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[DON'T BRUSH YOUR TEETH]

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DON’T BRUSH YOUR TEETH

The link between caries and diet when studying the Roman populations of the Western and Southern cemeteries in London

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Table of Contents

1 Introduction

London in the Roman World

London, the capital of the United Kingdom, has a long and rich history (www.britainexpress.com). Before the arrival of the Romans, London was characterized by scattered Brythonic settlements of the native populations living there (Perring 1991, 1). This has been illustrated by early Roman accounts like those of Julius Caesar and Cassius Dio, who wrote that the area of what is now London was scattered with huts that were founded on dry enclosures in the marshland (Craik 1841, 149).

Yet, the city changed much after the arrival of the Romans in 43 AD, as they founded the first major settlement in the Roman province *Britannia Superior* there (encompassing what is now Wales, Southern England and East Anglia), under the reign of emperor Claudius of the Julio-Claudian dynasty (Perring 1991, 3 and Todd 2008, xvii). The foundation of a town near a waterway, the Thames, was important, since the converging roads here yielded a direct link between the ports and the main military posts that were situated in the hinterland (Craik 1841, 148 and Watson 2004, 4), such as Colchester. In

order to reach these places, one needed to cross the river, making that point a provincial communication center and promoting a speedy growth (Perring 1991, 4-5). The early town of *Londinium* was not only a military hub, but also a commercial one, as the military supply base was largely in the hands of private contractors, stimulating the growth of mercantile suburbs (Perring 1991, 19-20).

In the Boudican revolt of AD 60, instigated by Boudicca, the leader of the Iceni tribe, the town was burned to the ground (Craik 1841, 150). Early archaeological excavations have demonstrated this, as the matrix of some uncovered strata was made up of pieces of brick and ash (Craik 1841, 151). After this event, in the AD 70s, the town became part of a large building program under the Flavian dynasty. During this time, London acquired a forum, surrounded by offices and shops, just as other cities that were incorporated in the Empire (Perring 1991, 23-24). Moreover, a port was founded, impressive for its location in the northern part of the Empire, and other monumental public buildings were built (Perring 1991, 26). This continued well into the first and second centuries, when the city was at its peak, although during that time buildings were mainly enlarged or replaced, instead of being built from the ground up (Perring 1991, 57).

The population declined somewhat at the end of the first century AD, indicated by a layer of dark earth covering earlier buildings in archaeological records, instead of foundation levels of previous buildings (Perring 1991, 76). There was a change in the economy as there was an increasing demand for luxurious ware that gradually replaced locally produced goods (Perring 1991, 84). In the second century AD there was another increase in building activity, as a town wall was erected, whereof some parts are still visible nowadays (Perring 1991, 91). By building a wall, the provincial government could encourage the local elite to become more active in civic affairs (Perring 1991, 98), in the sense that giving back to the community, *euergetism*, was an important Roman value and needed to keep the lower classes content (Naerebout and Singor 2014, 273, 323). The city slowly declined starting from the 3rd century AD, as it was faced with barbarian incursions from Saxon pirates, robbing and the decline of the Roman Empire as a whole (Perring 1991, 124).

The Problem and the Research Questions

The remains found in the Roman city of *Londinium* allow a study into the process of Romanization: a process where “Roman art styles, technologies, cults and customs spread and replaced or marginalized pre-Roman forms in the process” (Woolf 1997, 339). It was first defined as a one-way process of Roman culture being incorporated in local culture that, in this way, became more Roman. A shift occurred later where there was a focus on

the areas in the periphery and how these locals were active in the process by also influencing the Roman culture. Now, academics are trying to move away from the dichotomy by studying the spread of Roman culture as a process of globalization (Woolf 1997). Romanization is now defined as a globalization process.

Although Roman London has been studied thoroughly in the past in terms of material and architecture, bioarchaeological aspects have received less attention. Archaeologists are able to derive much more information than before due to various technological developments, such as reconstructing the environment by using samples from the earth or isotope studies to discover migration patterns of an individual. Also, reconstructions can be created of what populations might have eaten in the past. Yet, this is difficult, as reconstructing an individual's diet is harder to study. For example, the right materials need to be available, such as teeth. Due to postmortem tooth loss that occurs as a result of taphonomic, floral and faunal processes, not all teeth of an individual can be gathered. Moreover, an understanding of biology and chemistry is also needed. Lastly, it is not necessary whether textual evidence about the diet in a certain period survives or whether this textual data is objective and factual. This can be illustrated by looking at texts from the Roman period, where authors highlight the diet in the center of the Empire and focus on elite foods. Yet, studies on diet in the peripheral regions in the Roman Empire have succeeded in broadening the knowledge on diet in these regions. Some of these studies have emphasized the way Romanization is now seen as a process of globalization and that the diet in the periphery and the center of the Empire is likely the same.

Reconstructing the diet in archaeology is mainly achieved by using lesions that are directly visible, most noticeably in teeth, such as cavities. Teeth have long been used in understanding the prehistoric diet of people and what factors come into play (White and Folkens 2005, 412). Studies have shown that differences in sex, age and status can be important to understand the differences in the diet of populations (Walker and Hewlett 1990).

This is why this thesis will answer the following research question: "How can the diet of the populations in Roman London be compared to the diet of populations in the heart of the Roman Empire?". To answer this research question, the following subquestions have been formulated:

1. How does sex relate to differences or similarities in the diet of past populations when considering the peripheral sites themselves and how do these results compare to each other and the center of the Empire?

2. What are the differences and similarities in the diet of adults and non-adults when examining the peripheral sites themselves and how do these results compare to each other and the center of the Empire?
3. How does status link to the diet of populations of Roman London?

The thesis will compare the periphery of the Empire, namely the cemeteries, with Isola Sacra, a site in Rome, the center of the Empire. This comparison is performed in order to study the impact of the expanding Empire. Do regional differences still occur or is the Roman Empire on a whole homogenous? Does a Roman diet exist?

Aims and approach

The aim of this thesis is to study diet in Roman London with the use of an osteological approach. Over the past 30 years, excavations in the areas of various Roman cemeteries have been carried out by the Museum Of London Archaeology (MOLA). These cemeteries date from the 1st until the early 5th century AD. Both inhumations and cremation burials have been excavated, both outside and within the boundaries of Roman London. The Museum of London provides the summarized data from the excavations that are in the regions of these cemeteries (www.museumoflondon.org.uk).

The materials

The Western cemetery compromises by what is now Atlantic House, St. Bartholomew's Hospital and Little Britain, in the west of London (Figure 1). The cemetery was likely next to the road that led to Silcester. The cemetery was in use from the late first century AD up to the early fifth century AD. Both cremations and inhumations have been found. Furthermore, many burials contained grave goods such as toys, jewelry, glass and pins made of animal bone (www.museumoflondon.org.uk). It is not known whether this population had an elite status, but they were certainly individuals that had some degree of wealth (Watson 2003, 38).

The Southern cemetery covers the modern regions of Southwark and Lambeth, found near the South Bank of the Thames (Figure 1). It is unknown where the Southern cemetery ends, because the boundary to Roman Southwark has yet to be found. The excavated burials date from the first century through to the late fourth century AD. Archaeological projects in this area have shown the remains of mausoleums, indicating this population had a high status. Just like the Western cemetery, the burials were

accompanied by grave goods, for instance ceramics, flint, lamps and jewelry (museumoflondon.org.uk).

The London cemeteries will be compared with Isola Sacra, a site in Rome, dating from the first three centuries AD (Prowse et al. 2005, 4). The site appears to have been partly elite, as the site features elaborate tomb structures (Prowse 2001, 83). The site lies in the vicinity of Portus, the port of Rome. The inhabitants of Portus have been buried in the necropolis of Isola Sacra that lay along the road between Portus and Ostia. The cemetery went into disuse after the first three centuries AD and was gradually covered with sand. Over a thousand burials have been excavated (Prowse *et. al* 2005, 4).

Since the Roman Empire had a prospering economy, stability, a well-developed road system and population growth in the first two centuries AD due to the *Pax Romana* (Naerebout and Singor 2014), and that all the materials fit into this time period, this thesis will focus on this era in the Roman world. Partly, these factors impact what food is available in the areas of the Empire; and thus have an impact on the diet of past individuals.

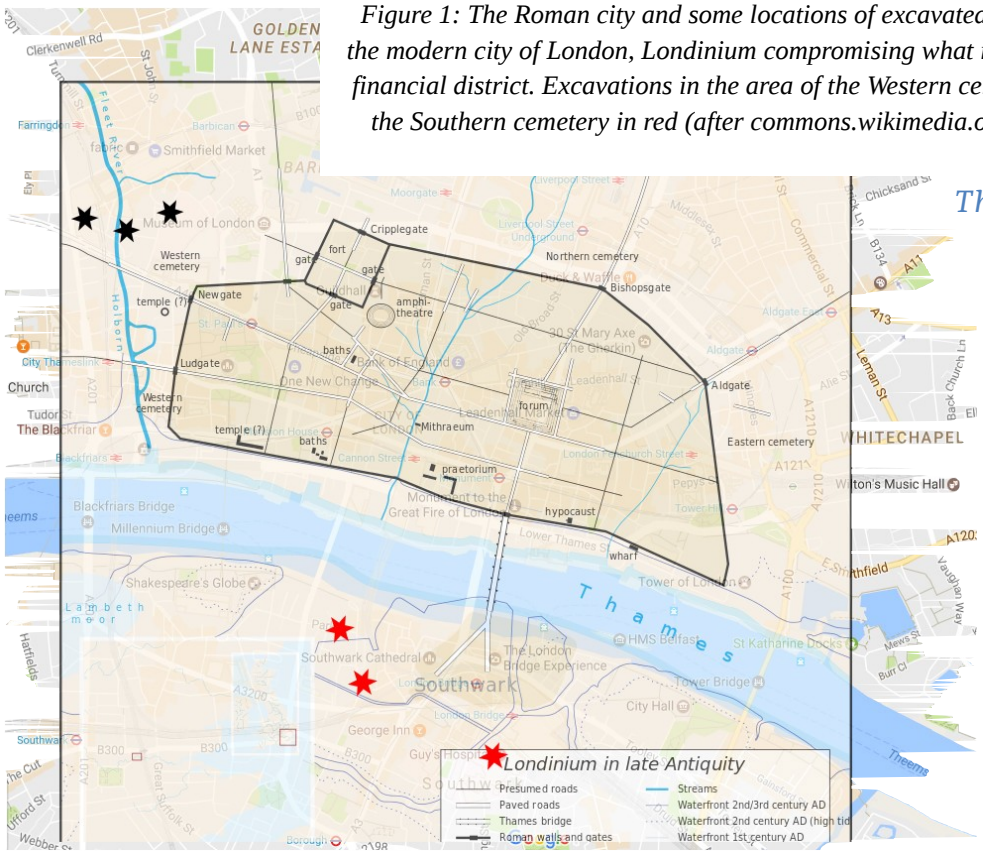


Figure 1: The Roman city and some locations of excavated areas are plotted on top of the modern city of London, Londinium compromising what is now roughly the size of the financial district. Excavations in the area of the Western cemetery are in black, those of the Southern cemetery in red (after commons.wikimedia.org and maps.google.com).

The method

The diet of the Roman populations will be researched by studying the prevalence of dental caries. Dental caries is a lesion that causes enamel or dentine to become

decalcified, causing holes or cavities as a result (White and Folkens 2005, 420). This demineralization of the hard tissues is caused by the acids that are produced when bacteria ferment carbohydrates, mostly from sugars. So, a diet high in carbohydrates will result in a higher caries prevalence (White and Folkens 2005, 412).

Thesis outline

The second chapter will focus on the Roman diet and provides a discussion on whether a Roman diet exists. In the third chapter, background information about dental caries and how it can effectively help with understanding the diet of a population will be discussed, illustrated with results gathered by previous archaeological projects. The fourth chapter focusses on the materials: elaborate information about the cemeteries under study will be given. Both the site context and excavation history will be discussed. The fifth chapter will focus on the method and explain how dental caries was collected and analyzed. The sixth chapter will present the results gathered by analyzing the caries data from the dentition from the different cemetery populations. The seventh chapter will offer a discussion. Here, the results of the two cemeteries will be discussed and be compared with the data from other Roman sites in the center of the Roman Empire. For example, does the diet of the populations from *Londinium*, as a city in the periphery of the Roman Empire, differ from Rome? In the final chapter, a conclusion will be drawn and the research questions will be discussed.

2 Diet

This chapter will focus on the diet in the Roman Empire and in Roman Britain. Romanization has been a thoroughly debated subject through the last decennia. Is it possible to speak of a Roman diet if it is unknown what "Roman" is? Does a pure Roman diet exist? Moreover, with the help of literary sources, the Roman diet in the center of the Roman Empire will be discussed. Then, we travel to the periphery of the Empire and study what information can be gathered about the diet in Roman Britain.

A "Roman" diet?

Romanization is the process where "Roman art styles, technologies, cults, and customs spread and replaced or marginalized pre-Roman forms in the process", according to Greg Woolf (1997, 339). This term caused negative connotations due to the link with a colonial way of thinking in the past (Versluys 2014, 5). The traditional view on Romanization was of a colonial nature, researchers hypothesized that areas became civilized due to the arrival of the Romans. The Roman-Italic culture was seen as superior and of vital importance to the history of Europeans (Woolf 1997, 339), as around the mid-19th century, nations started to rise. These nations needed a common history in order to create a sense of community to unite the people of a big region who previously had been part of smaller states. These nations believed that the Romans were part of their own history. Furthermore, they used their link with Roman culture to justify the possession of colonies because in antiquity, the Romans had been present in these areas (Witcher 2015, 198), take for example the countries in northern Africa.

Because of this negative connotation, researchers started to study mainly the areas where the locals lived, stating that Romanization was a two-way interaction rather than one. The term self-Romanization was introduced, where the local elite chose what to implement from the Romans and thus were active in this process (Millett 1990 in Woolf 1997, 340).

Yet, this way of thinking about Romanization is also partly problematic, since it is too reactive (Versluys 2014, 3), as these perspectives on Romanization try too hard to shift away from the colonial way of thinking. The Roman world was far too complex to think in a two-way system of Romans and locals. By holding on to the dichotomy of

Roman *or* local, it is (un)consciously implied that one can just think about Romanization only in a global or a local manner; the division of what is local and what is Roman is stressed. The Romans wanted to incorporate all different cultures into one Empire, making the Empire an area where highly divergent sets of ideas and traditions were travelling (Woolf 1997, 341). So, one should think about Romanization more in ways of globalization due to the vastness and complexity of the Empire (Versluys 2014, 11).

The idea that globalization describes the processes of connectivity that occur in the Empire can be incorporated in the understanding of the Roman diet in the entire Empire. Hawkes (1999, 89) presents this with the use of the 'Creolization theory', which is "The process of intermixing and cultural change that produces a creole society. It is not a product but a process incorporating aspects of both acculturation and interculturation, the former referring to the process of absorption of one culture by another; the latter to a more reciprocal activity, a process of intermixture and enrichment each to each," (Brathwaite 1971, 11). Creolization was founded in studies that investigated the emergence of African-American culture on slave plantations. On these plantations, slaves would eat from bowls of the slave-owner's culture, while the parents of the slaves ate from plates. So, while the materials that carried meals were of European descent, eating habits reflected African practices (Ferguson 1992 in Hawkes 1999, 90). This theory focuses on how artefacts were used and perceived on a whole in slave communities and how this whole related to relationships between natives and elites, and elites and the supervising organs (Hawkes 1999, 90).

When this theory is implemented in archaeology and the understanding of the Roman world, it can help in the insight of the ability people had to either accept or reject aspects of (Italic) Roman culture (Hawkes 1999, 90). An example comes from a study by Okun in 1989, who researched diet and culinary habits in the area of the Upper Rhine, establishing that new preparation methods and ingredients occurred next to cooking wares from the local La Tène period. Yet some Roman fashions were not adopted. So, what was cooked and what was eaten was more of a fusion (Okun 1989 in Hawkes 1999, 93).

Thus, creolization and Romanization have very much in common. Both see the Roman World as a dynamic and complex region with a diverse, fused set of ideas. When researching the Roman diet in the Roman world, it is important to consider the complexity of that world, and that a "Roman/local" diet does not exist, just as cultures are not "pure", but a mix of various ideas and traditions. Due to this, big differences could be present in terms of diet in the Roman Empire.

The diet in the Roman Empire and Roman Britain

The first two centuries of the Empire were seen as the *Pax Romana* or *Pax Augusta* (27 BC to 180 AD), instigated by the first emperor Augustus Caesar. These centuries were characterized by the stabilization of the Empire and the improvement in the quality and quantity of food as a result of a flourishing economy. New areas that were incorporated in the Empire underwent urbanization, causing more structures to be built in these regions. Due to the process of "Romanization", agriculture was intensified in the regions the Romans incorporated into their Empire, as they introduced new inventions such as aqueducts in these regions, that caused agriculture to become more productive (Roberts and Cox 2004, 248). Better communication was made possible by the use of vast road networks, so food from all over the Empire could travel to other areas within it (Moore and Corbett 1973, 141), causing the diet to be diverse in nature (Prowse *et al.* 2005, 2).

The diet in the center of the Roman Empire

Ancient sources provide a great range of information about food and drinks in the Roman world. Treatises on farming like Columella's *De Re Rusticā* provide information on how products were preserved, helping to understand residues found in amphorae (Cool 2006, 32). When looking at food and diet, the only recipe book that has been found is the *De Re Coquinariā (*On Cookery) by Apicius, but the quantities of ingredients are rarely given and instructions are short. Moreover, it is unknown whether all recipes are indeed written by him. The recipes only focus on the elite foods that were present in the Empire as well (Cool 2006, 33).

Literary works offer many insights on food in the Roman Empire too, but must be approached with a level of caution since many references to food are metaphoric or used as a form of satire. Yet, the writer Cato, whose works include *De Agri Culturā,* a handbook for a leaseholder of an agricultural business (Astin 1978, 182), informs that olives and bread were the staples of farmers and the working class (Brothwell & Brothwell 1969 in Bonfiglioli *et al.* 2003, 53).

Other written sources, such as encyclopedic accounts like the *Naturalis Historia* (Natural History) of Pliny the Elder give insight in the flora and fauna in the Italic part of the Roman Empire. This work gives, for example, an overview of the different regions that produced wine and what animals or plants were present (Cool 2006, 32).

All in all, the overall literature shows that the Roman world had a varied cuisine that was possible due to the well-developed agricultural system and the interconnectivity of the Empire. Yet it is not likely that everyone ate exotic foods and elaborate dishes that were part of the differentiated cuisine (Cool 2006, 34 – 35), as not everyone had the means to afford those foods.

Staples

Cereals, vines and olives have been called the staple foods of the Mediterranean diet, yet this "Mediterranean triangle" was not everywhere in place: only the cereal foods were almost omnipresent. Wheat and barley have been the most important cultigens of this group (Garnsey 1999, 13-14). Romans relied mostly on these, as no rival staple has been found such as rice or root crops. Furthermore, cereals had an important position in Roman (and Greek) religion and mythology, for example with the veneration of the goddess of harvest and grain, Demeter, and the consumption of cereal in the archaizing myths of Rome itself (Garnsey 1999, 18). Also in Galen's *On the Properties of Foodstuffs* , cereals are described first; and given food rations were mainly in the form of cereals (Garnsey 1999, 18). Yet, it is important to keep in mind that the lower classes of society most likely did not only eat cereals although it was consumed the most by these classes, as this would have led to chronic protein-calorie malnutrition (White 1976 in Prowse *et al.* 2005, 4). The lower and middle classes supplemented their diet with foods like cereal, pulses, fruit and vegetables, and meat from mostly various types of goat and sheep (Dosi & Schnell 1990 in Lanfranco and Eggers 2012, 10).

Vegetables and pulses

Legumes and pulses were important in the diet of the Romans, and caused them to gain the nutrients that are not found in cereals. Pulses are regularly found in the archaeological record (Garnsey1998 in Garnsey 1999, 15). In the Mediterranean region of the Roman Empire, broad beans, lentils and turnips were mainly eaten by rich individuals, while onions, chickpeas and garlic were typical for the lower classes (Dosi 1990 in Bonfiglioli *et al.* 2003, 53). It has been suggested that Romans supplemented their diet with a variety of wild and cultivated plants, in order to get the right amount of protein (Evans 1980 and Frayn 1975).

Animal products: Dairy, meat and fish

Dairy products are hard to identify archaeologically, as they only leave residues as direct traces. Yet literary evidence suggests that cheeses and other milk products were eaten at least in the Mediterranean region of the Empire (Alcock 2001, 57–60 and Dalby 2000, 253 in Cool 2006, 93).

Meat and fish were considered a luxury in the Roman world (Cool 2006, 104), and was not widely available. The sparsity of fish is mainly explained due to the fact that only a small number of people were fishermen, and that there were not any inventions made in fishing, in contrast with agriculture (Garnsey 1999, 16). The most popular fish dish

was *garum*, a fish sauce, that was also incorporated in medical recipes (Curtis 1991 in Prowse *et al.* 2005, 4). Meat remained much of a specialty and was linked to festive events (Bonfiglioli *et al.* 2003, 53), and even individuals with a higher status did not eat meat in large amounts (Garnsey 1999, 17). In the Mediterranean area of the Empire, the meat of pigs, sheep, goat and cattle was mostly eaten (Mackinnon 1999, 239). Pigs were common animals found on farms, probably because they could practically eat anything and thus live on any type of feeding-ground (Mackinnon 1999, 128). The demand was also high, since pigs were favored for sacrifices and civilians as well as the military ate pork (Mackinnon 1999, 130).

The diet in the periphery of the Roman Empire: Roman Britain

Some written evidence on what people in Roman Britain ate exists as well; in particular the Vindolanda Tablets. At Vindolanda, a site near Hadrian's Wall, people either wrote on a stylus tablet filled with wax or on thin sheets of wood with an ink pen. However, wax easily deteriorates, so only the traces of writing occur on the part of the wood that used to be filled in with wax, causing a palimpsest of different messages (Cool 2006, 30). Nevertheless, due to waterlogged conditions, writings on birch bark have been found. It is important to consider that the military units stationed in this area were mainly of Batavian descent, the area where mouths of the Rhine and the Scheldt are found, so they might not represent what British people in the Roman Empire ate (Bowman 1993, 26).

The Vindolanda tablets show many aspects of daily life, as some "letters" include shopping lists (Cool 2006, 32). This could mean that certain foods were available in the area, or were sought after. These texts are important to accompany archaeology, as one of these shopping lists mention pepper, a spice that is hard retrieve from archaeological records (Cool 2006, 32). Therefore, although the Vindolanda letters can be problematic, they offer insights in what products were circulating in the Empire.

Staples

When talking about cereals and staples, bread could have been preferred in Roman Britain, as spelt has been a regular find in carbonized grain deposits (Cool 2006, 75). Emmer, spelt and bread wheat have been represented in various assemblages. The latter only increased in numbers since Roman Britain was part of the Roman Empire (Jones 1981, 106).

Vegetables and legumes

In the periphery of the Empire, elite foodstuffs were present in the form of various legumes and vegetables. The Roman Britain dataset the exhibits 514 sites made by Van Der Veen in 2007 shows that exotic foods like almond and pomegranate, mulberry and

pine nut were found in the region of London from the earliest phase of Roman occupation (Van Der Veen, 2008, 83, 97). The same study shows that some rural sites, of which many of them are non-elite, show a wide distribution of exotic fruits and nuts and that the amount of these increases over time, suggesting that these fruits were imported (Van Der Veen 2008, 97-98).

Carrot and turnip seem to be the most common in Roman Britain. Parsnip and leaf beet occur from the middle of the Roman period onwards, yet mostly the leaves and roots of these vegetables have been eaten, making them a rarity in the archaeological record. Besides, these vegetables are hard to distinguish from the wild species, so the how often these plants were eaten is dubious (Van Der Veen 2008, 98).

Animal products: Dairy, meat and fish

Although milk-producing animals were certainly present in Roman Britain, it is unsure to what extend they were exploited for milk products (Cool 2006, 93). Moreover, strainers are needed to make cheese, but not many strainers that were made out of pottery have been found (Cool 2006, 95, 97). It is possible that most cheeses in Britain might have been produced with utensils made up of organic materials, just like in the Iron Age (Cool 2006, 97), that only survive in very wet or very dry conditions.

Many fish bone assemblages have been found in Roman Britain (Cool 2006, 104). The species of fish are mostly from those living in fresh or inshore waters (Cool 2006, 105). According to a study by Locker, who studied fish consumption in Roman Britain, noted that in London, species included eel, salmonids, bass and flatfishes. Cod was the most prominent in the area, as this fish was represented by 27% of the 26 sites, as it could have been locally caught in the North Sea (Locker 2007, 151). The consumption of fish did not change much when Romans arrived, as fish was considered a luxury that only elite members could afford (Frayn 1993 in Prowse *et al.* 2005, 4) .

When researching meat consuption however, there was a rise in beef consumption (Locker 2007, 154), as Romans introduced new cattle species in these areas when these became part of the Empire. Yet, beef was the least eaten in civilian contexts, as the animal was mostly used for draft (Prowse *et al.* 2005, 4). Nearly all the meat consumed in Roman Britain came from farm animals: mainly sheep and pigs; with the latter being the most prominent in civilian contexts (Cool 2006, 80, 83) and known to only be kept for meat produce (Garnsey 1999, 17). Sheep and goat were also eaten, but in lesser amount, as they were mainly exploited for wool and milk (Brothwell, 1988 and Garnsey, 1999 in Prowse *et al.* 2005, 4).

Conclusion

A pure Roman diet does not exist in terms of Romanization because of the vastness and complexity of the Empire. Moreover, it has been noted that differences between the diet in the center of the Empire and the periphery were observable, but it is not clear how much these diets differed from each other. Changes are visible in the periphery of the Empire, for example, there appears to have been an increase in beef consumption. Yet, the amount of meat did not change much overall. Fish remained a luxury in the center as well as the periphery of the Empire. Furthermore, staples seem to have been popular food items in the center and the periphery of the Empire.

It is difficult to comment on differences in diet, as different sources are available. These sources might not reflect reality, as food has been used metaphorically in ancient literature. However, some accounts on preserving food and handbooks could prove to be useful. Not many literary accounts tell us about the availability of different foods in Roman Britain, or what the diet consisted of in this area. Because of this, it is important to look at osteoarchaeological remains, such as diseases, in order to understand what foods were part of the diet in Roman Britain. By using dental caries, it is possible to gather information on food and diet in Roman London.

3 Caries and Diet

This chapter will provide a discussion on caries and the link to diet, by using some examples from past archaeological projects.

As stated in the introduction, dental caries causes the hard tissues of the teeth to become decalcified by lactic acid that forms when bacteria ferment carbohydrates, causing holes or cavities to form (White and Folkens 2005, 412). The acid lowers the pH-value of the dentine and enamel by stripping away the vital minerals such as calcium and phosphate, causing demineralization, resulting in tooth decay. In figure 2, the location of the dentine and enamel is found. Figure 3 shows how caries is found in archaeological remains.

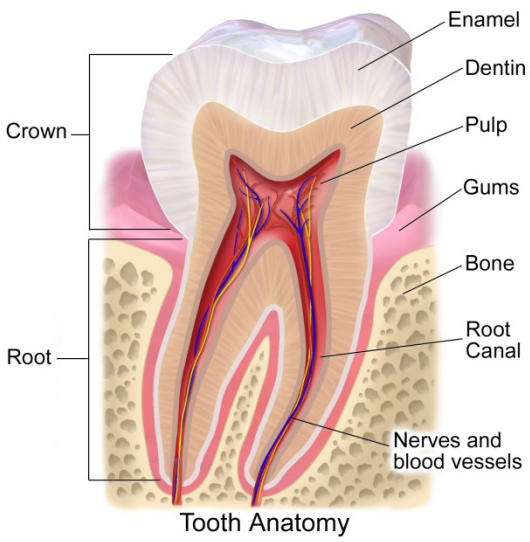


Figure 2: the anatomy of a tooth. Enamel and dentin form the hard tissues (justicedental.com).

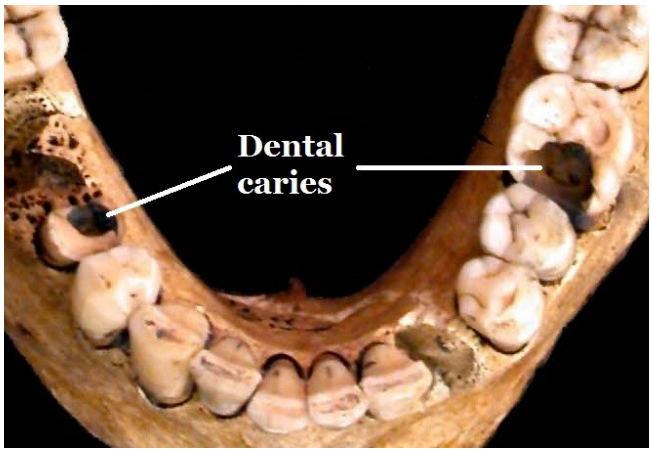


Figure 3: Dental caries caused by high sugar intake in archaeology (after https://allthingsaafs.com).

In 1944, R. Stephan calculated how quickly the bacteria react to sugars, beginning the formation of lactic acid, creating the Stephan Curve. He discovered that from the moment dietary sugars come into contact with the bacteria, the environment of the teeth become more and more acidic, until after 5 – 20 minutes the maximum has been reached. The level of pH returns to normal after 30 – 60 minutes (https://www.animated-teeth.com). In the modern age, caries can be partly prevented by fluoride, found in toothpastes (www.allesoverhetgebit.nl), which makes the hard tissues of the teeth harder, weakening the effects of the fermentation process (Ismail and Hasson 2008). The genetic make-up, dietary habits, and dental hygiene of a person can also influence the susceptibility to caries (Nicklish *et al.* 2016, 95). Since fluoride has only been used since the 1940s (Marshall 1990, 276), these lesions often occurred in teeth from individuals that lived thousands of years ago.

But how does the formation of caries link with the diet of an individual? What causes caries to be present in teeth? How effective is this method? In this chapter, these questions will be discussed.

Caries and the link to diet

Unlike bone, teeth cannot be remodeled, so caries cannot heal (Mays 2010, 218). Therefore, a person with these lesions in the past would have lived with holes in their teeth until their death or until the affected tooth fell out of their jaw, since caries often results in antemortem tooth loss (Mays 2010, 219). Although caries itself is not deadly, it can lead to potentially lethal infections like meningitis or cavernous sinus thrombosis,

because the pulp chamber and nerves can be exposed if the hard dentine is demineralized enough. Furthermore, caries in the mandibular teeth can cause infections in the throat, called Ludwig's angina (Mays 2010, 220). Yet, because this infection attacks soft tissues, itis not visible in archaeology.

Caries is most likely to occur where dental plaque accumulates. Dental plaque is the matrix where the bacteria form, which accumulates mainly in the occlusal fissures of tooth crowns and the interproximal areas between teeth (White and Folkens 2005, 329). When there is a high carbohydrate intake, caries prevalence is higher than when the carbohydrate intake is lower (Mays 2010, 223-224). The amount of time food with a high carbohydrate is in contact with the teeth (sticky foods) and the frequency of eating a meal can influence the development of caries, as the pH level in the mouth will remain low for longer periods of time (Prowse 2001, 63). The coarseness of the food is also important, since abrasion helps combat the buildup of bacteria, as the grit in food removes food remains and erodes the enamel on the teeth (Prowse 2001, 64). Furthermore, the amount of fluor in water can help protecting the teeth from the development of caries as fluor reduces the speed of bacterial growth when this is absorbed by developing teeth (Van Der Waal and Van Der Kwast 1981, 89). The type of tooth also affects caries levels, because premolars and molars have more fissures and pits on the crown and are therefore more likely to be affected by caries (Powell 1985 and Hillson 1996).

The rise of caries in human populations

The oldest case of caries has been found at Broken Hill in Zambia. Here, the cranium of a *Homo rhodesiensis* exhibits a severe case of caries, as only five teeth had remained unaffected. The caries seem to have occurred because of a vegetable rich diet or metal poisoning, since the area is rich in metals like lead and zinc (Bartsiokas & Day 1993). Thus, natural sources can contribute to the presence of caries; as modern apes also can have these lesions even though they have a raw herbivorous diet that consists of few starch-rich tubers (Lanfranco and Eggers 2012, 5-6).

Yet, the increase of caries has mainly been associated with the intensification of agriculture. By cultivating foods that were higher in carbohydrates, such as the "pioneer crops" consisting of cereals like einkorn and pulses later in time (Zohary 1996), it is no surprise that sedentary life relates to a higher rate in caries (Lanfranco and Eggers 2012, 7). This theory has been confirmed by several archaeological studies (Lanfranco and Eggers 2012, 7). For example, Caselitz analyzed the evolution of caries in 518 human populations from various areas of the world in 1998, confirming that in Paleolithic and

Mesolithic periods, hunter-gatherer populations had less carious lesions and that these lesions developed at a slower pace than sedentary populations (Caselitz 1998 in Lanfranco and Eggers 2012, 7).

The earliest written evidence for oral diseases, including caries, comes from a Sumerian clay tablet from the lower Euphrates valley, dated at 5000 BC (Lanfranco and Eggers 2012, 8). Due to the fact that there were no scientific explanation for tooth diseases, dental schools, or an equivalent of dental hygiene like today, people believed tooth worms were the cause of cavities (Forrai 2009, 187). In Egypt, the Papyrus *Ebers* (written between 1700 – 1500 BC) listed various remedies for various tooth aches (Forrai 2009, 188). Rates in caries in Europe only started to increase in the period between 1200 BC and 500 AD, probably because the spread of agriculture and sedentary life occurred later in these regions (Lanfranco and Eggers 2012, 8), together with the help of Romanization in these areas (Roberts and Cox 1995, 248).

The frequency of caries in humans has risen ever since. Because the new foods that were shipped from the Americas to Europe during the 17th and 18th centuries, an increase in refined sugar production occurred. Flour mills were invented at the same time (Lanfranco and Eggers 2012, 12). This impacted caries rates ever since. Before the invention of the flour mill, mainly occlusal caries were not able to develop as much due to the abrasion of the teeth by tiny stone fragments, that were left behind in bread due to the grinding of cereals in querns. This caused teeth to wear down constantly, and caries to develop slower. This is because the coarseness of certain foods help to scour teeth clean of food debris; dental plaque is not able to build up rapidly (Mays 2010, 223). Thus, caries was able develop in a slower pace.

In the modern age, the global population is affected with this lesion some time in their life. This is mainly because of the high carbohydrate intake, of which almost 50% of it being sucrose (Lanfranco and Eggers 2012, 8, 13), a sugar that is extracted from sugarcane or beet sugar (http://www.uzuma.nl), that is now an important additive in worldwide food production.

Caries research

As noted, much research has been carried out with the use of caries. It can provide valuable information about the diet of past populations. The next two case studies show how caries can impact the knowledge archaeologists have in regards to dietary reconstructions.

A recent study of Nicklisch *et al. (*2016, 93) has analyzed 494 preserved teeth from various Neolithic and Bronze Age sites in Germany. The study has shown that caries had no significant role in early childhood and that the number of carious lesions were small. Yet, there were differences between the sexes, as women exhibited more caries than men. This is attributed to the division of labor, since women prepared the food. Furthermore, it is assumed that women ate less animal protein, using carbohydrate foods instead to meet their calorie requirements. However, the hormonal differences need to be noted as well, since women have lower saliva flow rates due to estrogen (Nicklish *et al.* 2016, 96). Saliva protects the teeth as it acts as a buffer, it cleans the teeth from food remains and is an antibacterial agent (Dowd 1999, 579), slowing the pace of the formation of caries. Lastly, estrogen levels are the highest during pregnancy, thus influencing the saliva the most (Laine *et al.*, 1988; Laine, 2002; Salvolini *et al*., 1998 in Nicklish *et al.* 2016, 97). When the study is compared to other datasets and historical trends, some sites show a higher and some a lower amount of caries, which can be explained by regional differences and thus, the dietary habits (Nicklish *et al*. 2016, 97).

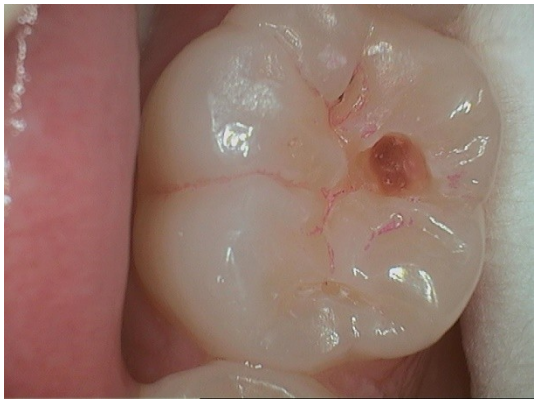
Another study in which caries has been researched has been carried out in Jordan, at the site of Sa'ad, comprising 1159 teeth; of which 16.8% (161 teeth) show caries (Albashaireh and Al-Shorman 2010, 208). Different studies have shown that the Sa'ad population was prosperous and thrived on agricultural products; carbohydrate-rich foods were available for the whole population. There was a moderate exposure of occlusal dentine (see figure four), suggesting the food could be abrasive or fine stone fragments were left in food due to the used milling equipment.

Moreover, the teeth have shown that the population drank wine in relative large amounts due to cupped surfaces with deep concavities, as wine has a low pH value and can therefore erode the dental surfaces. This causes caries to develop slower (Albashaireh and Al-Shorman 2010, 211). The caries frequency of this site is in the range of other sites in the area that were not flourishing as much. This could be because of antemortem tooth loss that was not included in the research, but also the fact that the wealth might have improved the status of citizens, allowing them to eat less cariogenic foods. Furthermore, other forms of tooth wear might have caused caries to stay at a normal frequency, such as the abrasiveness of food (Albashaireh and Al-Shorman 2010, 212), as illustrated in this chapter.

The studies show that much information can be gathered by looking at caries and that different factors can play a role. Also, it is possible to put caries in a wider context, as the division of labor could have played a part in the frequency of it, as seen in the study by

Figure 4: caries on the occlusal side of the tooth, the tooth crown (http://jessnien.blogspot.nl).

Nicklish *et al.*, 1996. Yet, as illustrated, hormones seem to have been a bigger factor when studying caries rates.



Besides, caries could be linked to the status of individuals, as shown in the study by Albashaireh and Al-Shorman, 2010. Yet, the results of this study have not yielded conclusive results.

Caries research also shows the importance of antemortem tooth loss. The results have shown that caries can reveal much about the lives of individuals from past populations and the differences between them, making this thesis a good contribution to the understanding of the population of the diet of the populations from London in comparison with Rome. Nevertheless, many factors can influence the frequency of caries, so it is important to take these into account in the research.

Conclusion

Due to the fact that caries occurs when bacteria in the mouth ferment carbohydrates, it has a direct link with the diet of populations. There are many factors that attribute to the susceptibility of caries such as the genetic make-up of individuals and the types of food eaten. However, it is clear that carious lesions have become more common since the rise of agriculture and therefore this oral pathology can be used to study the diet of past populations.

4 Materials and Method

In this chapter, it shall be explained how caries was recorded. Information on site context and excavation history will be given as well. Also, it will be explained how the datasets are analyzed. The dataset of the gathered teeth with dental pathologies was offered by the Museum of London. Their archaeological service has excavated various sites in London from various time periods. Their Wellcome Osteological Research Database (WORD) contains descriptions of the osteological remains excavated from various cemetery sites. These databases are regularly updated, too (museumoflondon.org.uk).

The dataset of the western cemetery consists of the data gathered by five excavations, of which Barnard's Inn, St Bartholomew's Hospital Medical School, Britannia House, Snow Hill and West Smithfield were (partly) Roman (archive.museumoflondon.org.uk). This chapter will only include the excavation history of St Bartholomew's Hospital Medical School and Atlantic House, since those reports were able to be gathered. Also, some sites do not have any published data or were part of desk-based assessments. Because publications about the excavations of the Southern cemetery were not accessible, not much information was gathered on this cemetery. Yet, the locations of the western and southern cemeteries were able to be plotted on the modern map of London, as seen in figures five and six.

Materials

The cemeteries: Roman West: Atlantic House

This area has been studied in 1997 up to 1999, after successful examination of test pits (1889-1990) and desk-based research (1998) (Watson 2004, 1-2). The report from Atlantic House, shows that the population was generally healthy[1], slightly taller than the average Roman Brit and show evidence for a balanced diet. There were no accounts of rickets, scurvy or iron deficiency (Watson 2003, 36).

The grave goods from the site at Atlantic House were not frequent, but this does not indicate that the population was of a low status, as luxurious grave goods such as jewelry and Samian ware (terra sigillata; a type of ceramic vessel of a high quality) were found (Watson 2003, 37). The population seems to be of an average wealth for the period with an absence of obviously high and low status burials (Watson 2003, 38).

1 Health in archaeology only comprises that of the skeleton, as this is the only element that can survive the test of time. Therefore, it is unknown whether an individual was mentally healthy, or had healthy soft tissues.

The excavations at Atlantic House have shown to be comparable to other excavation in the area of the Roman Western cemetery, although the sample size of the excavation is small. The grave goods and ceramic vessels are largely the same in the Western cemetery, as well as the positioning of graves (Watson 2003, 38).

St. Bartholomew's Hospital Medical School

After several inhumations had been found in 1979, the area of St. Bartholomew's Hospital was excavated in the same year. A total of 20 inhumations have been found, together with scattered human remains (Bently and Pritchard 1982, 134, 137). Individuals were not only buried singularly, as clusters of burials were excavated that were not results of incidental disturbances. Due to the appearance of cluster burials, it has been suggested that some burials had been visible in antiquity in some way, such as inscriptions stating the family name (Bently and Pritchard 1982, 157). It is possible that these marked areas were owned or reserved by certain individuals or even certain familial groups, since women, men and children have been found to be part of these clusters. A less favorable explanation is that it had been easier to bury a person in another grave due to difficult physical conditions. Yet this is unlikely, as the cluster graves show that individuals have been buried in a organized way (Bently and Pritchard 1982, 158).

Figure 5: All Roman western cemetery sites that are implemented in the WORD Database (after maps.google.com and Google Earth).

The cemeteries: Roman South

The area that compromises Roman Southwark prospered during the first two centuries AD, as architecture such as landing places, governmental structures, a market and a temple have been found. Also in the early third century this area remained prosperous, as illustrated by the presence of imported wares and foods, like dates and peppercorns. The area goes into decline by the late third century as buildings are abandoned and regions become flooded (Cowen *et al.* 2009 in Redfern *et al.* 2016, 13).

Evidence of mausolea at Great Dover Street suggests that the cemetery population had been wealthy and was of a high status . Lastly, the relatively high prevalence of non-adults (16 out of 46) suggests that there were familial relationships, strengthened by

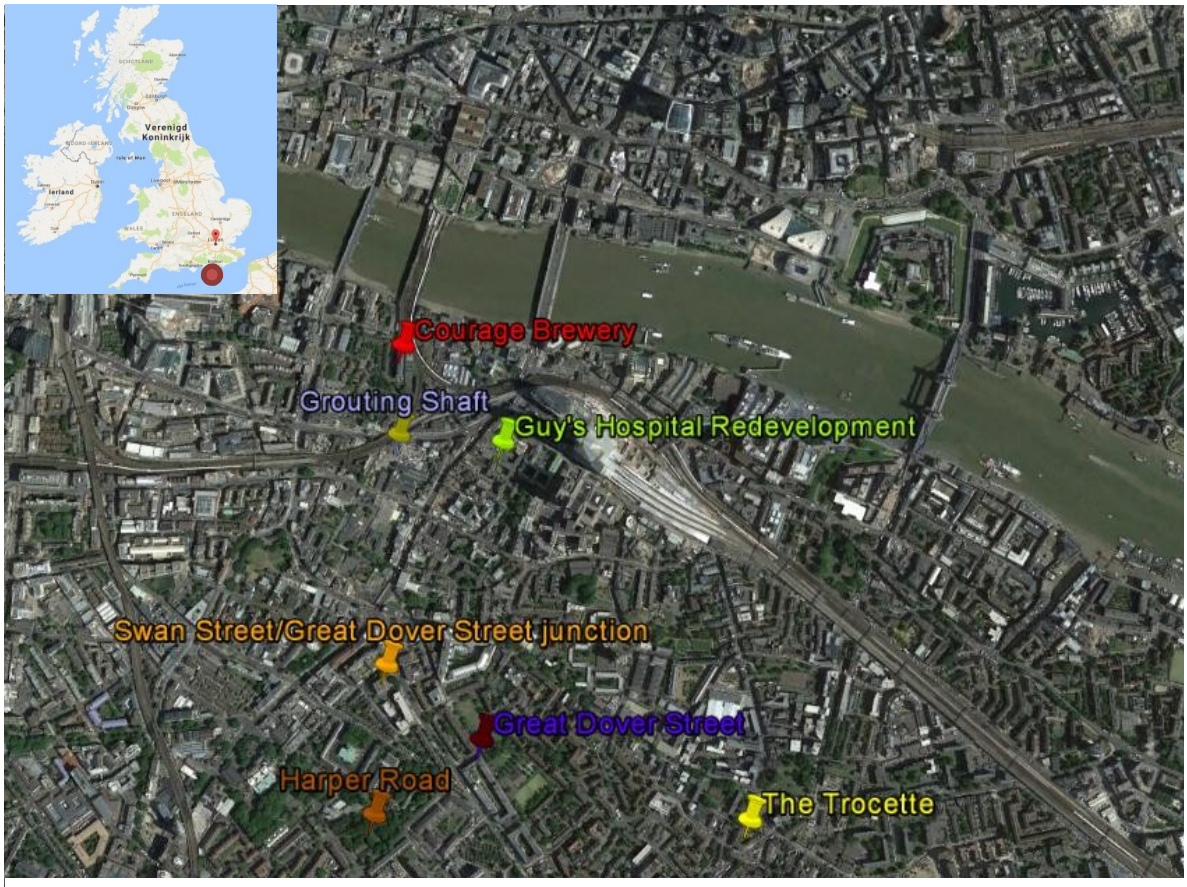


Figure 6: All Roman Southern cemetery sites that are implemented in the WORD Database (after maps.google.com and Google Earth).

Method

Caries scoring

The databases that will be used are publicly available from the website of the Museum of London. I will be using the database of dental pathologies, since caries has been included

in this database. The databases include which pathology was present per tooth. Therefore, the presence and absence of caries can be recovered from the datasets. Furthermore, the age and sex have been noted, as well the location in either the mandible (jaw) or maxilla (palate) (WORD database, 2016). The number of individuals included in this study is high, as can be seen in table 1. M/F/I/U shows the number of males, females, indeterminate and undeterminable individuals respectively.

The Roman West cemetery consists of a total of 137 individuals, of which the majority was represented by less than 50% of the skeleton. One third of the individuals were not able to be sexed, yet they were of adult age. The majority of individuals seem to have been adults (N=105). The mortality rate increased with age up to the age group of 36-45 years, with 16 individuals representing this group. Only three individuals that were over 46 years of age were represented. 27 individuals fitted in non-adult categories (table 1) (WORD database, 2016).

At the Roman South cemetery, there is a relatively even spread of all age groups, and sexes were also evenly represented (table 1). Around 85% of the individuals were preserved in a good state (WORD Database, 2016).
Although both sample sizes are big and therefore very useful for analysis, different authors have published the data. This causes a problem, since disparities between reports occur when looking at description details and the inclusion or omission of data, especially those for dental diseases. Little information has been provided regarding the total number of teeth and the totals of left and right dentition (Redfern 2003, 149). It is however noted if a tooth is deciduous or permanent and if it comes from the maxilla or the mandible, and to which sex and age group it corresponds.

Table 1: Sex distribution of adults; number of undetermined adults; number of non-adults; and totals of the Roman West (RW) and Roman South (RS) cemeteries (after www.museumoflondon.org.uk).

RS	11	10	7	28	18	46

Analysis of carious lesions

Five categories are available when looking at sex: male, female, intermediate, undeterminable, and unsexed child. Cases in which sex could not be estimated have been assigned a question mark (written as: "female?/male?"). To increase sample size, these are grouped together with the cases that are certainly female or male. Furthermore, age categories in adult age categories have been created for the adult age groups at both sites

to increase sample size (young adults ranging between 18-35 and old adults ranging between 36-45+).

This thesis has looked at the true prevalence of caries in the teeth using SPPS. The true prevalence of caries is calculated by studying the number of carious teeth versus the number of total recovered teeth. The following formula calculates the caries rate: This number is integrated in the tables in a separate column and expressed in percentages.

Contingency tables and frequency tables have been made to examine the diet of the cemetery populations. Differences within cemeteries in age (adult vs. non-adult), age groups (older adult vs. younger adult) and sex (male vs. female) have been studied. To test whether differences are statistically significant, χ^2 (Chi-square) tests have been used.

Furthermore, both cemeteries have been compared with each other. Here, differences in age (RW adult vs. RS adult; RW non-adult vs. RS non-adult) as well as age groups (RW older adult vs. RS older adult and RW younger adult vs. RS younger adult) have been examined, as well as the overall caries rates. Also, the adults will be compared with each other (RW males vs. RS males; RW females vs. RS females). Whether the differences are statistically significant has been tested using a χ^2 test.

The results of all these observations will be discussed in chapter six.

5 Results

In this chapter, the prevalence of carious lesions is displayed. Sex has been noted to gain knowledge about the diets between males and females. Furthermore, non-adults have been implemented in the research in order to understand the possible differences between the diet of adults and non-adults. This will be done per site first, following with a comparison between the sites.

Roman West

For the Roman West collection, 7137 teeth could be observed. Of these teeth, 1384 show carious lesions. This number makes up about 19.4% of all observed teeth.

Adults

Table 2 shows that similar caries frequencies occur between the sexes. Only individuals for whom sex could be estimated were included in the calculations. Males exhibit the same frequency in caries as females (~19.3%; 0.1% difference). A χ^2 test has been conducted to confirm the lack of a difference, which revealed no statistically significant differences between the sexes (χ^2=0.007, p=0.932, n=4480).

Table 2: Caries frequencies in adult sex, Roman West.

Sex	Carious teeth	Observable teeth	%
Male	556	2874	19.3%
Female	309	1606	19.2%
Total	865	4480	19.3%

When studying caries frequencies in adult age, 5184 observable teeth were available. Table 3 shows that there are similar caries frequencies when studying adult age (19.1%-19.8%). Yet, the age group of 46+ differs much from the other caries rates (9.7%). This is due to the underrepresentation that is visible when reviewing the observable teeth of adult age groups and may be related to antemortem tooth loss. The difference between the adult age groups has not proven to be statistically significant (χ^2=1.525, p=0.822, n=5184).

Table 3: Caries frequencies in adult age, Roman West.

Age in years	Carious teeth	Observable teeth	%
18-25	131	662	19.8%
26-35	153	773	19.8%
36-45	202	1047	19.3%
46+	3	31	9.7%
Unclassified	512	2671	19.1%
Total	1001	5184	19.3%

Table 4 shows the results of the caries frequencies when the two age groups are combined into two larger ones. The unclassified adult teeth have not been included in the age groups, since it is unknown to what adult age category they belong. This is why the total number of observable teeth is 2513. As the table shows, when the adults are subdivided into younger and older adults to increase sample size, the younger age group shows a slightly higher caries rate than the older adults (19.8%). The calculations did not show statistical significant differences between the adult age groups (χ^2= 0.235, p=0.628, n=2513).

Table 4: Caries frequencies in adult age groups, Roman West.

Age Groups	Carious teeth	Observable teeth	%
18-35	284	1435	19.8%
36-46+	205	1078	19.0%
Total	489	2513	19.5%

Non-adults

The non-adult age categories are made up of a total of 1953 observable teeth. Table 5 exhibits the data for the non-adult caries frequencies. The 12-17 age group exhibits the highest caries rate (19.8%), but differences are very small when compared to the other non-adult age categories, which is confirmed by a χ^2 test that has been conducted. The differences of caries rates in these non-adult age groups are not statistically significant (χ^2=0.058, p=0.972, n=1953).

Table 5: Caries frequencies in non-adult age, Roman West.

Age in years	Carious teeth	Observable teeth	%
1-5	119	602	19.8 %
6-11	129	668	19.3 %
12-17	135	683	19.8 %
Total	383	1953	19.6 %

Table 6 shows the comparison between the adult and non-adult categories. Here, unclassified adult age categories have been included as well. The non-adults exhibited a slightly higher caries frequency (19.6% versus 19.3%). When a χ^2 test was calculated, the difference in caries rates was also not statistically significant (χ^2=0.056, p=0.814, n=7147).

T

	Carious teeth	Observable teeth	%
Adult RW	1001	5184	19.3%
Non-adult RW	383	1953	19.6%
Total	1384	7147	19.4%

Roman South

The database of the Roman South cemetery dental pathologies compromises of 2219 observable teeth that could be studied, of which a total of 427 teeth show carious lesions. This number comprises about 19.3% of all observed teeth.

Adults

Table 7 shows the results that have been gathered when sex in relation to caries was studied. At the Roman south cemetery 1427 teeth are from adult individuals. Of these adults, 834 are male and 593 are female. The cross tabulation has conducted that men have a slightly higher caries rate than women (19.5% versus 18.9%). A χ^2 test has been

conducted in order to see whether this difference was statistically significant. This was not the case (χ^2=0.096, p=0.756, n=1427).

Table 7: Caries frequencies in adult sex, Roman South.

Sex	Carious teeth	Observable teeth	%
Male	163	834	19.5%
Female	112	593	18.9%
Total	275	1427	19.3%

Next, adult age has been studied in relation to caries. Table 8 displays the results. The individuals with unknown sex have been included; as well as the undeterminable age category. This analysis has shown that there is a relative even spread of caries between the age groups (between 18.9% and 19.9%). The differences of caries rates between the age groups is not statistically significant (χ^2 =0.188, p=0.996, n=1427). This comes naturally, as it is unlikely that a statistically significant difference is present, as the spread of caries rates is even among the different adult age categories.

Table 8: Caries frequencies in adult age, Roman South.

Age in years	Carious teeth	Observable teeth	%
18-25	86	438	19.6%
26-35	43	220	19.5%
36-45	82	438	18.7%
46+	31	156	19.9%
Undeterminable	33	175	18.9%
Total	275	1427	19.3%

The adult age groups have been subdivided into younger and older adult categories in table 9. The undeterminable age category has not been included, as the age is unknown. It has been concluded that the younger adults show a slightly higher caries frequency than the older adults (19.6%). The χ^2 test to review whether this difference is statistically significant, has demonstrated that this is not the case (χ^2=0.046, p=0.831, n=1252).

Table 5: Adult sex.

Table 9: Caries frequencies in adult age groups, Roman South.

Age group	Carious teeth	Observable teeth	%
18-35	129	658	19.6 %
35-46+	113	594	19.0 %
Total	241	1252	19.2 %

Non-adults

In table 10, caries frequencies in relation to non-adult age have been examined. In total, 791 teeth of non-adult individuals are present in the dataset and able to be studied. Of these, 151 teeth show carious lesions (19.1%), with the 6-11 year olds to have a higher rate than the other ages (19.6%). The fact that there is a difference between the caries rate of the 1-5 year olds and the 6-17 year olds is because caries is age-progressive. Nonetheless, this difference is small and not statistically significant between the three different age groups (χ^2 =0.418, p=0.811, n=791).

Table 10: Caries frequencies in non-adult age, Roman South.

Age in years	Carious teeth	Observable teeth	%
1-5	24	140	17.1%
6-11	28	143	19.6%
12-17	99	508	19.5%
Total	151	791	19.1%

Table 11 exhibits the results of comparing the adult teeth of the southern cemetery with the non-adult teeth of the southern cemetery. The adults show a 0.2% higher rate in caries when compared to the non-adults (19.3% versus 19.1%). When it was calculated whether this difference was statistically significant, results showed that it was not (χ^2=0.007, p=0.932, n=2218).

Table 11: Caries frequencies between adults and non-adults, Roman South.

	Carious teeth	Observable teeth	%
Adult RS	275	1427	19.3 %
Non-Adult RS	151	791	19.1 %
Total	426	2218	19.2 %

Western vs. Southern cemeteries

In this paragraph, the overall caries frequencies of both cemeteries will be compared with each other, as well as those of men, women, young and old adult, and non-adults separately with each other.

Table 12 shows the overall comparison of caries frequencies between the two sites. The cemeteries have similar caries rates (19.2/19.3%). Therefore, the difference between the caries frequencies of both sites is not statistically significant (χ^2=0.01, p=0.921, n=9365).

Table 12: Comparing overall caries rates, Roman West vs. Roman South.

Roman West	1381	7147	19.3 %
Roman South	426	2218	19.2 %
Total	1807	9365	19.3 %

Tables 13 to 17 present the results when comparing the teeth from men, women, younger adults, older adults and non-adults from the cemeteries with each other separately.

Table 13 indicates the results of the comparison of caries rates between the males of both cemeteries. The men from the southern cemetery have a slightly higher rate of caries than the men of the western cemetery (19.5%). The difference is small and not statistically significant (χ^2=0.016, p=0.898, n=3708).

Table 13: Roman West males vs. Roman South males.

	Carious teeth	Observed teeth	%
Males West	556	2874	19.3%
Males South	163	834	19.5%
Total	719	3708	19.4%

Table 14 indicates the results of the comparison of caries rates between the females of both cemeteries. The women from the western cemetery show a slightly higher rate of caries than those of the southern cemetery (19.2%). This difference is not statistically significant (χ^2=0.035, p=0.852, n=2199).

Table 14: Roman West females vs. Roman South females.

	Carious teeth	Observed teeth	%
Females West	309	1606	19.2%
Females South	112	593	18.9%
Total	421	2199	19.1%

Table 15 indicates the results of the comparison of caries rates between the young adults of both cemeteries. The younger adults from the western cemetery show slightly more caries than the younger adults of the southern cemetery (19.8%), but the difference is not statistically significant (χ^2= 0.0906, p=0.763, n=2687).

Table 15: Roman West young adults vs. Roman South young adults.

	Carious teeth	Observed teeth	%
Young adults West	284	1435	19.8%
Young adults South	242	1252	19.3%
Total	526	2687	19.6%

Table 16 indicates the results of the comparison of caries rates between the old adults of both cemeteries. The older adults of the western cemetery exhibit the same caries rate as the southern cemetery, so this is not statistically significant (χ^2=0.002, p=0.968, n=1869).

Table 16: Roman West old adults vs. Roman South old adults.

	Carious teeth	Observed teeth	%
Old adults West	205	1078	19.0%
Old adults South	151	791	19.1%
Total	356	1869	19.0%

Table 17 indicates the results of the comparison of caries rates between the non-adults of both cemeteries. The non-adults of the Western cemetery have a slightly higher caries rate

than those of the southern cemetery (19.6%). Nevertheless, this difference is also not statistically significant (χ^2=0.098, p=0.755, n=2744).

Table 17: Roman West non-adults vs. Roman South non-adults.

	Carious teeth	**Observed teeth**	**%**
Non-adults West	383	1953	19.6%
Non-adults South	151	791	19.1%
Total	535	2744	19.5%

6 Discussion

Now that the sites in London have been analyzed, it is possible to interpret the results and to observe whether there are indications for dietary differences when comparing the populations of Roman London to other Roman populations. The cemeteries of London will thus be compared with a site from the center of the Roman Empire: Isola Sacra in Rome.

London cemeteries

There are some minor differences in caries frequencies between the cemeteries; in the western cemetery, males show a slightly higher rate of caries than females, younger adults exhibit the highest caries, and there is a relatively even spread of caries in adult age groups and in non-adults, of which the 12-17 age group exhibits the highest caries rate. Yet, all these differences are not statistically significant, suggesting that the whole population ate the same amount of carbohydrates. Similar results are found at the southern cemetery. Here too, males show a slightly higher caries rate than females. Younger adults present a slightly higher caries rate when compared to the older adults, just as in the Western cemetery. The caries levels in non-adults increase slightly due to the fact that caries is related to age. The differences are not statistically significant. Furthermore, both cemeteries have a similar caries rate when comparing them with each other.

Both cemeteries have a caries rate of ~20%. In both populations, there are no statistical significant differences in caries rate between adults and non-adults. Men have a slightly higher rate in caries in comparison with women, but this is not statistically significant. There are also no statistically significant differences in the adult age groups. Younger adults exhibit slightly more carious lesions than older adults. Like the western cemetery, non-adults of the age between 12 and 17 show the highest caries rates in the southern cemetery, but the differences are not of any statistical significance.

When studying caries frequencies, it seems that there are no statistical significant differences between the diet of males and the diet of females. In both populations, males had a lower caries prevalence than females. Yet, this is an interesting observation, as women usually have a higher caries frequency due to hormonal balance as shown in an elaborate study by Lukacs and Thompson (2008) researching the differences in caries between sexes from populations from Europe, Asia, North and South America and Africa. This study has shown that females consistently have a higher caries rate than males

(Lukacs and Thompson 2008, 139, 155). As already discussed in chapter three, this is because these hormones cause females to produce less saliva that cleans the teeth of food remains, resulting in the development of caries. Yet, more factors come into play. Puberty, total fertility and menstruation affect caries prevalence when we take hormones into account. Pregnancy can cause caries to develop as well, because of the fact that pregnant women eat more, have a higher level of estrogen, and have a weakened immune system (Lukacs and Thompson 2008, 155).

It could be that men had better access to exotic foodstuffs than women, as illustrated by ancient texts; and that medical writers such as Galen advised men and women to eat different foods based on energy and nutritional requirements (Garnsey 1990, 103, 105). It is possible that due to the incorporation of regions into the Roman Empire, the dietary habits of inhabitants changed and men acquired higher caries rates in such a way, that the rates between the sexes reached the same value. Yet, when looking at Roman Britain, little is known about dietary habits, as few texts survive and it is unknown whether differences in diet between the sexes as illustrated by textual sources were represented in all regions of the Empire (Bonsall 2014, 1280).

When examining the non-adults, results have shown that these have relatively the same caries rate as adults. One could expect that caries was lower in non-adults, as caries is an age-progressive lesion. It appears that non-adults already had access to carious foods from an early age, and non-adults therefore show carious lesions when they get older.

It seems that although there is a slight social difference between the two cemetery populations (as one is surely elite and the other might be well-to-do citizens), this does not have impact on their diet, as both populations show similar caries rates. Yet, it is questionable whether these rates are characteristic for the rich strata of society in Roman London. Isotope studies at urban York, rural Gloucester and Cirester featured samples from individuals that were of an elite stratum and samples from the commoners that showed similarities in the diet (Cheung *et al.* 2012, Müldner and Richards 2007, Chenery *et al.* 2010). So, it would seem that the diet was overall consistent, whether a population was rural or urban, rich or poor. These sites will be discussed. It also has been established that “Romanization” influenced urban elite communities more than those on the lower end of the social hierarchy, or those living in rural areas (Haverfield 1923, Frere 1999 and Meadows 2002 in Cheung *et al.* 2012, 70), so the trends visible in research are likely not representative of the whole British-Roman population.

Western and Southern cemeteries vs. Rome and Isola Sacra, Italy

Isola Sacra dates from the first three centuries AD (Prowse *et al*. 2005, 4), and appears to have been partly elite, as the site features elaborate tomb structures (Prowse 2001, 83). When investigating caries, 297 out of a total of 5548 teeth show caries; this is 5.4% of all teeth (Prowse 2001, 154), with the overall sample representing 365 individuals (Prowse 2001, 159). 141 individuals were assigned male, while 128 were female. The other 96 individuals were of intermediate sex.

The total caries rate of caries in females was 5.5%. In males, the caries rate was 7.8% (Prowse 2001, 159). Thus, men had a higher level of caries when only studying caries. Nevertheless, this observed difference was not statistically significant (Prowse 2001, 235).

In London too, no statistical differences between the sexes were observed. So, this is similar to Isola Sacra. Yet, the rate of caries differs greatly between the two sites, as the cemeteries in London show a caries rate of 19-20%.

The study also concluded that caries increased with age, as expected, since caries is overall an age-progressive lesion (Prowse 2001, 159), as more food is eaten when an individual ages. Therefore, more caries are able to develop. The rate of caries differs with the rates from London. At Isola Sacra, the rate of caries increases with age, while the rate of caries in the samples of London remain stable (tables 2 and 6), with an exception of the oldest age category of 46+ years. Yet, this age group was severely underrepresented, as a total of 31 teeth fitted in this age group instead of a couple of hundred, such as in the other age groups.

Table 18: Caries rate per adult age category at Isola Sacra (after Prowse 2001, 160).

<10	1.45
10-20	2.99
20-30	3.67
30-40	6.86
40-50	8.02
50+	14.14

The low frequency of caries at Isola Sacra greatly differs from the sites in London. The low rate in caries at the site of Isola Sacra may be explained by isotope studies. With isotope studies, one is able to reconstruct the diet with the use of isotopes present in food, that are ingested. Isotopes in organisms differ in the number of neutrons. By using the ratio of heavier versus lighter stable isotopes, one is able to deduce what kind of foodstuffs a person has eaten (White and Folkens 2005, 413).

As Isola Sacra was part of the *Portus Romae,* it is possible that the individuals were able to eat more marine foods instead of those that were high in carbohydrates. Nevertheless, the location of the site does not make the results representative of the average Roman diet (Prowse *et al.* 2004). Furthermore, by eating fish that carry a high level of fluor, caries is less able to develop (Sealy *et al.* 1992 in Prowse 2001, 238). It is also possible that the majority of the population could not afford high quality bread, causing them to eat more gritty and denser bread, that was abrasive (White 1988 in Prowse 2001, 238), as more abrasive material could have been incorporated in the bread. This is interesting to note, as abrasions in foodstuffs cause caries to stop developing, since the surfaces of the hard tissues of the teeth erode.

Isotope studies

Isotope studies consider the protein component of an individual's diet. The recent dissertation of Powell (2014) regarding isotope studies has been carried out with the use of the WORD database. She used all the cemeteries that lay outside the city walls of *Londinium*, as well as some intramural sites (Powell 2014, 115). Isotope data shows that the protein intake of the Roman Londoners was largely of a terrestrial nature and that these individuals ate this protein-source regularly (Powell 2014, 288). Besides, it seems that the lower classes of London were able to afford meat and dairy products, therefore contradicting assumptions that the peasantries ate a diet that was referred to by texts (Sippel 1988, 47-48, Garnsey 2004, 226-256, Wilkins and Hill 2006, 56-57, and Grimm 2007, 86 in Powell 2014, 288). Furthermore, these studies affirm that beef was more sought after in Britain while pork was favored on the Italic peninsula, as a result of the militarization of the diet with the arrival of the Roman army (King 1984, 1999). The preference of beef over mutton in Britain is also associated with Roman influence (King 1984; Hawkes 1999, 91; Cool 2006, 80). Lastly, within the archaeozoological record of Roman London, cattle is the most represented overall (Bluer *et al.* 2006, Cowan and Wardle 2009 and Pipe 2011b and 2011c in Powell 2014, 288). Yet, no statistically significant difference was observed between the isotopic ratios of the cattle, sheep/goat and pigs at the site (Powell 2014, 288). Furthermore, chicken, marine and freshwater fish seem to have been added in the diet, as observed by the $\delta^{13}C$ and $\delta^{15}N$ values (Powell

2014, 289). Fish intake is an interesting dietary aspect, as fish was absent in the diet of populations in Britain prior to the isle's incorporation in the Roman Empire (Dobney and Ervynck 2006; Locker 2007; Müldner 2013). The fact that the diet in London seems to be consistent with other contemporaneous Roman sites in Britain, such as Gloucester, York and Cirencester is noteworthy (Müldner and Richards 2007; Cummings 2008 in Powell 2014, 289; Chenery *et al.* 2010; Cheung *et al.* 2012). For example, research in Gloucester showed that the diet largely consisted of terrestrial diet with a large contribution of animal-based protein (Chenery *et al.* 2010, 155-156). Besides, in the Roman Period, fish bones are much more abundant as illustrated by the shift in stable isotope values (Cheung *et al.* 2012, 70).

This study illustrates that fish was definitely eaten, but not in such high amounts that it would slow or stop the development of caries in the teeth of Roman British individuals, since a caries rate of ~20% is still high. At York, studies have shown the population relied mostly on cereals and that beef was mostly eaten when studying animal products (Müldner and Richards 2007, 683). As the sites of York, Gloucester and Cirencester have shown to be comparable to London, it is likely that these societies relied mostly on cereals as well. This can be illustrated by the observed caries rates. Isotope studies concluded that individuals ate a small, yet regular amount of marine foods; but not enough to result in a low caries rate, as is observed at the site of Isola Sacra. Fish in Britain might have been supplied directly from nearby estuaries, yet fish like salmon were probably caught at local rivers when these fish migrated (Müldner and Richards 2007, 690).

Fish consumption in Britain

Evidence of fish consumption in Roman Britain is varied, but is mostly represented by traces found in amphorae. These vessels were used for transport in the whole Empire and were frequently filled with fish sauces: a popular dish throughout the Empire. Vessels that had contained fish or fish sauce are also found in London and other parts of Britain (Locker 2007, 142). It is possible that instead of fishing locally, individuals preferred the imported fish products, and that caries frequencies in London are therefore high. Moreover, the fact that fish was considered a luxury and only available in relatively small amounts due to the small number of fisheries that occurred when Britain was annexed (Locker 2007, 151-152, 157), could be important factors relating to the high caries frequencies observed in the database.

The occurrence of fishponds at villa sites in Britain might add some knowledge to the use of fish in Britain and the Roman Empire. Elites in the center of the Roman Empire were

thought to keep fish as a symbol for status, yet the abundance of fish ponds at villa sites is small, and there is no evidence that these ponds had fish in them (Locker 2007, 142-143). Moreover, no fish traps have been found in Britain that date from the Roman period. This differs greatly with the periods before and after the Roman period, as fish traps from the Bronze Age, Neolithic period and Medieval times survive (Locker 2007, 143). Lastly, fish consumption in Roman art from Britain is underrepresented, maybe because fish was so highly valued (Bekker-Nielsen 2002a, 29 in Locker 2007, 143). All in all, the change in diet that occurred when Britain became a Roman province is most notable in meat consumption instead of fish consumption. Since meat cannot cancel the development of caries, it is not peculiar that caries rates in Roman Britain do not diminish.

Is the diet in London comparable to the center of the Roman Empire? In the study by Powell, sites on the Italian peninsula have been compared to London. Only the site of Casa Bertrone, outside of Rome's wall was the most comparable (Killgrove and Tykot 2013 in Powell 2014, 291). Yet, this is not striking when taking into account the Italic population that first established London, therefore bringing dietary preferences with them. Furthermore, the status of London as an important harbor allowed the inhabitants to access foodstuffs isotopically similar to Rome (Powell 2014, 291). Nevertheless, as already stated, there are more sites within the Italic peninsula that differ from London than there are similar cases.

Dental Practices?

Although this can illustrate that ingested non-cereal foods could differ greatly when analyzing the center and periphery of the Empire, it does not really explain why the caries rate is of a high value. When comparing the teeth from London with Roman Ancaster and Winchester, the same trends can be gathered. Here too, more than half of the population is affected, but no statistical significance occurred between the sexes (Bonsall 2014, 1285).

The low rate at Isola Sacra might also be explained by examining the research on caries in Rome from 50-100 AD, carried out by Fejerskov *et al.* in 2012, using extracted teeth found during excavations at the temple of Castor and Pollux on the Forum Romanum. Here, shops (*tabernae*) were excavated on the podium of the temple (Fejerskov *et al.* 2012, 468). A total of 86 extracted teeth had been recovered. All but two of these teeth had caries that extended near or into the pulp chambers. These carious teeth did not have any big fractions as a result of extracting them (Fejerskov *et al.* 2012, 469). The fact that the teeth have caries that reach to the pulp chamber might suggest that the caries were only extracted when they became too painful (Fejerskov *et al.* 2012, 471). Yet, it is

unknown to what individual the teeth belonged to, yet these individuals had access to some dental care when it was needed.

It could thus be that the low rate of caries in Isola Sacra is also a result of tooth extractions. When looking at the types of caries for example, it is noted that 14 carious lesions were large and therefore probably extended into the pulp chamber (Prowse 2001, 169). Yet, no other clear examples of a 'dentist practice' have been found in the center of the Roman Empire, as these practices were largely carried out by doctors (www.therabreath.com).

Conclusion

Although the diet in London is comparable to one site in the center of the Roman Empire, it is not the answer to the question whether diet differed between the center and the periphery, as other sites, like Isola Sacra, exhibit some big differences in caries frequencies. It is noteworthy that the sites from London differ greatly with what is seen at Isola Sacra, as both sites (partly) have an elite population, yet caries rates are higher and more stable in non-adult and adult age groups in London. When studying sex there is a similarity, as males have a higher rate of caries than females. Both in London and in Isola Sacra, this differentiation is statistically insignificant. This is not perculiar, as Isola Sacra is a cemetery close to the Roman port *Portus*. In Britain, there is no hard evidence that habits of fish consumption changed when the isle was annexed, in comparison with meat consumption. This affects the rate of caries, as fish carry fluor, a substance that cancels the development of caries. When inspecting meat consumption, in the Iron age, people mostly consumed sheep/goat meat, but a rise in pork and beef was visible when Britain became a Roman province. The Roman influence is clearly visible here, as the Romans preferred pork and beef products; and thus differs greatly with the trend visible in fish products.Yet whether the fact that London differs from Isola Sacra might not be a special case, as other research has proven that the diet varied greatly within all parts of the Roman Empire. It is likely that a typical "Roman" diet did not exist (King 1984, 1999; Cool 2006, 243; Wilkins and Hill 2006, 22f in Powell 2014, 292; Van Der Veen 2008; Van Der Veen *et al.*2008 in Powell 2014, 292; Cheung *et al.* 2012).

7 Conclusion

This thesis the following research question was formulated in: “How can the diet of the populations in Roman London be compared to the diet of populations in the heart of the Roman Empire?”. This question was answered with the help of looking at differences and similarities in the diet between males and females within and between the cemetery sites of London, the dietary differences and similarities between adults and non-adults within and between the cemetery sites of London and the role of status when researching diet. This proved to be an interesting research question, since not much attention has been given to caries and other dental pathologies at the excavations of the western and southern cemeteries in London.

Question 1

“How does sex relate to differences or similarities in the diet of past populations when considering the sites themselves and how do these results compare to each other and the center of the Empire?”

Interesting observations have been made when studying sex similarities and differences between and within the populations of London. In both populations, males had a similar prevalence of caries; differences between men and women were not statistically significant. This also applies to the comparison between the sites from London and Isola Sacra. Here, a much larger difference occurred.

It is interesting that to note that when examining sex differences and caries frequencies, males exhibited this similar rate in caries. One would suspect that females have a higher caries rate, because of sex-specific factors and hormones. Estrogen levels and pregnancy influence a women’s susceptibility to caries. Yet, at the sites of London and Isola Sacra, males have a higher prevalence of caries. It could be that men had a good access to elite foods that were rich in carbohydrates.

Question 2

“What are the differences and similarities in the diet of adults and non-adults when examining the sites themselves and how do these results compare to each other and the center of the Empire?”

In London, both cemeteries show stable levels in caries levels between adults and non-adults, suggesting they had the same diet. Within non-adult age groups, caries rates

were also stable and did not differ from each other. In adult age groups, caries levels were also stable.

This differs with the caries rates in age groups in Isola Sacra. Here, the non-adults show that the caries rate gradually increases the older an individual gets. This also applied to the adult age categories, explained by the fact that caries is an age-progressive lesion. That the caries in London stay stable, can be explained by the fact that local fishing was not avidly practiced, and that fish remained a luxury in the whole Empire. This is an important factor, as fish are high in fluoride. This anion can help in decreasing the development of caries.

Question 3

"How does status link to the diet of past populations in Roman London?"

It has been concluded that both sites in London were part of a well-to-do community, or at least partly of elite status. These communities were able to afford foods of a higher quality. The populations did not differ too much from each other, although the southern cemetery was surely elite and the western one was not. In both sites, over half of the individuals had carious lesions; suggesting both populations had a high-carbohydrate diet.

This differs with the population of Isola Sacra, a site partly made up of an elite population. Here, overall caries rates are much lower. This is explained by the location. The site is close to the port of Rome, causing these people to have access to fish.

Another factor for the difference in caries rate can be attributed to possible extraction practices, where large caries were treated by extracting them from the mouth. In this way, caries that were present on certain teeth are not visible. Only elite individuals had access to some dental care, as they had the means to afford this. Yet, as only one site with extraction practices has been found, it is unknown whether this also applies to other sites.

Research Question

"How can the diet of the populations in Roman London be compared to the diet of populations in the heart of the Roman Empire?"

It could be concluded that the diet in Roman London differed somewhat from that of Rome. It is possible that in Roman London, people had a higher rate in caries due to the fact that they ate more carbohydrate foods, and fish products were less accessible, or only available in small amounts . Besides, the dietary habits regarding fish do not seem to change when Britain became a Roman province, in comparison with meat products.

That the populations of London enjoyed a diet full of carbohydrates is supported by the fact that caries levels do not increase with age in the adult teeth. It could be that in Roman London, individuals from both sexes and all age categories had access to a selective array of foods, while in Rome, people enjoyed a more differentiated diet, as this was the center of the Roman Empire. However, the conclusion that the diet in London differed from the center of the Roman Empire is nuanced when looking at other studies. Furthermore, some aspects limit what conclusions can be made.

Limitations

Although much can already be concluded from this research, there were some limitations. Firstly, only one Roman sample from the Italian peninsula has been used. As this is also a harbor site, a self-fulfilling prophecy can be achieved, as it comes naturally that sites close to ports are more likely to have access to fish and therefore exhibit a lower caries rate. In order to have an unbiased interpretation when studying dietary differences between the center and the periphery of the Empire, more sites from Italy should be included. Secondly, to improve this research, it would be useful to have access to more updated versions of the WORD databases from the Museum of London, as they provide limited amounts of data comparing to the data available from Isola Sacra. Lastly, excavation histories and publications of data need to be more accessible. If more data is available, a better understanding of the diet can be achieved.

Future directions

In future research, antemortem tooth loss should be taken into account. As caries has a correlation with antemortem tooth loss, including it would prove to be a more accurate caries rate. Calculating caries rates while including antemortem tooth loss can be done with the Diseased Missing Index (DMI). Yet, this formula has proven to overestimate the number of caries, while by neglecting this formula, one underestimates the caries rate. The overestimation is caused since DMI assumes that antemortem tooth loss is the direct consequence of caries. This is not always true, as trauma and tooth wear can also cause a tooth to fall out of the jaw. Since tooth loss was not accounted for in the data from the cemeteries, it is likely that the caries rates in the populations from London are underestimated.

Furthermore, research would be more useful when the location of caries had been noted, as location is an important factor when studying carbohydrate dietary preferences. This is because the location can show if an individual had a high carbohydrate diet or a low one. Besides, when the type of caries is noted, one can uncover much more about the diet of individuals.

Finally, to gain a better understanding of the diet of the Roman Londoners, more isotope studies should be incorporated, as caries only features the carbohydrate aspect of an individual's diet. Isotope studies, for example, can uncover what protein, what plants and what fish species were mostly eaten, giving more insight in what was available or preferred; and whether this corresponds to the dietary trends visible in other regions of the Empire, although, as illustrated, a typical "Roman" diet was absent in the Empire. Future research might improve when one interprets the diet in the Roman Empire as if it was a part of the globalizing process of Romanization.

English Summary

By researching dental caries, it is possible to gather information about a population's diet, specifically if the diet consisted of high-carbohydrate foods, like cereals, a staple in the diet of the Romans.

With the use of WORD (Wellcome Osteological Research Database) provided by the Museum of London, it was possible to study the diet of two Roman cemeteries in London. These sites were later compared with Isola Sacra, a site from the center of the Empire. The sites in London did not differ greatly from each other. Both adults and non-adults had similar caries levels. These levels also apply to the age groups between and within non-adults and adults. Males exhibited a slightly higher rate of caries than females, but this rate was not statistically significant. It is noteworthy however, that females (in theory) should show a higher caries rate due to sex-specific factors such as estrogen and pregnancy.

At the site of Isola Sacra caries increased with age, in adult age categories and non-adult ones. Here too, men show a higher, but statistical insignificant prevalence of caries. The overall rate of caries in comparison with Roman London is different, as the caries rate at Isola Sacra was around 7%, and in Roman London around 20%. The low rate has been attributed with possible extraction practices from Rome that are known about. Here, teeth were extracted when caries reached the pulp chamber. The low amount of (large) caries in Isola Sacra could mean that this practice was also done here, yet no hard evidence has been found. The low rate could also be attributed to the consumption of fish, as they provide fluoride, that halts the development of caries. In Roman Britain, fishing appears to be practiced only mildly.

It has been concluded that the diet differed when placing the periphery and the center of the Empire opposite each other. This could be attributed to the fact that the Empire was of a complex nature, as ideas and foods traveled all over the place.

Dutch Summary

Het dieet van vroegere populaties kan worden gereconstrueerd door cariës te bestuderen. Deze aandoening wordt veroorzaakt door de zuren die vrijkomen bij het fermentatieproces van koolhydraten. Koolhydraten zijn bijvoorbeeld in grote getalen aanwezig in graan, essentieel voor het dieet van de Romeinen.

Met behulp van de WORD (Wellcome Osteological Research Database) van het Museum van Londen was het mogelijk om het dieet van twee Romeins Londense populaties te analyseren. Deze sites werden met de Romeinse site van Isola Sacra vergeleken, dat in het centrum van het Romeinse Rijk ligt. De sites in Londen verschilden niet veel van elkaar. De volwassenen en de niet-volwassenen hadden ongeveer dezelfde hoeveelheid cariës. Mannen hadden een hogere hoeveelheid aan cariës in hun tanden dan vrouwen, maar dit verschil was niet statistisch significant. Dit is interessant, omdat het gebit van vrouwen eerder meer cariës zouden moeten aantonen door seks-specifieke factoren, zoals zwangerschap en oestrogeen.

De site van Isola Sacra toont dat hoe ouder een individu werd, hoe meer cariës deze persoon kreeg. Dit was zowel in de data van niet-volwassenen als volwassenen te zien. De site laat ook zien dat mannen meer cariës hadden dan vrouwen, dat ook te zien is in Romeins Londen. Meer dan de helft van alle individuen laten sporen zien van cariës, terwijl in Isola Sacra maar 7% dit letsel vertoont. Dit lage percentage kan worden verklaard aan de hand van extractieprocedures die men kent uit Rome. Deze praktijken zouden ook kunnen zijn voorgekomen in andere delen van het Rijk, maar hier is geen hard bewijs voor. Daarnaast zou ook de populatie van Isola Sacra meer vis kunnen hebben gegeten dan de populaties uit Londen door de ligging naast de haven van Rome. Vis bevat fluoride, een stof die de vorming van cariës helpt tegen te gaan. Daarnaast zijn er in Romeins Brittannië weinig vondsten en sporen overgebleven die relateren aan het vangen en eten van vis.

In de periferie van het Romeinse Rijk werd waarschijnlijk een ander dieet gevolgd, als er alleen koolhydraten in acht worden genomen. Dit is te illustreren met het feit dat het Rijk complex was: het was een gebied waar verschillende ideeën en verschillend voedsel konden worden uitgewisseld.

Figures, tables and websites

Figures

Tables

Websites

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