teeth than chipped anterior teeth. The females, however, engaged in a non-masticatory activity which counteracted this difference between anterior and posterior chipping, which resulted in similar values for both. This interpretation is somewhat speculative, however it seems a conceivable explanation for the interesting patterns observed in the sample.

Although the anterior teeth were in some cases more frequently chipped than the posterior teeth, in all age and sex groups they were less severely chipped. The latter is no doubt due to the greater amount of pressure which can be exerted on abrasive materials by the posterior teeth. The posterior teeth are made for grinding materials, and are therefore well-adapted to exerting great pressure using the powerful jaw muscles. The anterior teeth are made for cutting and tearing portions of food for mastication, however they function very well as a clamp in grasping objects.

Posterior chipping need not necessarily be interpreted as the result of masticatory activities, however. The posterior teeth are very useful tools, due to their strength and ability to exert a great amount of pressure

on a small area. It is for this reason that these teeth are used as tools in some cultures, e.g. the Inuit and Aleuts. Here the teeth are used for cracking bones, killing fish with a bite, and chewing frozen seal skin. Turner and Cadien strongly associate dental chipping with a diet consisting mainly of meat and with the masticatory action of crushing bones with the teeth (Turner & Cadien 1969).

We have already seen that the teeth are used to crack very hard nuts and tough lianas in indigenous groups in Suriname. The latter two uses of the teeth seem very plausible culprits for dental chipping in the Caribbean, as nuts were consumed there too, and lianas grew in the region. Another very plausible cause of non-masticatory dental chipping is the use of the teeth to crack shellfish and crabs, to extract the inner flesh. Linda Budinoff concluded that the teeth she observed in the skeletal population from the site of Maisabel, Puerto Rico, must have been chipped in this manner. It is known that pre-historic Caribbean inhabitants consumed large amounts of shellfish and land crabs, which if accessed using the teeth would have caused considerable damage to the teeth over time. Furthermore, they consumed tough palm nuts, such as *Acrocomia media*, which they could have cracked using the teeth. In some North American populations hard nuts (e.g. walnuts) were smashed and boiled in water with shell and all. The larger pieces of shell were then extracted, but many small particles of nutshell would have remained in the residue which was then made into a cake (L.A. Newsom, pers. comm. 2007). This practice may offer another possible (masticatory) explanation for dental chipping.

Next to the aforementioned causes and possible causes of dental chipping, the act of bruxing needs to be taken into account. The figures of bruxing people today are very high; some estimates suggest 8 out of 10 humans brux on a fairly regular basis. Based on these figures, and examination by dentist Willem Kuiters, is seems possible that some of the dental chipping in the sample was caused by bruxism. As bruxism is a condition which is often associated with physical or mental stress, any evidence of bruxing in the sample would suggest that these prehistoric peoples endured some form of stress in their lives. The latter may seem odd, as stress is often perceived as a modern phenomenon of our industrialized achievement-oriented society, due to overworking and peer pressure, however other stress factors such as malnutrition and physical trauma could also cause bruxism.

All in all there were a large number of factors at work which would have been able to cause dental chipping. Therefore, it is most likely that the patterns of dental chipping observed in the sample are the result of a combination of these different factors; particles of stone and grit in the diet, the hard outer shells of foodstuffs, any other hard materials which needed braking or tearing, and bruxism. Nonetheless, it does seem possible to distinguish the causes of dental chipping on a basic level: the fact remains that the Tutu teeth were chipped more frequently than the Anse à la Gourde teeth, which seems to be the result of the greater percentage of lost teeth at Tutu, and the consumption of more refined foods.

The positive relation between frequency of dental chipping and degree of wear has been shown for both sites in section 4.5.1, however the exact relation still remains unclear; does dental chipping accelerate the rate of wear, or do severely worn teeth chip more easily? In my opinion both are equally plausible, and the combination of both seems most likely.

6.4.2 Dental Notching

In section 4.5.2 dental notching is discussed. It is generally accepted in dental anthropology that dental notching is the result of non-masticatory activities. In this discipline, notching is usually linked to the pulling or clamping of threads or sinew between the teeth. Notching has in the past often been associated with the use of the teeth as tools in basketry, where the teeth are used as an 'extra pair of hands' to clamp the materials. In modern dentistry dental notching can often be directly linked to a certain non-masticatory activity or occupation. Examples can be found in seamstresses (thread), carpenters (nails), musicians and pipe smokers (mouth pieces), and office workers (pens). In prehistoric dentitions establishing the cause of dental notching is far more difficult (Alt & Pichler 1998). However, for the present sample it seems quite likely that the practice of basketry could have caused the dental notching recorded. Undoubtedly many perishable containers such as baskets were used by the indigenous populations of the Caribbean, as has been recorded for the indigenous populations of the South American tropical lowlands. Furthermore it is known from accounts by Las Casas that the indigenous peoples of the Caribbean made use of fine nets in fishing, although he sadly did not describe how they were manufactured.

The fact that none of the molars from both assemblages were affected by dental notching confirms the assumption made in dental anthropology that dental notches are the result of non-masticatory activities. It is to be expected that only the anterior teeth are used in such activities, as the teeth which are most easily accessible from outside the mouth to manipulate materials would be employed in such tasks. The anterior teeth can easily be accessed from the front of the mouth, and the premolars can easily be accessed from the side of the mouth. Furthermore these teeth are capable of handling delicate tasks or materials, whereas the molars are far less adapt for such activities.

It is not surprising that the mean age estimates for dental notching fall within a slightly older category, as a dental notch needs time to form, which makes (severe) dental notching in younger individuals less likely than in slightly older individuals.

The microwear analysis of the groove in element 1.1 from male individual 30 at Tutu indicated that the groove could have been caused by compression, due to the pits in the groove surface. However, these pits could also have been caused by the *"forceful dragging of tough, fibrous material across the teeth"* (Larsen et al. 2002). Larsen et al. suggest the manufacture of cordage as a possible cause for groove with such characteristics. Assuming the aetiology of the Anse à la Gourde grooves is the same - as is the case for the appearance of the grooves examined under a microscope - then it is very likely that the same action of pulling tough fibrous material across the teeth, e.g. in making cordage, was the cause of these grooves.

The fact that a larger percentage of the Tutu population is affected by dental notches than the Anse à la Gourde population is interesting, however, it is important to remember the previously mentioned fact that dental notching is more readily identifiable in older individuals, as it takes some time to develop. The individuals buried at Tutu were mainly slightly older individuals, around 40-50 years of age. The Anse à la Gourde group is comprised of individuals from more - younger - age groups than the Tutu group. It is possible therefore, that the Tutu dental notching is over-represented due to the group's age profile.

We have in section 4.5.2 that at Anse à la Gourde only females have notched teeth, whereas at Tutu both males and females are affected. This is extremely interesting, as it suggests that there was some type of gender based task division at Anse à la Gourde, due to which only females partook in the activity that caused dental notching. Based on this assumption, it would be fair to suggest that the individual of unknown sex was most likely also a female[25], however it must be kept in mind that gender based labour divisions, although often very strict, can allow exceptions to the general rule, in which case this individual may just as well be a male. Furthermore there is the possibility that the dental notches in question were caused by different activities altogether, which again makes it difficult to infer the sex of the unknown individual based on the predominant sex of the group.

Although the differences between Anse à la Gourde and Tutu are interesting, they make the similar aetiology of the dental notching at both sites difficult to explain. In this case it is important to keep in mind that different activities can result in the same (or very similar) appearance in dental wear patterns. On the other hand, gender differentiation is not a prerequisite, as males and females could be practicing the same activities at one site, while in another village the activity is gender orientated.

6.4.3 LSAMAT

In section 4.5.3 we have seen that LSAMAT is present in all age and sex groups in both Anse à la Gourde and Tutu. At Tutu the males seemed to be affected more frequently than the females, but there were no exclusive gender-based differentiations. This informs us that the activity which was responsible for the dental wear pattern LSAMAT was engaged in by members from all age and sex groups within the community. It is interesting in this respect to find that a substantial number of individuals in both samples do not have any apparent LSAMAT. Examination of the material by dentist Willem Kuiters has led to the conclusion that this type of lingual wear was not caused by the normal process of dental wear due to (mal)occlusion or food mastication. For this reason we can tentatively conclude that this lingual wear was caused by one or more non-masticatory activities. These activities were engaged in by a large portion of the community, however a significant number of individuals, for some reason, did not take part in this activity. No distinctions can be made between age and/or sex within these groups. There are a range of possibilities why certain individuals do have LSAMAT and others don't, all of which can merely be guessed at. For instance, it is possible that the activity which caused LSAMAT could be done using different techniques, of which only one involved the use of the teeth as a tool.

The unclear pattern of manifestation of LSAMAT makes this form of dental wear very difficult to interpret. From the appearance of the wear, it is quite clear that it was not caused by acidic erosion; in this case the lingual surfaces would be hollowed out. The tiny striations and in some cases polishing, suggest that the abrasive agent at work here was a fibrous plant material. Larsen et al. suggest plant material as the possible agent for LSAMAT in their study of the Tutu teeth. They agree with Turner and Machado's original suggestion that LSAMAT is most likely caused by the peeling and sucking of raw manioc root peel, although they do suggest that other plants could have caused the same type of lingual wear.

[25] This concerns individual F450.

Turner and Machado feel that the peeling and sucking of raw manioc peel also explains the association of LSAMAT with a high caries rate. Manioc is extremely nutritious and especially rich in carbohydrates. However, the unprocessed manioc root is extremely poisonous[26], as it contains a high percentage of cyanogenic glucosides, and it needs to be thoroughly processed before consumption is possible. Raw manioc peel therefore, would have been an unlikely snack for any wise Amerindian. Furthermore, if LSAMAT was directly associated with a high degree of caries due to the consumption of raw manioc peel - which is very high in carbohydrates - then one would expect the anterior maxillary teeth to be particularly severely affected by caries, due to their close contact with the carbohydrate rich plant material. This is not the case however, as we have clearly seen in Figures 7 and 8 that the posterior teeth are significantly more frequently affected by caries than the anterior teeth. In the case of Tutu, none of the (maxillary) anterior incisors were affected by caries.

All of the above suggests that LSAMAT was caused by a fibrous plant material, which was rubbed across the lingual surface of the maxillary anterior teeth, but in some cases the mandibular anterior teeth. It is extremely unlikely that this plant material was manioc, although another fibrous root crop may be the culprit. The fibrous plant which could have caused LSAMAT is unlikely to have an exceptionally high carbohydrate content, as the frequency of caries in the anterior teeth is lower than the posterior teeth.

[26] It is true that the sweet variety of manioc (*yucca dulce*) is much less toxic than its bitter relative (*yucca brava*), however it still would have been very dangerous to consume in its raw state. Furthermore, it is generally accepted that the Amerindians of the Caribbean region most likely cultivated bitter manioc as a staple crop as opposed to sweet manioc, as the bitter variety is much less susceptible to disease and vermin.

Chapter 7: Conclusions in summary

7.1 Concise conclusions: Anse à la Gourde and Tutu

7.1.1 Diet

The high degree of ante mortem tooth loss and the considerable degree of dental caries at both sites indicate that the diets of the inhabitants of Anse à la Gourde and Tutu were rich in carbohydrates. However, the inhabitants of Anse à la Gourde consumed fewer carbohydrates than the Tutu inhabitants. Where the Tutu people enjoyed a varied diet with a high-carbohydrate staple food, the Anse à la Gourde people relied much more heavily on marine resources, a fact exemplified by the results of stable isotope analysis done by Norr and Stokes (Norr 2002; Stokes 1998). The latter is reflected in the smaller percentage of carious teeth at Anse à la Gourde in comparison with Tutu. By today's standards, oral health at both sites would have been very poor, as the carious lesions would have led to infections and a great deal of pain.

The molar dental wear patterns of the inhabitants of both sites indicate that their diets contained a considerable agricultural component of 'soft' processed foods, which is in concurrence with previous expectations for these peoples. This component of refined foods did not, however, prevent the severe dental wear which can be expected for prehistoric populations. Sand and grit adhering to processed foods helped cause the severe dental wear recorded for both groups. In comparison it has been shown that the inhabitants of Tutu consumed a larger proportion of refined agricultural (horticultural) products in their diet than the Anse à la Gourde inhabitants. Again this seems to be the result of the heavier reliance on marine resources at Anse à la Gourde, which considering the site's location is not surprising. Once more we see concurrence with the results from stable isotope analysis here.

Most likely, this difference in dietary composition was also the reason for the difference in dental wear rates between the sites. In adult life, after the eruption of the third molar, the rate of wear at Tutu remained constant, while at Anse à la Gourde the rate of wear decreased somewhat. It seems that the large horticultural component in the Tutu diet had a far more abrasive effect on the teeth than the large marine food component had on the Anse à la Gourde diet.

7.1.2 Dental Chipping

Severe damage to the teeth in the form of dental chipping was caused by the combination of various masticatory and non-masticatory factors. Again sand and grit adhering to refined foods would have been a major factor in this form of dental wear. Some foodstuffs may have been naturally very damaging to the teeth, for instance the nut cakes which may have been made would have included large amounts of damaging and abrasive particles. Furthermore, the use of the teeth as tools to e.g. crack nuts, shellfish, crab shells, and possibly bones would have contributed to the fracturing and chipping of tooth enamel. What is more, there is a strong possibility that stress factors led to bruxism, which in turn could have led to severe dental wear and/or dental chipping. Dental chipping has been proven to have a positive relation with degree of wear. The higher the degree of wear, the more frequent the dental chipping is. The latter relation is most likely the result of a two-way interaction: severely worn teeth chip more easily, and chipped teeth wear faster.

7.1.3 Dental Notching

At Tutu non-masticatory activities which caused dental notching were engaged in by both males and females, however at Anse à la Gourde only females and one individual of unknown sex were affected by dental notching. Surprisingly, considering the apparent gender-differentiation at Anse à la Gourde, the appearance of the dental notches at both sites is the same. The latter suggests that they were caused by a similar agent. This could mean that there was gender-differentiation at Anse à la Gourde with regards to a certain task, while the same task was not gender associated at Tutu. Another possibility is that the inhabitants of both sites were practicing different activities altogether, which just happened to leave a very similar dental wear pattern. In any case it can be said with some degree of certainty that the agent causing dental notching at both sites is most likely a tough, fibrous plant material. The most plausible causes for dental notching are the practice of basketry and possibly the manufacture of cordage for instance for fishing nets.

7.1.4 LSAMAT

A large proportion of both groups was affected by a form of lingual wear of the maxillary anterior teeth, which has been identified as LSAMAT. Analysis by a modern dentist has indicated that this lingual wear pattern is most likely the result of one or more non-masticatory activities. The range of forms of lingual wear in the sample indicates that multiple factors were of influence of the lingual surfaces of the maxillary (and in some cases the mandibular) anterior teeth. One of these factors appears to be erosion, either due to gastric or dietary acids, but most likely due to the combination of both. The wear pattern LSAMAT affects individuals of all ages and sexes at both sites. The individuals without apparent LSAMAT also come from different age and sex groups. As is the case for dental notching, LSAMAT appears to have been caused by pulling tough, fibrous plant materials across the lingual surface of the teeth. Manioc in its raw state can be ruled out as the agent for this form of dental wear, however other root crops seem plausible agents for LSAMAT. Whether the activity (or activities) which caused LSAMAT entailed the use of teeth as tools in manufacturing artefacts or extracting nutrition from foodstuffs is as yet unclear.

7.2 Teeth and lifestyle in Anse à la Gourde and Tutu

The individuals selected in this sample very actively engaged their teeth in many non-masticatory, culturally defined activities, which put their dentitions under a great deal of stress. Together with the high prevalence of carious lesions, and undoubtedly the many infections which were caused by these, this use of the teeth resulted in extreme dental wear and poor oral health. These Amerindians' attitude towards their dentition seems to have been one characterized by the heavy utilization of their teeth in a variety of culturally defined activities. The teeth were not only used as tools, they must have been perceived in this utilitarian way too. It is important to keep in mind, in the light of the previous, that the heavy wear and (premature) tooth loss would have severely impeded these peoples in their normal daily lives. As teeth wore down, became infected, and finally were lost, an individual would have been hampered not only in his/her food consumption, but also in a range of cultural activities. Therefore, possessing a healthy and complete dentition must have been important to these people. It seems these

people's use of their bodies in this way was a very conscious decision, characterized by their cultural background.

7.3 Dental Anthropology and Archaeology

Not only was this research aimed at discovering how the inhabitants of Anse à la Gourde and Tutu used their teeth during daily life, it was also aimed at emphasizing the importance of studying human dental wear in archaeology. Just like the study of the rest of the skeletal remains of humans, the study of dental wear has been proven to afford a wealth of information on human cultural practices. In some cases these can confirm what archaeologists already knew. In other cases this type of research can even offer new insights into past cultural practices. It is my belief that the analysis of dental wear in human remains from archaeological settings should be routinely practiced in the same manner that other lines of evidence are pursued within this discipline. Dental wear analysis has proved itself worthy as one of the tools used in the multi- and interdisciplinary approach. Equally, the practice of dental wear analysis requires a multi- and interdisciplinary approach. What is more, just as the combined effort of different disciplines is vital in dental wear analysis, so also is the ability to compare different dental assemblages from different archaeological contexts. Clearly, it is the combined effort of both disciplines using multiple lines of evidence that provides us with many new insights. It has become clear to me during the course of this research that both disciplines - dental anthropology and archaeology - complement each other both in their research methods and their results.

Glossary

Aetiology - also known as etiology in American English, this term refers to the causes or origin of a disease; the factors which produce or predispose toward a certain disease or disorder. In dental anthropology and dentistry, it refers mainly to the (combination of) factors which produce a certain type of dental wear or dental pathology.

Anterior dentition or teeth - the teeth positioned in the front of the mouth. This generally indicates the incisors, canines, and premolars.

Attrition - the dental wear caused by contact of the teeth with other teeth.

Abrasion - dental wear caused by the contact of the teeth with food or other materials passed over the teeth.

Buccal surface - the surface of the tooth directed towards the cheek.

Bruxism - the habit of clenching and/or grinding the teeth together (tooth-on-tooth contact when not eating).

Calculus or tartar - a hard, yellowish to brownish-black deposit on teeth formed largely through the mineralization of dead bacteria in dental plaques by the calcium salts in salivary and sub-gingival secretions.

Canines - the four pointed, conical teeth in the upper and lower jaws located next to the incisors.

Caries - the decay of the tooth in the form of a cavity caused by bacteria that attach to teeth and form acids in the presence of sucrose, other sugars, and refined starches. Progressive decay can lead to the death and/or loss of the tooth.

Cavernous sinus thrombosis - the blockage of one of the large veins at the base of the brain (the cavernous sinus) which causes a blood clot to form. The cavernous sinuses are situated immediately behind each eye socket. Their purpose is to drain blood from the brain and face back to the heart. The cavernous sinuses are also surrounded by sets of nerves called the cranial nerves, which are necessary to control eye movement and for the feeling in the top and middle part of the head and face.

Cementum - the bonelike tissue that forms the outer surface of the root of a tooth.

Cusp pattern - the pattern of small elevations and crevices of the grinding surface of a tooth.

Dental anthropology - the multi-disciplined field of research which focuses on the study of dental wear and dental morphology in prehistoric and modern populations as a key to the biology and behaviour of past and living populations.

Dental elements - the individual teeth which make up the dentition.

Dental wear - the wear of the (mainly occlusal) surfaces of the teeth due to contact with other teeth, food, erosive chemicals, and other materials.

Dentine - the hard, calcareous tissue, similar to but denser than bone, that forms the major portion of a tooth, surrounds the pulp cavity and root canals, and is situated beneath the enamel and cementum.

Dentition - the type, number, and arrangement of a set of human or animal teeth.

Distal surface - the surface of the tooth which is directed in the posterior direction.

Edentulism - the condition of being toothless.

Enamel - the hard, calcareous covering of the crown of a tooth, which contains only a slight amount of organic substance.

Erosion - the chemical dissolution of the enamel surface and subsequently the underlying dentine of the teeth, due to the presence of acids in the mouth.

Fluorosis - an abnormal condition caused by excessive intake of fluorides, characterized by discoloration and pitting of the teeth and by pathological bone changes.

Gastro-oesophageal reflux disease (GORD) - alternatively known as gastro-esophageal efflux disease (GERD); this condition is caused by abnormal relaxation of the lower oesophageal sphincter (the muscular ring at the lower end of the oesophagus) which allows the stomach's acidic contents to flow back or 'reflux' into the gullet (oesophagus).

Incisors - the sharp-edged teeth for cutting or gnawing, which are located in the front of the mouth between the canine teeth.

Interproximal surface - the surface of the tooth which adjoins its neighbouring tooth.

Labial surface - the surface of the tooth directed towards the lips.

Lingual surface - the surface of the teeth facing the tongue.

Ludwig's angina - the bacterial infection of the floor of the mouth, which may involve swelling that could block the airway. This condition often occurs following an infection of the roots of the teeth.

Malocclusion - the incorrect alignment of the teeth and/or incorrect occlusion between the teeth of the two dental arches

Mandible - the lower jaw in vertebrates.

Maxilla - the upper jaw in vertebrates that is fused to the cranium.

Meningitis - the inflammation of the protective membranes covering the brain and spinal chord.

Mesial surface - the surface of the tooth which is directed in the anterior direction.

Molars - the teeth located toward the back of the jaws located behind the premolars, which have broad crowns for grinding food.

Occlusal surface - the grinding/cutting surface of the tooth. In a normal dentition this is the surface which comes into direct contact (or occlusion) with the teeth in the opposite jaw.

Oesophagus - the gullet or muscular tube which transports food from the throat to the stomach.

Periodontitis - or periodontal disease; inflammation of the periodontium caused by bacteria that infect the roots of teeth and the surrounding gum crevices, producing bleeding, pus formation, and gradual loss of bone and the tissues that support the teeth.

Periodontium - the bone, connective tissue, and gum surrounding and supporting a tooth

Posterior dentition or teeth - the teeth situated in the back of the mouth. This generally indicates the molars (and sometimes also the premolars).

Plaque - a soft, sticky, whitish mat-like film attached to tooth surfaces, formed largely by the growth of bacteria that colonize the teeth.

Premolars - the eight bicuspid teeth located in pairs on each side of the upper and lower jaws between the canines and the molars.

Temporomandibular disorder (TMD) - the chronic inflammation of the temporo-mandibular joint, as a result of bruxing or other excessive jaw movements.

Temporomandibular joint - the complex joint which connects the lower jaw to the skull.

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Appendix

Tables

	Male	Female	Child	Unknown	Total
Anse à la Gourde	**19**	**31**	**8**	**8**	**66**
Tutu	**6**	**14**	**5**	**1**	**26**
Total	**25**	**45**	**13**	**9**	**92**

Table 1: The number of individuals per sex category per site

Feature no.	Tutu	Sex	Age	Age class	No. of teeth
1		**Female**	**45-55**	**40-60**	**4**
2		**Female**	**40-50**	**40-50**	**9**
3		**Female**	**40-50**	**40-50**	**22**
4		**Female**	**18-25**	**20-40**	**22**
5		**Female**	**40-50**	**40-50**	**14**
6		**Child**	**5.5-7**	**0-10**	**15**
9		**Male**	**45-55**	**40-60**	**27**
10		**Female**	**45-55**	**40-60**	**10**
12		**Male**	**45-55**	**40-60**	**9**
13		**Female**	**40-55**	**40-60**	**6**
13A		**Female**	**45-55**	**40-60**	**16**
16		**Female**	**35-45**	**30-60**	**24**
19		**Female**	**40-50**	**>40**	**20**
20		**Child**	**9**	**0-10**	**5**
21		**Male**	**40+**	**>40**	**16**
22B		**Child**	**4-5**	**0-10**	**12**
23B		**Female**	**35+**	**30-60**	**7**
26		**Female**	**17-21**	**10-20**	**25**
29		**Female**	**45-55**	**40-60**	**3**
30		**Male**	**35-45**	**30-60**	**20**
31		**Female**	**35-45**	**30-60**	**17**
32A		**Child**	**5**	**0-10**	**1**
33		**Male**	**35-45**	**30-60**	**23**
36		**Unknown**	**40-50**	**>40**	**4**
38		**Male**	**45-50**	**>40**	**24**
39		**Child**	**8**	**0-10**	**24**

Feature no.	AAG				
50		Female	20-34	20-40	8
89		Female	20-32	20-40	31
108A		Male	30-40	20-40	11
137A		Unknown	Adult`	20-80	1
139		Male	40-49	30-60	13
159		Female	30-36	20-40	29
171		Male	Adult	20-80	16
195		Child	3-6	0-10	17
196		Male	40+	>40	10
197		Male	23-40	20-40	22
200		Female	20-34	20-40	1
202		Female	Adult	20-80	5
206A		Male	50-60	>50	13
207		Female	32-50	30-60	19
212		Female	20-80	20-80	12
219		Child	9-14	10-20	28
238B		Female	20-80	20-80	15
241		Unknown	20-80	20-80	1
253		Female	20-80	20-80	4
288		Male	20-80	20-80	9
291		Child	7-12	0-10	1
292		Female	40-60	30-60	29
304		Female	20-50	20-40	17
307		Male	40+	>40	13
311		Female	23-40	20-40	28
335		Female	20-80	20-80	1
339		Male	20-80	20-80	2
342		Male	40-60	30-60	27
348		Unknown	20-80	20-80	2
349A		Male	Adult	20-80	22
349C		Unknown	20-40	20-40	10
377		Child	3-5	0-10	17
378		Female	19-28	20-40	31
430		Female	30-60	30-60	25
447		Female	20-40	20-40	24
450		Unknown	Adult	20-80	22
451		Female	Adult	20-80	18
452		Female	20-34	20-40	10
454		Female	50-70	>50	2
529		Female	20-80	20-80	29
706		Unknown	20-80	20-80	19
726		Male	28-43	20-40	21
953		Female	47-59	>40	5
1126A		Female	20-80	20-80	4
1203		Male	20-80	20-80	19

1207	**Child**	**5-9**	**0-10**	**1**
1226	**Male**	**30-40**	**20-40**	**27**
1413	**Child**	**3-5**	**0-10**	**9**
1496	**Unknown**	**23-40**	**20-40**	**27**
1651	**Male**	**40-80**	**40-80**	**21**
1922	**Child**	**0.67-1.33**	**0-10**	**4**
1944	**Child**	**4-8**	**0-10**	**2**
1945	**Female**	**30-36**	**20-40**	**20**
1947	**Male**	**40-80**	**40-80**	**13**
1948	**Unknown**	**23-40**	**20-40**	**10**
1958	**Female**	**20-80**	**20-80**	**2**
2005	**Female**	**20-80**	**20-80**	**13**
2106	**Male**	**30-60**	**30-60**	**4**
2107	**Female**	**14-20**	**10-20**	**25**
2109	**Female**	**20-80**	**20-80**	**1**
2212	**Male**	**32-50**	**30-60**	**20**
2213	**Female**	**25-56**	**30-60**	**5**
2214	**Female**	**40-70**	**>40**	**26**
2215	**Female**	**20-80**	**20-80**	**18**
2216	**Male**	**25-46**	**20-40**	**16**
2217	**Female**	**20-80**	**20-80**	**14**
Total				**1320**

Table 2: Age, sex, and number of teeth present per individual

Degree of dentine exposure			Direction of wear	Occlusal surface form
Incisors and Canines	**Premolars**	**Molars**		
1. Unworn.	1. Unworn.	1. Unworn	1. Natural form.	1. Natural form.
2. Minimal wear facets.	2. Wear facets, no dentine.	2. Wear facets, no dentine.	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/heavy.	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 3: Molnar's dental wear evaluation method

Assemblage	No.	r for M1, M2	No.	r for M2, M3	No.	r for M1, M3
Anse à la Gourde	**31**	**0.75**	**23**	**0.41**	**20**	**0.32**
Tutu	**12**	**0.74**	**8**	**0.82**	**9**	**0.97**

Table 4: Spearman's rank correlation coefficients for molar wear

* These categories were added during this research, and are not a part of Molnar's original dental wear evaluation method.

Assemblage	Natural form	B-L	L-B	M-D	D-M	Hori-zontal	Round B-L	Round M-D
Anse à la Gourde	**182**	**9**	**13**	**16**	**1**	**12**	**-**	**-**
Tutu	**31**	**5**	**11**	**11**	**5**	**21**	**-**	**2**

Table 5: Number of molar teeth per direction of wear. B=buccal, L=lingual, M=mesial, D=distal

Assemblage	Nat. Form	Flat	½ Cupped	Cupped	Notched	Round	½ Round	Other
Anse à la Gourde	**179**	**14**	**25**	**11**	**-**	**-**	**-**	**4**
Tutu	**28**	**18**	**36**	**3**	**-**	**1**	**-**	**-**

Table 6: Number of molar teeth per occlusal surface shape

Assemblage	Male	Female	Unknown	All adults	Child
Anse à la Gourde	**7.3**	**8.6**	**12.5**	**8.1**	**42.6/15.6**[27]
Tutu	**12.8**	**11.6**	**33.3**[28]	**12.6**	**5.4**

Table 7: Percentages of carious teeth per site and sex

	Occlusal	Interproximal	Smooth surface	Cervix
Anterior	**12.9**	**1.6**	**4.8**	**12.1**
Posterior	**41.1**	**0**	**4**	**23.4**
Total	**54**	**1.6**	**8.9**	**35.5**

Table 8: Percentage of caries in different oral locations at Anse à la Gourde

[27] Including and excluding individual F377 respectively.

[28] The category of Unknown sex at Tutu comprises only one individual, with just 3 teeth present of which one is carious.

	Occlusal	Interproximal	Smooth surface	Cervix
Anterior	**2.3**	**0**	**4.6**	**2.3**
Posterior	**30.2**	**11.6**	**25.6**	**23.3**
Total	**32.6**	**11.6**	**30.2**	**25.6**

Table 9: Percentage of caries in different locations at Tutu

Anse à la Gourde	Male			Female			Unknown			Child		
	No.	Chip.	%	No.	Chip.	%	No.	Chip.	%	No.	Chip.	%
Anterior	**194**	**63**	**32.5**	**312**	**63**	**20.2**	**47**	**7**	**14.9**	**28**	**3**	**10.7**
Posterior	**233**	**62**	**26.6**	**360**	**37**	**10.3**	**49**	**4**	**8.2**	**23**	**-**	**-**
Total	**427**	**125**	**29.3**	**627**	**100**	**15.9**	**96**	**11**	**11.5**	**51**	**3**	**5.9**

Table 10: Occurrence of chipping at Anse à la Gourde for anterior and posterior dentition

Tutu	Male			Female			Child		
	No.	Chipped	%	No.	Chipped	%	No.	Chipped	%
Anterior	**36**	**16**	**44.4**	**81**	**26**	**32.1**	**26**	**2**	**7.7**
Posterior	**80**	**51**	**63.8**	**117**	**39**	**33.3**	**30**	**9**	**30**
Total	**116**	**67**	**57.8**	**198**	**65**	**32.8**	**56**	**11**	**19.6**

Table 11: Occurrence of chipping at Tutu for anterior and posterior dentition

Tooth	Female			Unknown		
	No.	%	Mean notching degree	No.	%	Mean notching degree
Maxilla						
I1	**41**	**3 7.3**	**1.67**	**8**	**-**	**-**
I2	**53**	**3 5.7**	**2.33**	**6**	**2 33.3**	**1.5**
C	**51**	**-**	**-**	**12**	**-**	**-**
P1	**39**	**1 2.6**	**3**	**4**	**-**	**-**
P2	**38**	**1 2.6**	**2**	**4**	**-**	**-**
M1	**36**	**-**	**-**	**7**	**-**	**-**
M2	**30**	**-**	**-**	**8**	**-**	**-**
M3	**31**	**-**	**-**	**7**	**-**	**-**
Total	**319**	**8 2.5**	**1.7**	**56**	**2 3.6**	**1.5**
Mandible						
I1	**53**	**4 7.5**	**1.25**	**7**	**-**	**-**
I2	**62**	**4 6.5**	**2.25**	**7**	**-**	**-**
C	**52**	**1 1.9**	**1**	**7**	**-**	**-**
P1	**56**	**1 1.8**	**3**	**7**	**-**	**-**
P2	**46**	**-**	**-**	**3**	**-**	**-**
M1	**32**	**-**	**-**	**4**	**-**	**-**
M2	**32**	**-**	**-**	**3**	**-**	**-**
M3	**20**	**-**	**-**	**2**	**-**	**-**
Total	**353**	**10 2.8**	**1.8**	**40**	**-**	**-**

Table 12: Occurrence of Dental Notching at Anse à la Gourde by sex, element and jaw

Tooth	Male			Females		
	No.	%	Mean notching degree	No.	%	Mean notching degree
Maxilla						
I1	**4**	**3 75**	**3**	**4**	**-**	**-**
I2	**8**	**1 12.5**	**3**	**16**	**2 50**	**3**
C	**10**	**-**	**-**	**16**	**1 6.3**	**3**
P1	**12**	**-**	**-**	**17**	**-**	**-**
P2	**12**	**-**	**-**	**13**	**-**	**-**
M1	**7**	**-**	**-**	**9**	**-**	**-**
M2	**8**	**-**	**-**	**3**	**-**	**-**
M3	**2**	**-**	**-**	**6**	**-**	**-**
Total	**63**	**4 6.3**	**3**	**84**	**3 3.6**	**3**
Mandible						
I1	**5**	**1 20**	**2**	**15**	**3 20**	**2.33**
I2	**7**	**-**	**-**	**20**	**3 15**	**2.33**
C	**3**	**-**	**-**	**10**	**-**	**-**
P1	**12**	**-**	**-**	**22**	**-**	**-**
P2	**10**	**1 10**	**3**	**20**	**-**	**-**
M1	**7**	**-**	**-**	**13**	**-**	**-**
M2	**6**	**-**	**-**	**9**	**-**	**-**
M3	**4**	**-**	**-**	**5**	**-**	**-**
Total	**54**	**2 3.7**	**2.5**	**114**	**6 5.3**	**2.33**

Table 13: Occurrence of Dental Notching at Tutu by sex, element and jaw

	Male	Female	Child	Unknown	Total
Anse à la Gourde Tutu	**2**	**9 3**	**-**	**1 -**	**10 5**
Total	**2**	**12**	**-**	**1**	**15**

Table 14: Number of individuals with Dental Notching per sex and site

Feature	Sex	Age	LSAMAT	Chipping	Notching	Caries
108A	**?**	**30-40**		**X**		**X**
196	**M**	**40+**	**X**	**X**		
212	**F**	**20-80**	**X**	**X**	**X**	**X**
197	**M**	**23-40**	**X**	**X**		**X**
219	**C**	**9-14**	**X**	**X**	**X**	**X**
307	**M**	**40+**		**X**		**X**
311	**F**	**23-40**	**X**	**X**	**X**	**X**
430	**F**	**30-60**	**X**	**X**		**X**
450	**?**	**Adult**		**X**	**X**	**X**
2214	**?**	**40-70**		**X**		**X**

Table 15: The dentitions analyzed by dentist Dr. Willem Kuiters

Figures

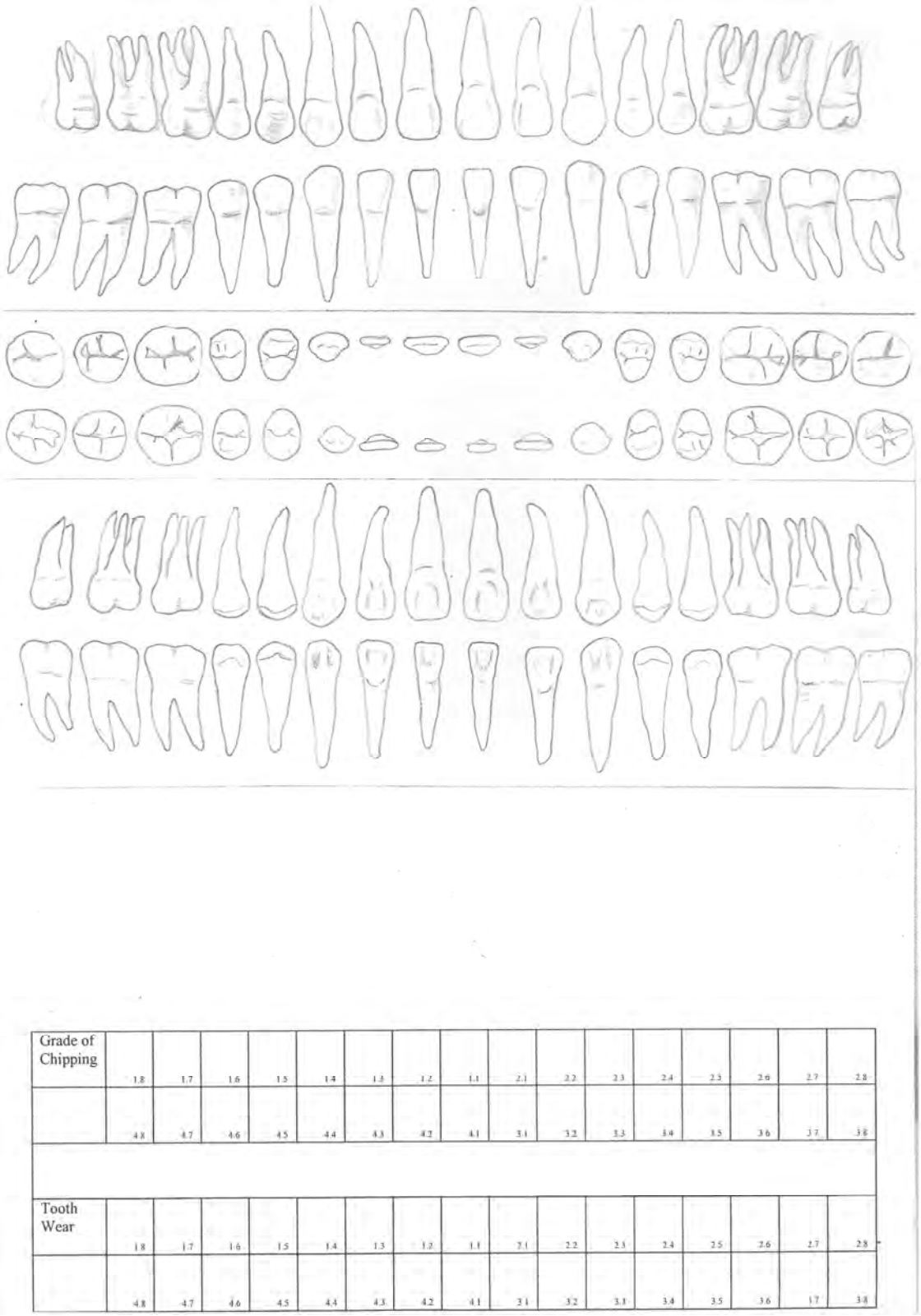


Figure 9: The dental wear evaluation form, empty (true size A4)

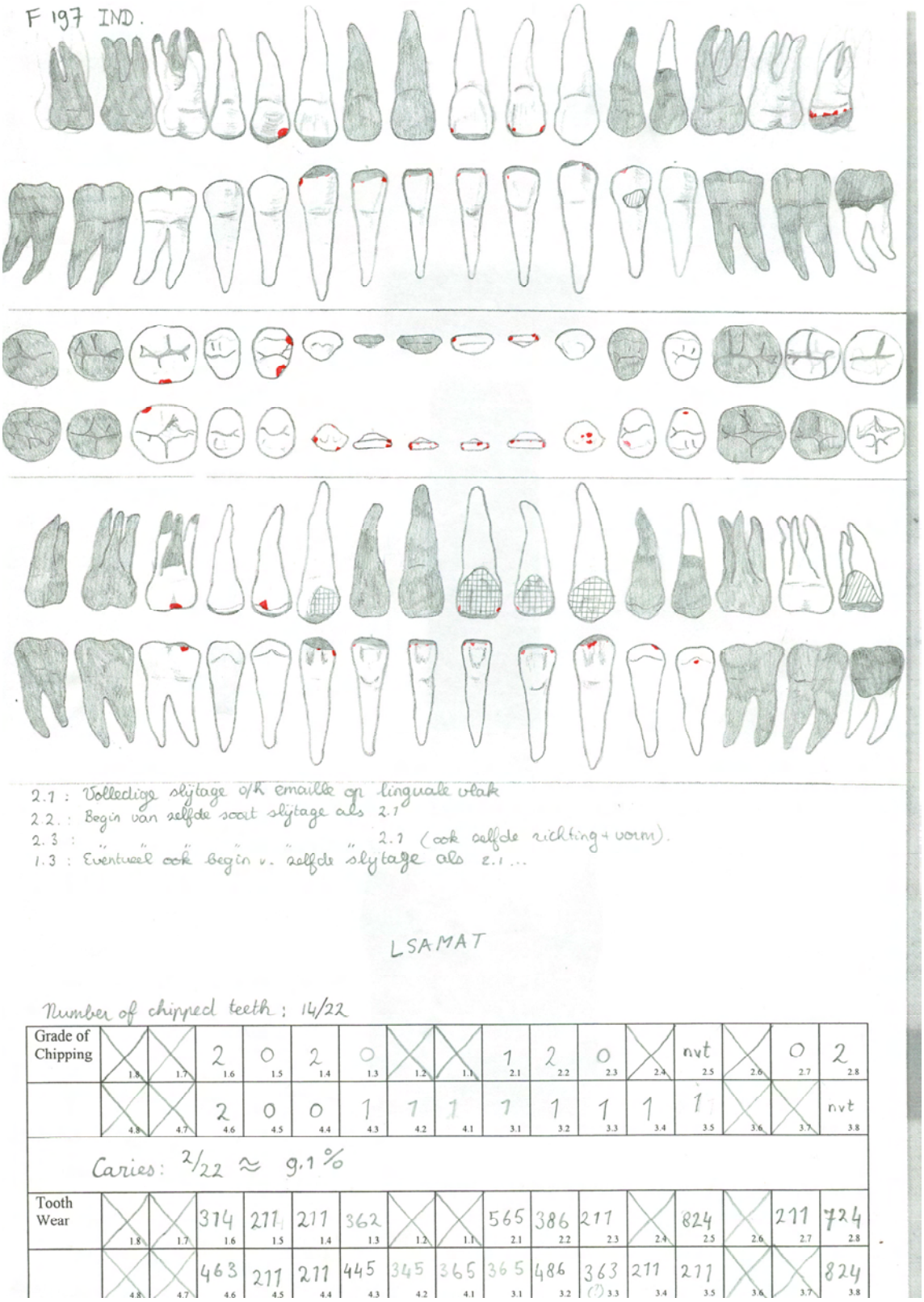


Figure 10: The dental wear evaluation form, filled-in for individual F 197 (true size A4)

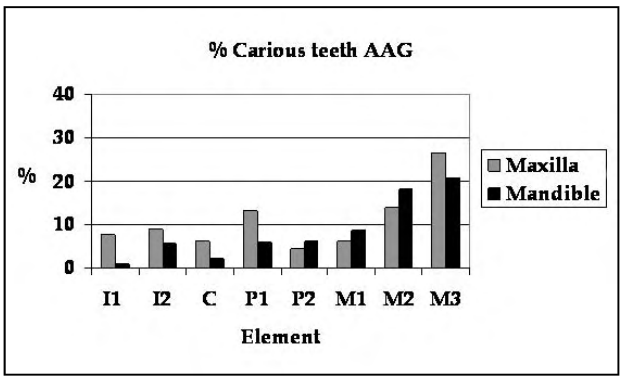


Figure 11

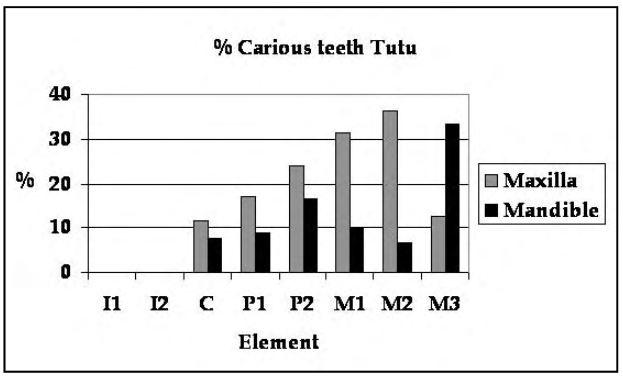
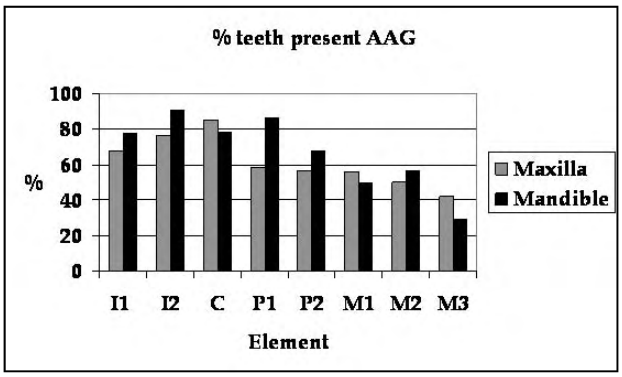


Figure 12



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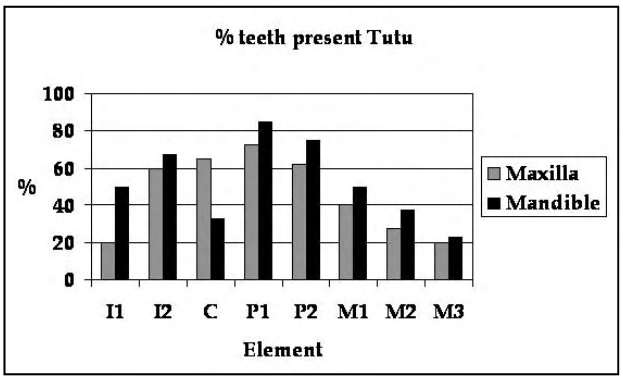


Figure 14

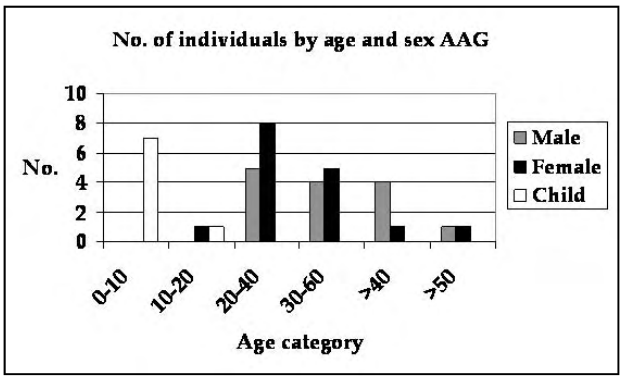
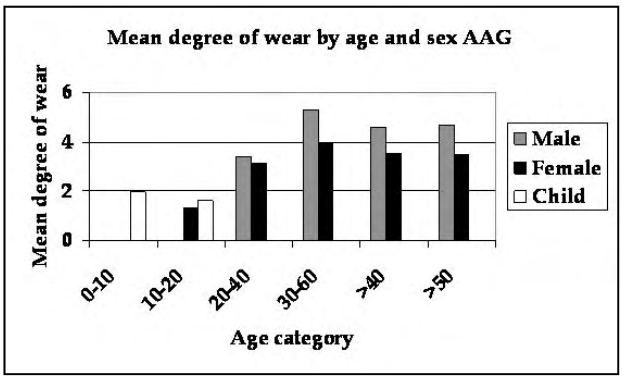


Figure 15



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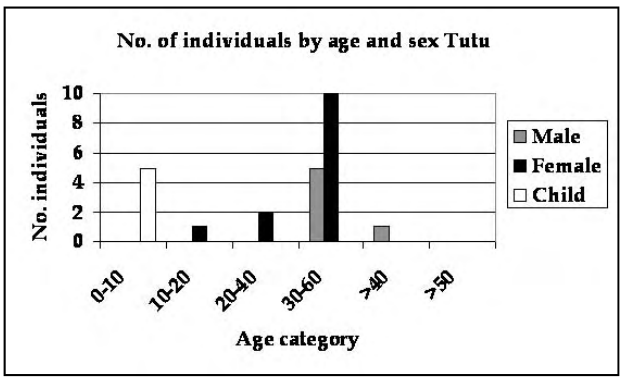

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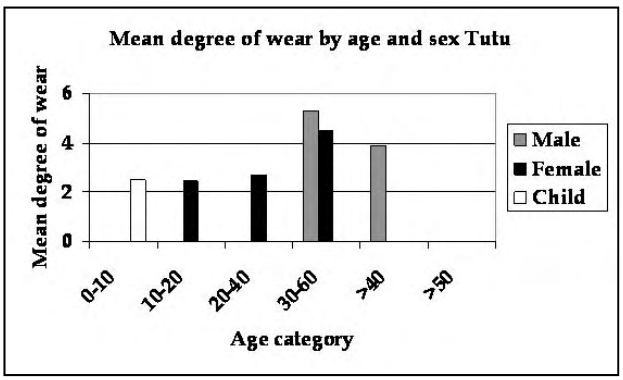

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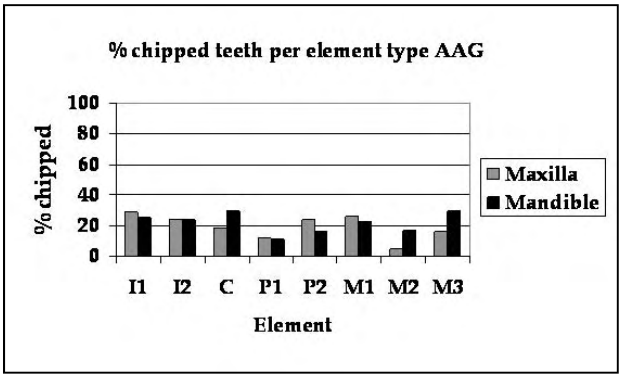

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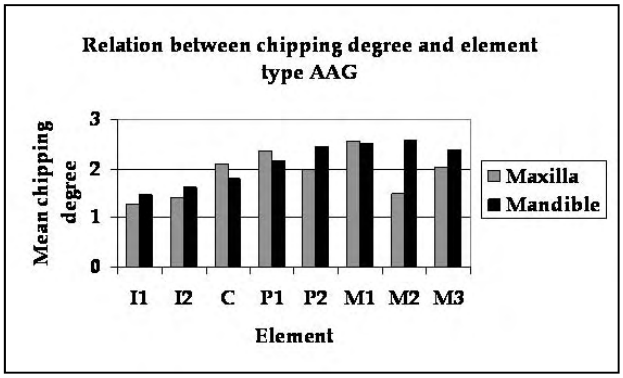

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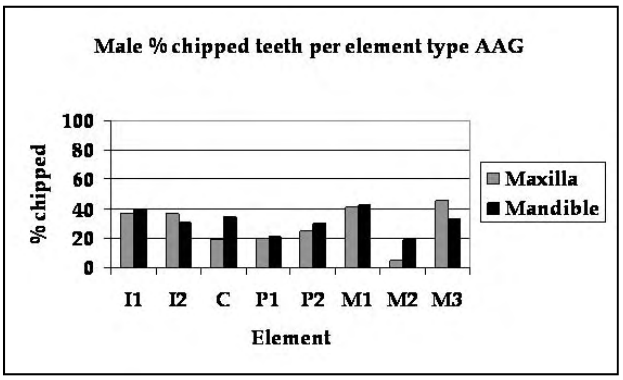

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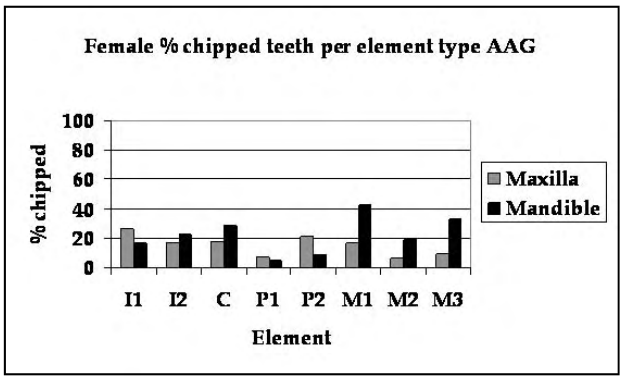

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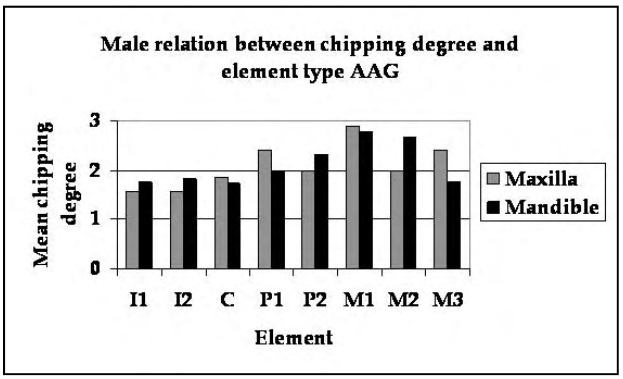

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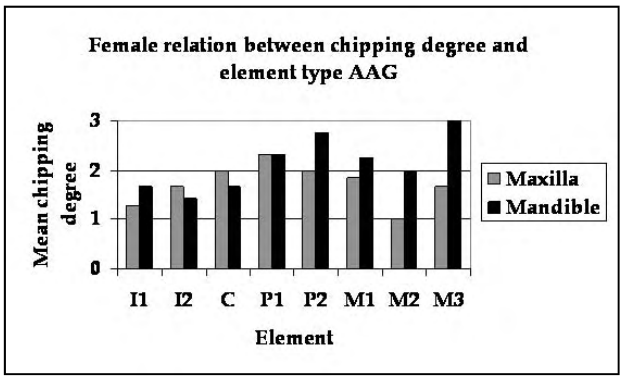

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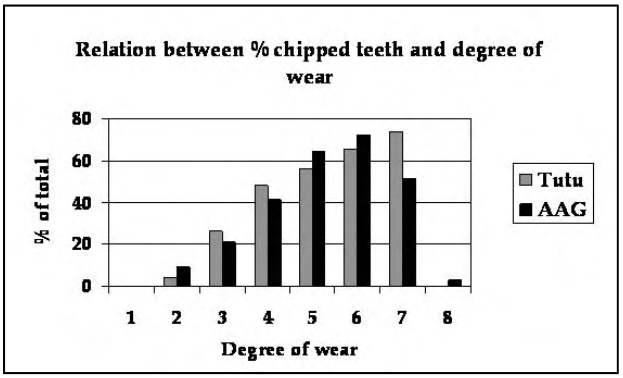


Figure 25

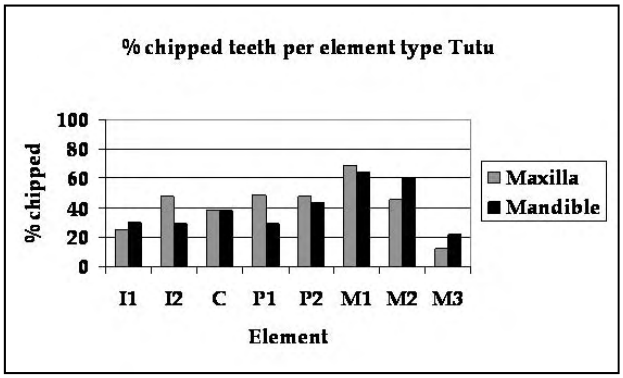
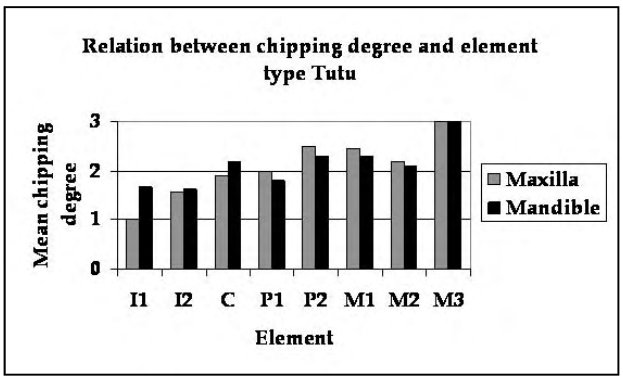


Figure 26



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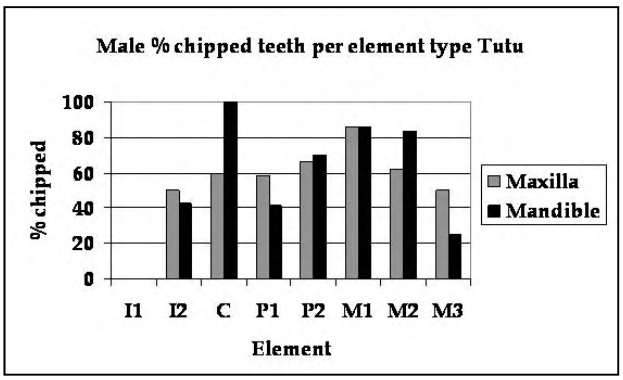

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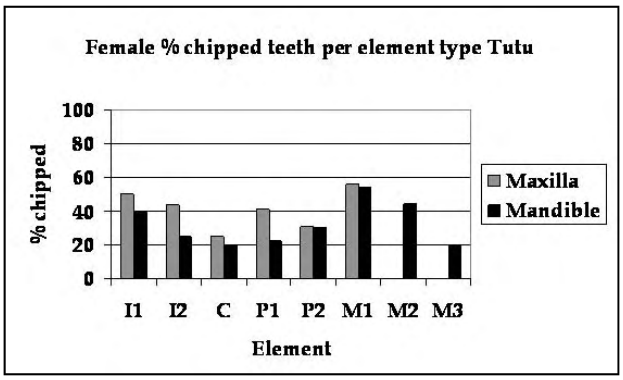

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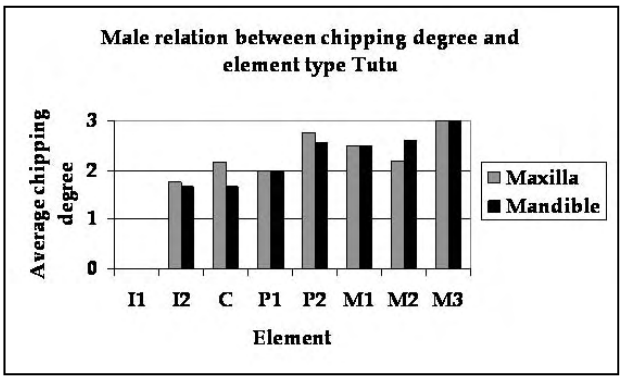

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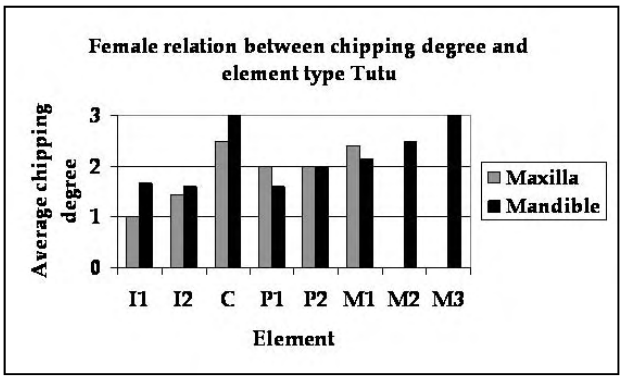

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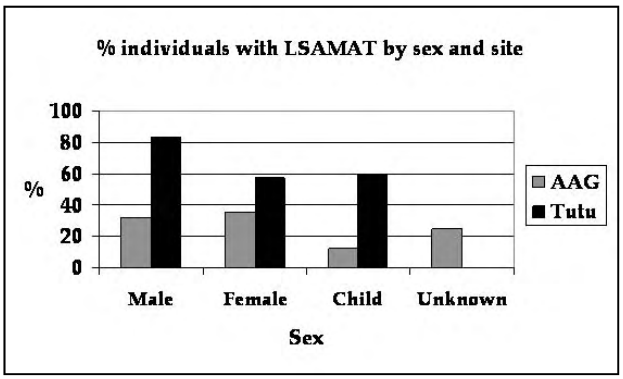

Figure 32

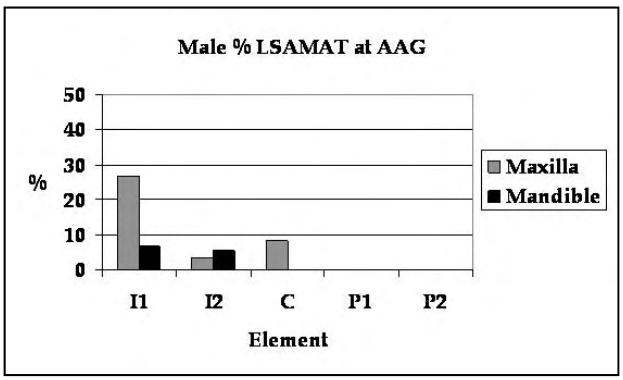

Figure 33

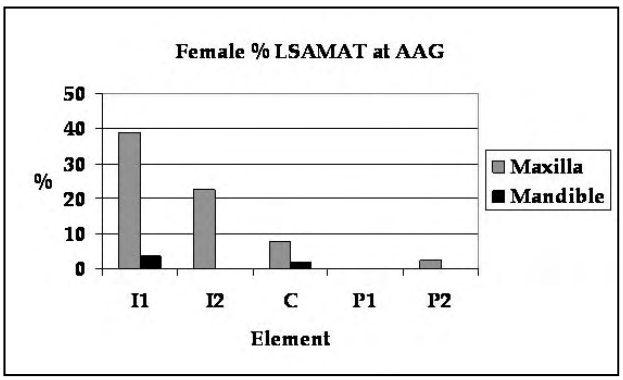

Figure 34

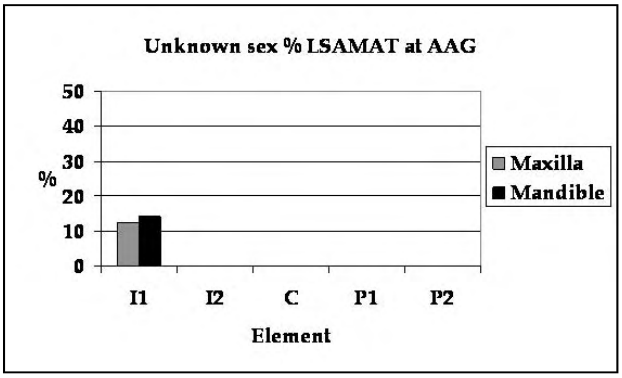

Figure 35

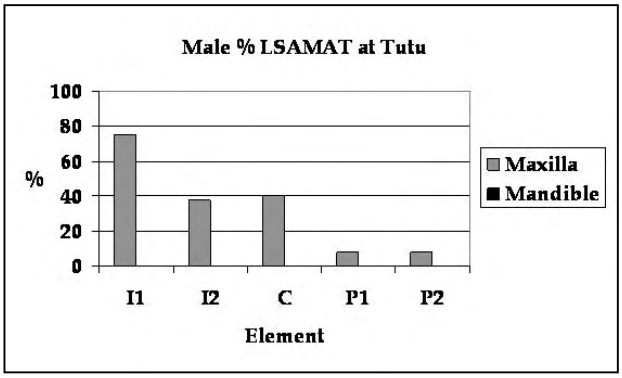

Figure 36

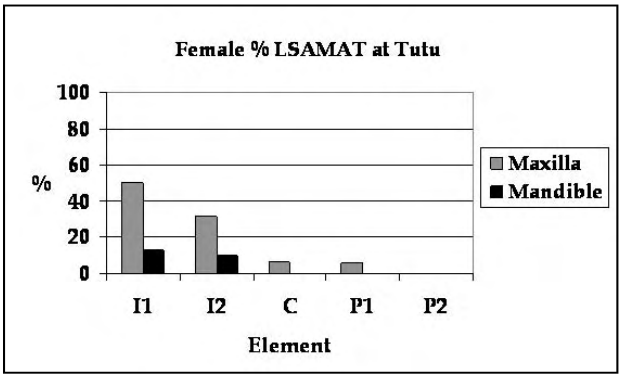

Figure 37

Index

Similar to the osteological study of prehistoric human remains, the study of human dental wear has been proven to afford a wealth of information on human cultural practices. This study is aimed at recording and understanding the dental wear patterns in human dentitions from the Caribbean archaeological sites of Anse à la Gourde, located on the most eastern point of Guadeloupe, and Tutu located on the small island of St. Thomas, U.S. Virgin Islands. The premise of this research is the assumption that dental wear patterns are informative of a great many aspects of human health and lifestyle. The use of the mouth and teeth in both masticatory and non-masticatory activities is assumed to leave traces which can be studied post mortem to infer the lifestyle linked to such activities.
In order to build a complete picture of these activities and the lifestyle linked to the dental wear patterns, other lines of evidence are also followed here, such as ethnohistoric and ethnographical accounts, and evidence from modern dentistry.

Using the combined effort of different lines of evidence, it has been possible to characterize the diet and a range of cultural practices of the inhabitants at each site. The individuals selected in this sample very actively engaged their teeth in many non-masticatory, culturally defined activities, which put their dentitions under a great deal of stress. It seems these people's use of their mouths and teeth in this way was a very conscious decision, characterized by their cultural background.

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