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The Post Hole

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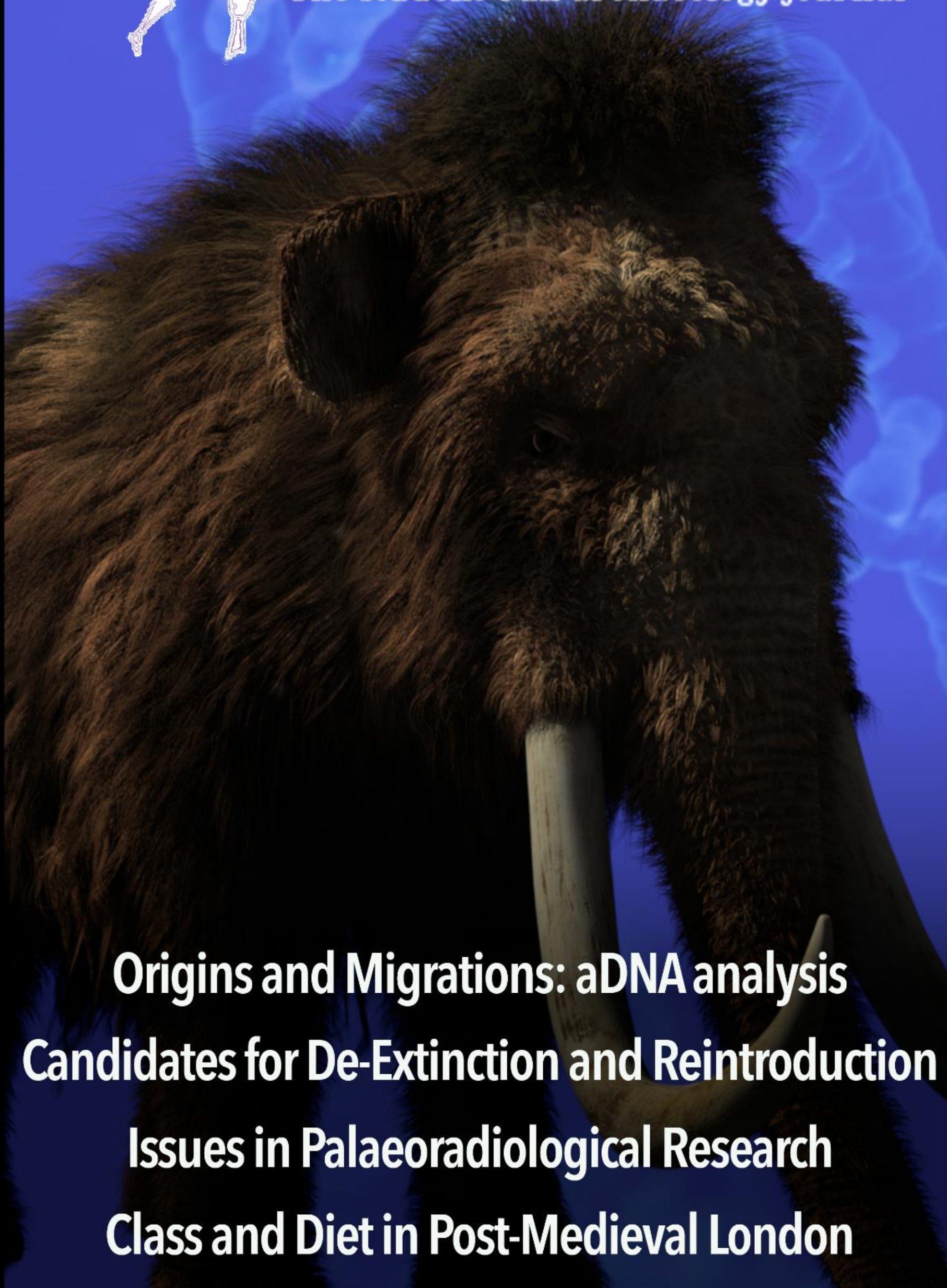

Origins and Migrations: aDNA analysis

Candidates for De-Extinction and Reintroduction

Issues in Palaeoradiological Research

Class and Diet in Post-Medieval London

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Issue 55

Table of Contents

The Post Hole

Editorial: Uncertain Times

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It is with great pleasure that I write my first editorial for *The Post Hole*, despite Issue 55 being published in both extraordinary and unprecedented times. I would like to extend my best wishes to our readers and contributors. Furthermore, I am aware that this is a period of uncertainty, and I would like to offer my regards to the dedicated members of *The Post Hole* team; without whom Issue 55 could not have been possible. In this academic year, the team at *The Post Hole* has moved from strength to strength. A highlight of which has been *Pints and Postholes,* made possible through the hard work of Bryony Moss and the ArchSoc team at the University of York. I would also like to extend a huge thank you to the authors who feature in this Issue. Their work has provided the team and I with an extensive range of topics, many of which I would otherwise not have had the pleasure to encounter.

Ancient DNA (aDNA) is endlessly fascinating. The study of aDNA is extensive, and therefore I shall only provide a brief discussion within this editorial. aDNA has allowed the transformation of archaeological narratives, which has now developed into a 'revolutionary scientific field in the study of human beings' (Lalueza-Fox 2017, 1). The discipline has transformed since the initial studies of Higuchi *et al.* (1984) and Pääbo (1985). Through various technological changes, more specific questions can now be asked. For example, some studies have suggested that Neanderthal variants have influenced modern human phenotypic traits. These traits include the expression of skin colour, the risk of nicotine addiction, the presence of red hair, and immunological qualities (Simonti *et al.* 2016, 737; Akst 2019, 1, Dannemann, Andrés and Kelso 2016, 22; Lalueza-Fox 2007, 1453).

Furthermore, when many Europeans and Asians have ~1.5-4% Neanderthal DNA from the admixture ~50,000 years ago (Simonti *et al.* 2016, 737), aDNA has allowed us to question what it truly means to be human (Papagianni and Morse 2013, 9). However, many issues arise when using aDNA to understand the past such as: the high risk of degradation in warmer environments (e.g. Africa), contamination, and the minor destruction of archaeological material (Mitchell, Willerslev and Hansen 2005, 265). Therefore, my editor's

Choice for this issue is the work of Alfie Talks titled *Origins and migrations: how aDNA analysis is not necessarily the answer.* Talks provides an eloquent review of the frequent issues that can be encountered in studying aDNA, moving from the issue of gene flow and mtDNA to an engaging discussion on the rate of mutations in the Y chromosome. If we are to fully understand the limitations of our methods, scientific reviews such as this are crucial within the field of archaeology.

Issue 55 of *The Post Hole* displays a wide array of archaeological interest. Ian Noble (University of York) conducts a statistical analysis, providing an insight into the relationship between disease and socio-economic status; Megan Schlanker (University of York), presents a critical review of the variety of archaeological techniques utilised by Danish Museums, followed by a discussion of the issues within Palaeoradiological research; James Osborne (University of York) analyses the realities of reintroduction of extinct species to the UK; and Charley Porter investigates the impact of social status and health within the context of the industrial revolution.

Issue 55 has been a pleasure to compile, and we are now accepting submissions for Issue 56. *The Post Hole* is the student-run academic journal from the Department of Archaeology at University of York. However, it is always a pleasure to accept submissions from both within and outside of our institution. If you would like to submit an article, please send your work to submissions@theposthole.org in a Microsoft Word Document. For any guidance on the submission process, please visit https://www.theposthole.org/contribute or email editor@theposthole.org. You can also follow our social media accounts (@theposthole) on twitter, (theposthole) on Instagram, and (The Post Hole) on Facebook.

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Danish Museums and the Dead

Megan Schlanker

Introduction

When museums transform the dead into exhibitions, how do they choose to represent them? In some cases, the dead are anonymous - evidence of a burial culture rather than an individual (see figure 12). In others, the information gathered from a burial or deposition is used to create a detailed reconstruction of the individual concerned. In 2014, the British Museum held an exhibition named 'Ancient Lives; New Discoveries,' focused on scientific advancements allowing archaeologists to further explore the lives of mummified individuals from ancient Egypt. In the accompanying book, Taylor and Antoine (2014, 7) write that these advancements allow the modern viewer to 'draw closer to these long dead individuals and to recognise them as fellow human beings.' This exhibition raises questions regarding what information can realistically be interpreted about the lives (and deaths) of individuals from their remains, and how museums approach the lives of the people who have become their exhibits.

This report explores how Danish museums portray the dead, and the extent to which we can recreate the lives of individuals, using funerary sources. Information for this report was gathered mainly from museums and supplemented with additional research. A range of methods of recreating the lives of past people are explored; focusing on isotopic analysis, determination of cause of death, identification of chronic illness, determination of sex and age, reconstructions of clothing, facial reconstructions, and romanticisation in the exhibits.

Stable Isotope Analysis

Stable isotope analysis is a relatively new discipline used to gather information about past lives. Isotopic ratios of strontium vary based on geology and oxygen ratios vary based on climate and rainfall (Mays 201, 265). Both are absorbed into human tissue via food and water, meaning isotopic ratios of strontium and oxygen can be used to estimate the geographical regions an individual occupied at different stages in their life (Mays 2010, 265). Generally, archaeologists use dental enamel to gather information on where an individual spent their childhood - if the local isotopic ratios of strontium and oxygen do not match those of the dental enamel, it is likely that the individual spent their childhood elsewhere (Mays 2010, 288). It is also possible to establish whether an individual traveled in the period preceding their death, through analysis of hair and fingernails, if these are present (Frei *et al.* 2015, 4). Limited preservation of both hard and soft tissue of the same individual means that it is rarely possible to trace their movements in detail. However, some cases lend themselves well to this form of analysis.

The remains of the Egtved girl, a Bronze Age individual with well preserved hair and other tissues, are on display in the National Museum of Denmark in Copenhagen (see Figure 1). There are two captions above her coffin, illustrating the finds of 'new research,' undertaken by Karin Margarita Frei and her team as part of a project tracing the movements of Bronze Age women (Frei *et al.* 2015). Isotopic analysis of the Egtved girl's first molar enamel revealed she did not grow up in the region where she was buried (Frei *et a*l. 2015, 5). The museum display posits that her childhood home may have been the Black Forest in Germany, 800 kilometres from Egtved, Denmark (Frei *et al.* 2015, 5). Analysis of her hair and nails suggests that she lived in Denmark until about a year before death and, in the final year of her life, she appears to have travelled to her childhood home twice before returning to Denmark where she died (Frei *et al.* 2015, 4).

Figure 1: The Egtved Girl, National Museum of Denmark (Photograph: M. Schlanker 2018)

Further isotopic research is presented in Danish museums, for example the analysis of a tooth from the Haraldskær woman has revealed that she was probably born in northern Jutland, and hair analysis suggests that she lived near Haraldskær for some time before her death (Mosens Kraft 2018). According to information on Iron Age bog bodies, presented by Museum Silkeborg (Tollund Man and Elling Woman, 2018), further strontium analysis of the Haraldskær woman's hair revealed she had travelled to Germany or Scotland shortly before death.

Stable isotope analysis can also establish the diets of past communities and individuals. Stable isotope ratios of carbon and nitrogen vary in different kinds of foodstuffs, and these isotopic variations are absorbed into the tissues of the consumer (Mays 2010, 265). Frei et al's. (2015, 4) isotopic analysis of the Egtved girl revealed a terrestrial diet, and microscopic observations of her hair suggest that she may have experienced periods of significantly reduced dietary protein.

Cause of Death

Cause of death can be difficult to determine, as most injuries do not leave observable marks on the skeleton, and remains often show no evidence of lethal injury, as most deaths result from illness or natural causes (Mays 2010, 236). In some cases, the cause of death is obvious. For example, the Vedbæk woman (see figure 2) appears to have suffered a heavy blow to the head, identifiable by the damage to her skull (Danish Prehistory, 2018). It is apparent that this wound began to heal, indicating she lived with this injury for some time (Nielsen 2016, 30).

Figure 2: The Vedbæk woman's injuries, National Museum of Denmark (Photograph: M. Schlanker 2018)

Cause of death may be easier to establish in cases where other tissues are preserved, for example in the cases of bog bodies and other mummies. The rope tied around the Tollund man's neck is widely accepted to have killed him, evidenced by marks still present on his neck and the swollen tongue revealed by CT scans (see figure 3), and the lack of cervical spine damage shows he was not dropped from a height, shedding further light on the manner of death (Fischer 2012, 46;108; Tollund Man and Elling Woman, 2018). Conversely, the death of the Haraldskær woman (figure 4), another Danish bog body, is a subject of some controversy. While some sources, including Kulturemuseet Spinderihallerne (Mosens Kraft, 2018), advertise strangulation as her cause of death, there is some speculation as to whether she was buried alive, as pegs were used to pin her body down (Parker Pearson 1986, 18; Sanders 2009, 91).

Figure 3: X-Ray image of the Tollund man (Fischer 2012,47)

Figure 4: The Haraldskær Woman, Kulturmuseet Spinderihallerne, Vejle

(Photograph: M. Schlanker 2018)

Chronic Illness

In the case of some chronic illnesses, identifiable marks are left on the skeleton. One such disease is osteoarthritis; one of the two most common joint diseases observed in archaeological remains (Mays 2010, 186). Investigation of the skeleton of the elderly man from Borum Eshøj (figure 5) showed he experienced a severe case of arthritis (Nielsen 2016, 96). While it is more complex to observe the skeletal remains of bodies where other tissues are preserved, medical imaging has also revealed evidence of osteoarthritis in the Haraldskær woman's thumb. Kulturemuseet Spinderihallerne (*Mosens Kraft,* 2018) presents this information alongside her body. Is this an attempt to astound the visitor with the level of detail that can be interpreted, or is it intended to encourage a connection between the visitors and the exhibit? As Simon Mays (2010, 198) points out: 'when examining a carious tooth or an arthritic bone we are able to empathise, and indeed sympathise, with the pain and discomfort the individual must have endured.'

Figure 5: The Old Man from Borum Eshøj, Moesgaard Museum, Aarhus

(Photograph: M. Schlanker 2018)

Aging and Sexing

A variety of techniques may be employed to determine the biological age of an individual from their skeletal remains, including observation of the pubic symphyseal morphology, and dental wear analysis (Mays 2010, 61-76). Mature skeletons are more difficult to accurately age, due to rate variations of aging and degeneration (Mays 2010, 59). Pubic symphysis analysis results in widely estimated age ranges which overlap significantly with one another, and studies into aging techniques on mature remains have shown to have a low degrees of accuracy (Brooks and Suchey 1990, 233 Mays 2010, 68-70).

Immature remains can be aged with a greater accuracy. As some aspects of growth and development are influenced by disease and malnutrition, dental development - which is less affected by these factors - is the most commonly used method for aging juvenile skeletal remains and has a high degree of accuracy (Mays 2010, 52-54). In cases where aging using dentition is not possible , observation of epiphyseal bone fusion is used, although this method is more subject to extraneous variables and less reliable for determining age (Mays 2010, 55-56).

The sexing of mature skeletal remains has a high degree of accuracy when both the skull and the pelvis are present (Meindl *et al.* 1985; Henderson 1989, 79). However, as sexual dimorphism in skeletons results from hormonal differences, it is more difficult to determine sex from prepubescent remains (Mays 2010, 48). The sex of prepubescent skeletons can be determined using teeth, which tend to show some elements of dimorphism, but this is much less reliable than methods used for adult skeletons (Mays 2010, 48; Henderson 1989, 77).

In the case of the Vedbæck child, sex was determined using another method. The child was buried with two flint knives, in an arrangement typical of adult male burials from this period, leading to the interpretation that the child was male (*Danish Prehistory,* 2018; Nielsen 2016, 30). Sexing individuals based on grave goods is problematic, and there is debate as to which grave goods can be reliably used as gender indicators (Wicker 2012, 248). Bearing in mind the cultural and social nature of gender and the biological nature of sex, Henderson (1989, 81-82) urges caution when using grave goods to sex a burial. Museums appear to utilise aging and sexing to build detailed recreations of individuals and their lives, regardless of potential inaccuracies.

Clothing

Since the 1950s, archaeologists have been involved in recreating the clothing of individuals found in Danish Bronze Age graves, including the Egtved girl and the family from Borum Eshøj (Bröndsted 1950). These costumes remain the subject of a substantial display at the National Museum of Denmark (*Danish Prehistory,* 2018). The Egtved girl, in particular, has received a lot of attention for her costume: a corded skirt that was new to archaeologists excavating her burial in 1920 (Bröndsted 1950, 17). A replica of the Egtved girl's costume is displayed in the National Museum, and an information board at Sagnlandet Lejre posits that this skirt may indicate she was a priestess (*The Dancing Laberynth,* 2018). Her disk-shaped belt plate, despite being common in female burials of this period, has also been interpreted as an indicator of priestesshood (Frei *et al.* 2015, 3).

Facial Reconstructions

Almost inarguably more compelling than being presented with a long dead individual's clothing is being presented with their face. Karin Sanders (2009, 197) points out, 'the face is at the very core of our understanding of "identity", "personhood", "personality" and, not least, our "humanity."' Museum Silkeborg's interactive display (*Tollund Man and Elling Woman,* 2018)

Figure 6: The Egtved Girl's clothes (reconstruction), National Museum of Denmark

(Photograph: M. Schlanker 2018)

presents visitors with a blinking digital reconstruction of the Tollund man (see figure 7). Facial reconstructions are considered by many to be an important part of recreating the past, and Prag and Neave (1997, 219) even argue: 'if there is any value at all in the study of history and of one's past, then the reconstructions should be seen as an important element in completing the story.'

Figure 7: Digital facial reconstruction of the Tollund man, Silkeborg Museum

(Photograph: M. Schlanker 2018)

Facial reconstruction has been eagerly adopted by Moesgaard Museum, who feature several reconstructions in their collection (*People of the Sun: 1700-500 BCE,* 2018; *Go on Voyage with the Vikings: AD 800-1066,* 2018; *The First Immigrants - Stone Age exhibition,* 2018). These figures are incredibly realistic, perhaps unsettlingly so, as Prag and Neave (1997, 223) point out is often the case with such lifelike models. The family from Borum Eshøj (figure 9) are presented in a scene portraying the old man's death, and the Tybrind girl (figure 8) is shown collecting oysters for her dinner. These are dynamic portraits of individuals from the past and, crucially, they do not look particularly different from the museum's many guests. The museum establishes that these reconstructions cannot be one hundred percent accurate, but the effect of these lifelike, lifesize figurines, gives the impression that the visitor is coming 'face to face' with the past.

Reconstructions allow visitors to form a more personal connection with museum exhibits and the people they represent. This can provoke empathy, even through thousands of years of human history. The Tybrind girl died aged between the ages of 14 and 16. Despite her death occurring in the Stone Age, the curators create a sense of mourning around her, and the young baby buried with her. Denmark has one of the lowest infant mortality rates in Europe, and such young deaths would be particularly shocking, but not unimaginable, to a local audience. The caption underneath her skeleton reads: 'she is still a child [...] Loss and hardship are part of daily life in a time of short life expectancy and high child mortality' (MacDorman *et al.* 2014;

Figure 8: Reconstruction of the Tybrind girl, Moesgaard Museum

(Photograph: M. Schlanker 2018)

The First Immigrants, 2018). A similar sense of tragedy is also seen in the information regarding the Vedbæk child which reads: 'amulet beads [...] failed to protect him, and his death shattered the family's hopes for a great new hunter' (*Danish Prehistory* 2018). Their young age becomes part of the tragic story of lives lost too soon, which may reflect modern Western attitudes to death. As Sayer writes (2010, 483): 'the idea that the young can be cheated of life by death suggests that they were *owed* a life course.'

Figure 9: The Woman and Old Man from Borum Eshoj - Reconstructions

Moesgaard Museum, Aarhus (Photograph: M. Schlanker 2018)

Romanticism and Mistaken Identity

There is a clear element of romanticisation in the way the information about the Tybrind girl and the Vedbæk child is portrayed by their respective museums. Romanticisation also played a major part in the mistaken identity of the Haraldskær woman (figure 10). On first discovery, the Haraldskær woman was believed to be Queen Gunhild, a Norwegian queen supposedly drowned in a bog around 970 CE (Sanders 2009, 92). More recent investigation revealed that the body dated much earlier to the Iron Age (*Mosens Kraft,* 2018). However, Sanders (2009, 94) argues that without the dramatisation of the Haraldskær woman's life, she would have been disregarded. We may owe her continued preservation to her embellished history.

Figure 10: The Haraldskær woman and 'Queen Gunhild', Kulturmuseet Spinderihallerne

(Photograph: M. Schlanker 2018)

Moesgaard: A Voyage with the Vikings

Moesgaard Museum cultivates a personal relationship between one of their exhibits and the visitor in a memorable way. Their Viking exhibit (800-1066 CE) allows visitors to follow the stories of eight inhabitants of Viking Aarhus. Most of these individuals are entirely fictional, however one is particularly notable in the context of this report. The Randlev woman (figure 11), who expresses distress over her husband's long voyages and her own tooth loss, is heavily implied to be the skeleton on display of the same name. By following the Randlev woman's story, visitors see her as a person with distasteful views. For example, her frequent advocacy of slavery. She also displays more relatable aspects, as a middle aged woman concerned about losing the respect of her community as she ages, and also helps visitors to better understand the role of women in Viking society (*Go on a Voyage with the Vikings: AD*

600-1066, 2018). While a great deal of the Randlev woman's story is fabricated, it remains a memorable way of presenting the dead and engaging with the past.

Figure 11: The Randlev woman, Moesgaard Museum (Photograph: M. Schlanker 2018)

The Anonymous Dead

It is worth mentioning that not all human remains exhibited by museums are allowed such elaborate personalities, nor are they scientifically examined or presented alongside research material. The anonymous dead, displayed as exhibits rather than people, made up a significant portion of the museum exhibits investigated, despite controversy in other European countries regarding the ethics of display (See figure 12; Sayer 2010 482-485). According to Jones and Whitaker (2013, 652), prehistoric remains in particular are often considered as 'anatomical objects rather than the remains of people-now-dead,' and this anonymity serves to 'protect both the corpses and the onlookers'. Along this line of thinking, Prag and Neave (1997, 219) ask: 'is the making of a reconstruction a prying into a person's private life, almost a form of voyeurism?' There is an idea that reconstructing the past lives and presenting these reconstructions could, in fact, be negative. However, Sayer (2010, 488)

Figure 12: Reconstruction of a woman's grave, Moesgaard Museum (Photograph: M. Schlanker 2018)

argues ‘the public do not need to be protected from the ancient dead,’ and that the display of human remains allows museum patrons to better understand the past.

Conclusion

A variety of techniques can be used to interpret information from an individual’s burial or deposition. These techniques are utilised by Danish museums to recreate the stories of past people. Using various methods, we can better understand individual mobility and analyse an individual’s diet in various ways. Forensic-style analysis can reveal cause of death, but only in cases where damage is left on preserved remains. Damage can also be seen on remains through chronic illness, such as arthritis, which may be included in museum displays in order to create empathy for the individual on display. Techniques used to sex remains and estimate age are commonly utilised by museums, despite the difficulties in accurately determining age in mature remains or sex in prepubescent remains.

While much can be interpreted or estimated using these methods, we cannot comprehensively determine an individual’s story from their remains. Institutions such as the National Museum of Denmark and Moesgaard Museum utilise facial reconstruction and reconstructions of clothing to encourage a more personal connection between visitor and exhibit. Both of these museums also attempt to create sympathy for their exhibits, and museums may embellish information to form a connection between the visitor and the exhibit. Despite this, not all remains are treated equally, and many of the dead presented in Danish museums remain anonymous and lack narrative. Ethical concerns have been raised regarding the display of human remains, and opinions are divided on which path is best to take. However, there is value in the display of human remains and particularly in reconstructing the lives of past individuals, demonstrated by the effect that this has on visitors and their relationship to the past.

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Current Issues in Paleoradiological Research

Megan Schlanker

Introduction

The term 'paleoradiology', coined by Notman, refers to the study of bioarchaeological materials using such medical imaging techniques (Chhem and Brothwell 2008,1). This paper provides an in depth account of the issues present in current paleoradiological research. Several commonly occurring issues have been identified, namely regarding sample sizes, anatomical positioning of human remains, poor image quality produced by thick CT slices, conservation, issues associated with bog bodies, and concerns with equipment, and issues of interpretation.

Sample sizes

A great deal of paleoradiological research is conducted with a case study approach (eg. Asingh and Lynnerup 2007; Gostner *et al* 2011; Panzer *et al* 2017; etc.), which has been widely criticised. Elliott (2018,6) acknowledges that some researchers have put effort into increasing their sample sizes, but the majority of research still focuses on case studies. Nelson and Wade (2015,942) are extremely critical of this approach, describing it as 'highly limiting', noting that such research can make it difficult to identify regional, temporal, and social trends.

Some issues with the case study method, as presented by Hodkinson and Hodkinson (2001,10-11), are that the results are not generalisable, and are easily dismissable by those who disagree with the results. For researchers like Wade and Nelson (2013,4198), who stress the value of avoiding 'pan-Egyptian stereotypes', it is obvious that these are serious issues. Their finding that transnasal excerebration was much less common in Egyptian mummification than suggested by classical depictions (Nelson and Wade 2015,943), would not have been as dramatic a discovery if it had been based on an individual mummification, examined using a case study method. Using a larger and more representative sample ensures that findings are more widely generalisable and harder to dismiss.

Anatomical positioning

CT scanners are designed for the medical investigation of living human beings, who are typically able to move themselves into a position allowing them to fit inside the scanner, which is obviously not the case when dealing with human remains. A common issue occurring with investigations of bog bodies, mummies, and other examples of archaeological human remains, such as the Pompeii casts (Lazer 2017,9), is awkward anatomical positioning which makes it difficult for remains to be placed into a CT scanner.

For instance, Grauballe Man's right elbow did not fit into the scan field of the CT scanner, so was not recorded in the CT image (Asingh and Lynnerup 2007,95). The positioning of the Tyrolean Iceman's left arm meant the body had to be placed into the scanner once head first and again feet first, in order to scan the entire body (Gostner et al 2011,3426). The positioning of the body may also have caused the ulnae to appear shorter on CT scans (Gostner et al 2011,3429). In the case of the Llullaillaco mummies, scan techniques had to be adapted to the anatomic position of each mummy (Previgliano *et al* 2003,1474). As seen in the cases of the Tyrolean Iceman and the Llullaillaco mummies, adaptations can be made to overcome anatomical issues, although these adaptations represent a compromise rather than a solution to these issues.

CT slice thickness

The thickness of CT 'slices', the intervals between each x-ray, hugely impacts image quality, and thicker CT slices can lead to structure misinterpretation (Lynnerup 2009,366). Modern CT scanners can achieve slices of less than 1mm thick, compared to the several millimetre slice thickness of earlier scanners (Lynnerup 2009,366). This means that modern CT images are much higher quality than their predecessors, generally speaking. However, scans of the Llullaillaco mummies conducted by Previgliano et al (2003,1474) have a slice thickness of 5mm, obtained at 5mm intervals. CT working sessions were limited to 20 minutes to prevent thawing and to conserve the bodies, however this produces an impression of the structure of the bodies with a limited accuracy.

Figure 1. The Llullaillaco Maiden

(Ceruti 2015, 7)

Issues associated with bog bodies

There are several challenges presented by bog bodies when using medical imaging. Due to the taphonomic influences of the bog environment, calcium content of bone is reduced, causing the tissue to become softer and less dense (Lynnerup 2010,444). Soft tissues, such as skin and tendons, seem to increase in density within the bog environment (Asingh and Lynnerup 2007,99; Lynnerup 2010,445). These factors combine to result in poor visualisation of the internal structures of bog bodies when the clinical range of Hounsfield Units are applied to the scans (Lynnerup 2009,367; Lynnerup 2010,444). In the case of Grauballe Man, the high radiodensity of the soft tissues and the low radiodensity of the skeletal tissues meant the structures were difficult to differentiate, and the CT scans had to be carefully manually segmented using MIMICS software (Asingh and Lynnerup 2007,114). One of the femurs of Lindow II shows considerable loss of bone density due to the acidity of the peat bog, and the Huldremose bog body also displays poor bone density (Chhem and Brothwell 2008,67-68).

Figure 2. The Huldremose Woman, National Museum of Denmark (Photograph, M. Schlanker 2018)

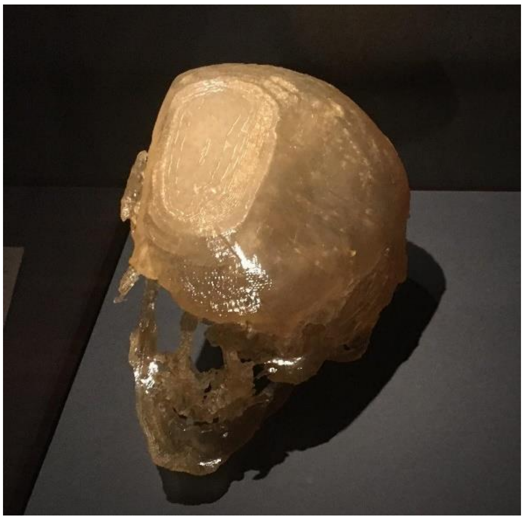

Figure 3. Grauballe Man's skull replicated from CT scans, Mosegaard Museum (Photograph, M. Schlanker 2018)

Another issue presented by bog bodies is the methods of 'conservation' used soon after the bodies were discovered often make it difficult to form any meaningful observations on more recent scans. When the body of Grauballe Man was reappraised using x-ray and CT in the early 2000s, no signs of disease was found but the filling material inserted into the body during the 1950s conservation process could have obscured any fractures or signs of disease (Asingh and Lynnerup 2007,109). This means the findings of the reappraisal are not as reliable, as there may have been evidence of damage or pathologies that were simply obscured. There were also no remains of internal organs found in the abdomen, and what appears to be blackboard erasers in the chest cavity (Asingh and Lynnerup 2007,118-119). This of course means the internal organs could not be investigated paleoradiologically as part of the body. Methods of conserving bog bodies in the 1950s also frequently involved dehydration, which makes the use of MRI more of a challenge when investigating the remains (Elliott 2018,9; Shin *et al* 2010,329).

James Elliott (2018,9) believes bog bodies are not ideal candidates for paleoradiology, namely due to a great degree of post-mortem disfiguration (both before and after excavation), and the de-mineralisation of bone. I am inclined to disagree with Elliott, given that research by Villa and Lynnerup (2012,127) has already provided a set of Hounsfield Unit ranges for tissues mummified under peat bog conditions, with the aim that the knowledge of typical HU ranges will help to prevent the misinterpretation of CT images and improve their clarity without extensive manual post-processing.

Issues associated with equipment and interpretation

There are issues associated with the use of hospital equipment for paleoradiology. Radiologists used to working with living patients are not trained in dealing with bioarchaeological materials, and there is the issue of taking resources away from medical cases (Chhem and Brothwell 2008,15). Anthropology labs are unlikely to have as advanced equipment, including CT scanners, compared with hospitals, and anthropology lab equipment is often designed for smaller specimens and therefore cannot be used to investigate mummies or large bones (Chhem and Brothwell 2008,15).

Conclusion

A range of issues are prominent within current paleoradiological research. These include issues relating to the case study approach, such as results not being generalisable and therefore easy to dismiss, although researchers such as Nelson and Wade (2015) have put concerted effort into using larger sample sizes. The anatomical positioning of human remains can make it impossible for the body to be examined using CT and can also result in distorted radiographic images, and issues presented by using thicker CT 'slices' when scanning, usually to preserve the integrity of frozen remains, resulting in limited anatomical accuracy. Researchers must also deal with conversational concerns and liaise with the museums and sites at which the remains are housed, which can slow, limit, or prevent paleoradiological investigations. Another major issue is advanced equipment, such as CT scanners, which are only available at hospitals.

Bog bodies present several unique issues in the field of paleoradiological research, leading some, including Elliott (2018, 9) to argue they are not ideal candidates for this form of investigation. Early conservation techniques, involving filling material and rehydration, make radiographic reappraisal and the use of MRI more challenging, and changes in bone density and soft tissues lead to poor visualisation. However, Villa and Lynnerup (2012) have established a range of Hounsfield Units for bog bodies, aiding anatomical visualisation.

Recent work appears to be reducing the impact of paleoradiological issues. Villa and Lynnerup's (2012) HU ranges allow for clearer radiographic images and less ambiguity in interpretation, Chhem and Brothwell (2008) call for more interaction between radiographers and archaeologists, and databases such as Nelson and Wade's (2015) I.M.P.A.C.T. reduce the negative impact of the case study method. While there definite issues remain, these advancements mark positive developments in paleoradiology.

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Investigating the impact of social status on the health of individuals during the Industrial Revolution (1760-1840), England: An osteoarchaeological perspective.

Charley Porter

1.0 Introduction

Post-medieval England (1700-1850) demonstrated a vast amount of change in society; the urbanisation of cities that came with the Industrial Revolution (1760-1840) altered the landscape and health of the populations considerably. Although arguably a noticeable change was the rise of middle and upper classes, which created a larger divergence between the poor and the wealthy (Mays *et al*. 2008, 86).

The conditions for the working classes tend to be reflected upon with negative connotations; for the urban disadvantaged, work was often in industrialised factories; the hours were long, and the workers were only allowed rest for one day a week (Gowland 2018, 153). Life for the rural poor, in contrast, is suggested to have had a relatively improved quality of life attributed to the lack of pollution and overcrowding, although laborious work was equally as intense for both sexes and all ages as urban life (Gowland *et al*. 2018, 27). The middle and upper classes enjoyed a more leisurely life, with the only indicators of trauma often being reflective of social sport, rather than laborious work (Cunningham 2016, 12).

The significance of investigating post-medieval burials is that the identity of the individuals can often be ascertained with reference to direct historical accounts and grave-markers, which allows a direct comparison of social status and health, as the status can be inferred more directly. Evidently, the transition to urbanisation and industrialisation is likely to have affected the health and diet of different class populations. Three cemeteries from urban London of equal size will be assessed; two of which hold a more affluent status (Chelsea Old Church and St Marylebone), while the third example (St Brides Lower) represents the lower classes. To explore the extent that social status was an exclusive factor in influencing health and diet, a fourth cemetery from a rural environment (Fewston) will be discussed. See Figure 1 for a map of the context.

Figure 1: Map of cemeteries studied in this essay. Porter, C, "Map of Cemeteries Used" [JPG map], Scale 1:100000, GB Overview [geospatial data], Updated: 2019, Ordnance Survey (GB), Using: EDINA Digimap Ordnance Survey Service, <http://digimap.edina.ac.uk/>, Created: October 2019.

2.0 Health and Diet

Health and diet are not mutually exclusive; it is widely asserted that a poor diet can result in a diminished immune system which will lower the chances of successfully combatting infections and diseases, and contributes to the development of chronic skeletal defects (Roberts and Manchester 2010, 223). This section will explore how far social affiliation negatively impacted the health and diet of individuals from contrasting social classes within urban and rural England by assessing the skeletal data for four possible status-impacted conditions.

2.1 Working Class

The consequences of being born into a poor socio-economic family were rooted during this period. Women and children were more likely to be involved in non-domestic labour, which comprised of long hours away from home, often in factories with little exposure to sunlight (Roberts and Manchester 2010, 238). Taking women out of the household and inserting them into manual work also had a negative effect on familial health pertaining to diet; commercially produced meals were made available but were deficient in essential vitamins (Horrell and Oxley 2012a, 1359).

The human body cannot synthesise vitamins alone, therefore, skeletal and dental development must be maintained by a balanced diet (Fitzpatrick *et al*. 2012, 395). Consequential to the health of poorer households, food consumption was largely based on regional availability and household earnings; a consequence of bad harvests lead to price inflation, lack of time and common land to grow fresh produce, in addition to the decline of livestock due to the high prices of feeds (Horrell and Oxley 2012a, 1359-1364).

Vitamin C is found in fresh fruit, vegetables, and marine fish. Chronic lack of Vitamin C is more prevalent in the poorer socio-economic individuals within the sample (Figure 2). This dietary deficiency manifests in cases of scurvy, which is caused by a prolonged Vitamin C depletion and is identified skeletally by the presence of ossification and porosity (Figure 3) (Newman and Gowland 2016, 220).

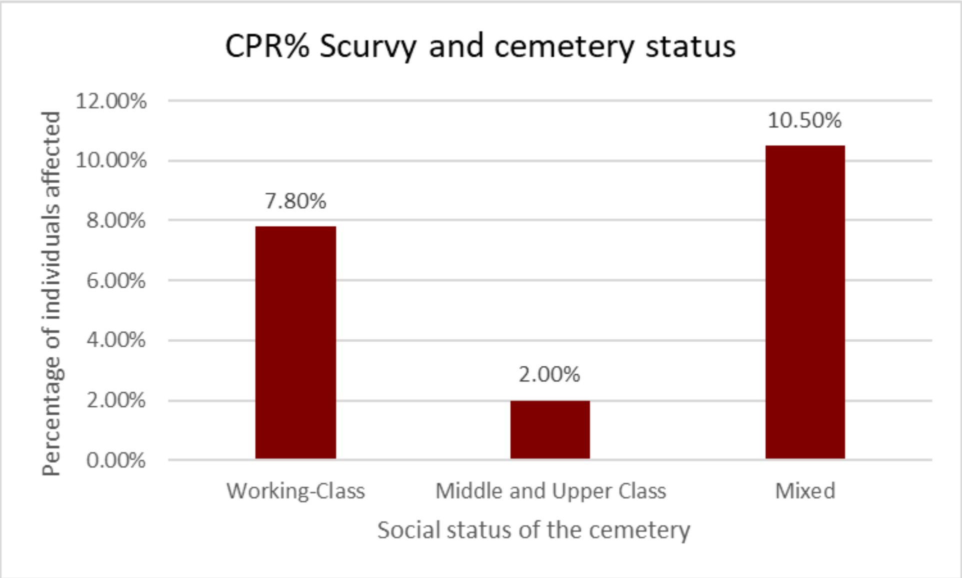


Figure 2: Crude prevalence rates for scurvy. Authors own, references provided in Appendix I.

Figure 3: Scurvy- porotic hyperostosis of the frontal bone. St Brides Lower. Museum of London 2019.Accessed 18.10.19.

In contrast, Vitamin D deficiency is predominantly caused by a lack of exposure to ultraviolet rays, which is essential for the mineralisation of osteoid and cartilage to maintain bone density (Roberts and Manchester 2010, 237). In children, a sufficient lack of Vitamin D during the vulnerable stages of development, can disrupt bone mineralisation in the growth plates and lead to rickets, and subsequent deformation of the weight-bearing limbs (Roberts and Manchester 2010, 237).

Children are more susceptible to developing rickets due to their weakened immune system and the physiological demands of skeletal development; whereas adults are more likely to develop osteomalacia, which occurs as a result of delayed mineralisation of osteoid in cortical and spongy bone (Newman and Gowland 2016, 220; Roberts and Manchester 2010, 237). While rickets tends to be a condition of infancy (Mays *et al*. 2006, 362), it can be argued that the post-medieval children often developed rickets during later childhood years (Figure 4 and 5). The direct influence can be attributed to the reliance of many families on the wages of their young children; with the work comprising of long hours in factories with sparse exposure to sunlight, in addition to non-nutritious meals and the adverse mental state caused by poor working conditions (Roberts and Manchester 2010, 238).

Figure 4: Residual rickets, marked bowing of femur and tibia from St Brides Lower. Museum of London 2019, extracted 18.10.19.

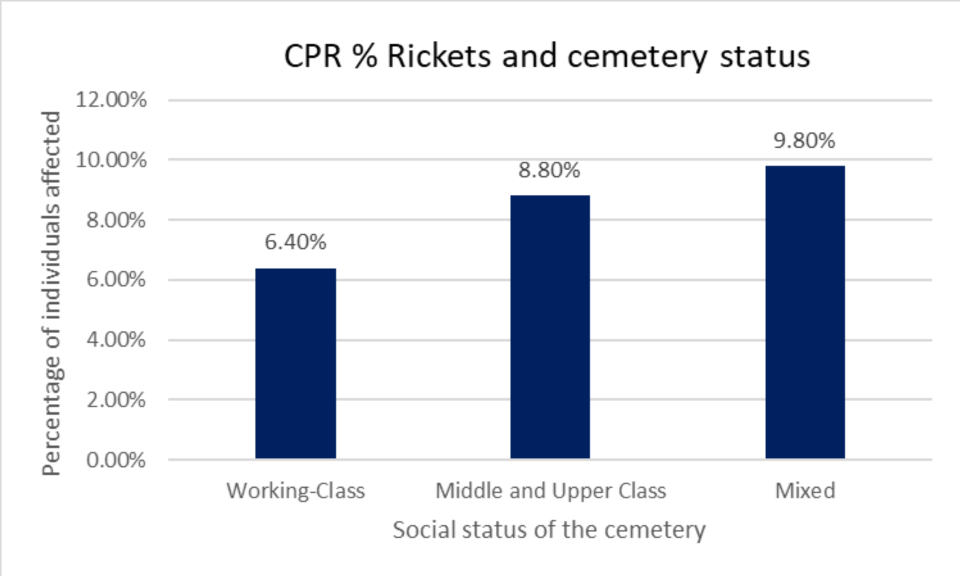


Figure 5: Crude prevalence rates for rickets. Authors own, table populated with results referenced in Appendix I.

2.2 Middle and Upper Classes

It is assumed that the more affluent members of society would display less evidence for dietary deficiencies, and would instead show a positive correlation for dietary excess due to their accessibility of expensive food sources (Roberts and Cox 2003, 310). However, both the lower and higher-class individuals from this sample shared high prevalence rates for Vitamin D deficiency rickets.

It can be suggested that the individuals affected from the high-status cemeteries were less likely to develop rickets from deplorable working conditions, and were more likely to develop rickets at a younger age attributed to contemporary parenting practices (Roberts and Manchester 2010, 239). For high-class women, breastfeeding declined as shop-bought formula was readily available, albeit deficient in vitamins and proteins (Roberts and Manchester 2010, 239; Stevens *et al*. 2009, 34-37). Therefore, although poorer children developed rickets as a result of poverty, the practices of the socially elite did not always constitute a healthier society.

One of the effects of urbanisation in England was the efficient transport infrastructure, which enabled food to be shipped around the country for those who could afford it (Bleasdale *et al.*

2019, 6161). As a high calorific intake for this period is representative of wealth and therefore high-status, a direct consequence of a high-status lifestyle on health can be identified skeletally by the presence of diffuse idiopathic skeletal hyperostosis (DISH). The direct aetiology of DISH is complex, although its predominant associations have been linked to obesity and diabetes mellitus (Roberts and Cox 2003, 311; Bombak 2012). DISH manifests on the spine and is identified by new bone formation in a candle-wax like appearance on the right side of the vertebra, causing fusion (Bombak 2012; Roberts 2018).

In this sample, the higher-class individuals displayed a prevalence rate of DISH which was double the individuals affected from the lower-class cemetery (Figure 6 and 7). Therefore, the increasing range of food resources that were available to the higher classes, particularly animal proteins, can be suggested to have negatively impacted health.

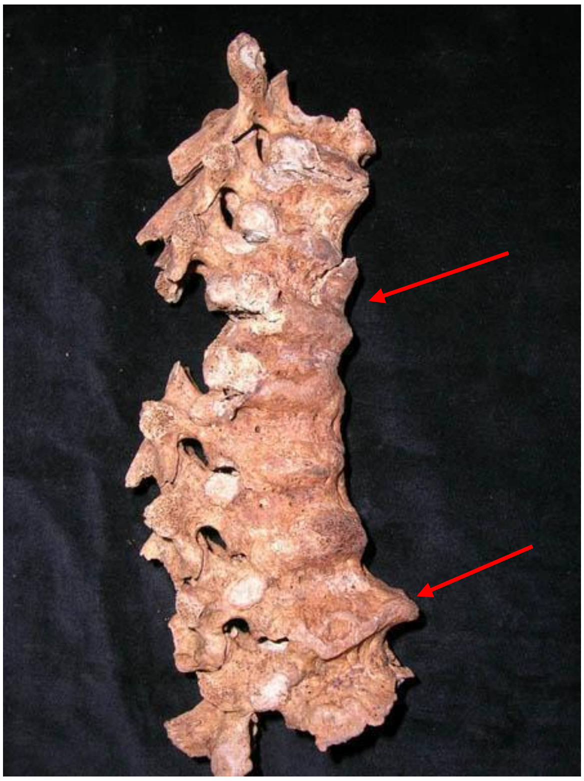


Figure 6: DISH, right lateral view- Chelsea Old Church. Museum of London 2019, extracted 18.10.19.

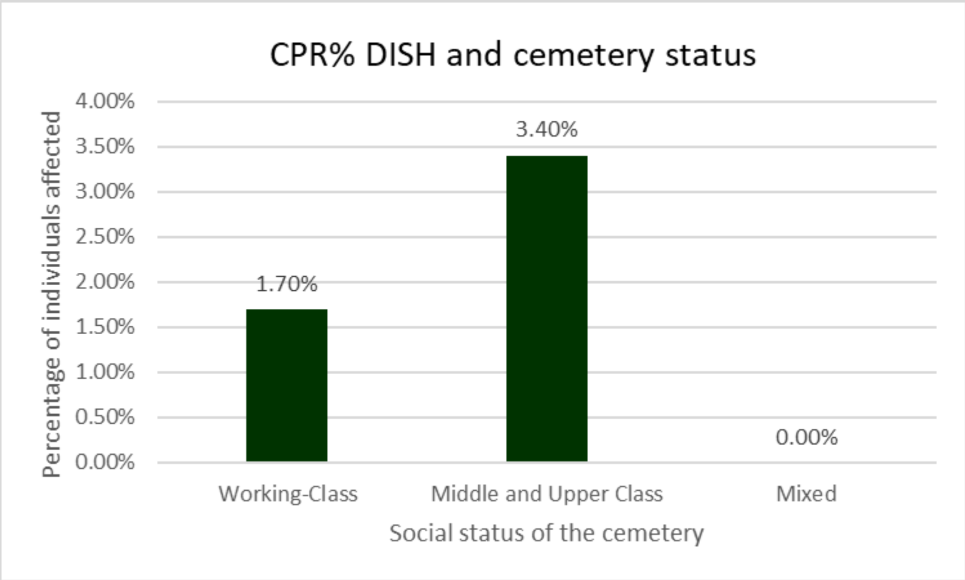


Figure 7: Crude prevalence rates for DISH. Authors own, table populated with results referenced in Appendix I.

A final example of the consequences of an excessive diet, which is often associated with high status, is gout. Gout is a form of inflammatory arthritis, which is caused largely by prolonged consumption of purine-rich foods and alcohol (Buckley 2011, 110; Howard *et al.* 2016, 2). A key marker of gout skeletally is erosive lesions on the joint surfaces (Figure 8). Contradictory to expectations, the prevalence rates for the presence of gout were relatively low in this sample at 1.2% (6/502) (Figure 9); although this could be attributed to a bias in regional availability of food resources.

Figure 8: Destructive lesion on the distal aspect of metatarsal 1, lateral view of gout. Chelsea Old Church. Museum of London 2019, extracted 18.10.19.

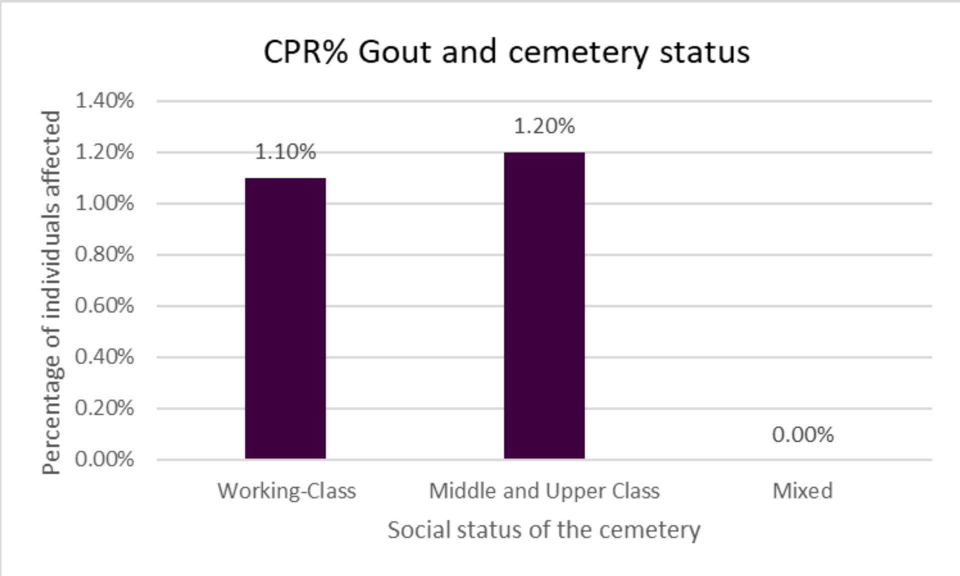


Figure 9: Crude prevalence rates for gout. Authors own, table populated with results referenced in Appendix I.

3.0 Longevity: Lower and Higher Social Classes

In the cemeteries assessed, age at death within adults appears regular, with the main peak of death occurring during later on in life, which was consistent between both sexes (Figure 10 and 11).
Sub-adult mortality was notably high for both lower and higher social classes (Figure 12); with the lower class prevalence calculating that 91.4% (160/175) of the children had died before they had reached 12 years of age, and a similar 91.0% (101/111) from the high-status cemeteries; indicating that poor health can occur during the crucial stages of development for all social classes.

Infant mortality, however, was greater in poorer socioeconomic assemblage with 3.7% (59/175) of the infants dying before the age of 1. In contrast, the prevalence of infant mortality from the high-status cemeteries calculated to be 22.5% (25/111) (Figure 12). Therefore, although there are multiple factors for high infant mortality, it can be suggested that those from a poorer economic status were possibly more susceptible to fatality and disease from malnourished mothers, or conversely predisposed to other diseases from conditions such as rickets (Kirby 2013, 49; Gowland 2018, 158; Gowland et al 2018, 26).

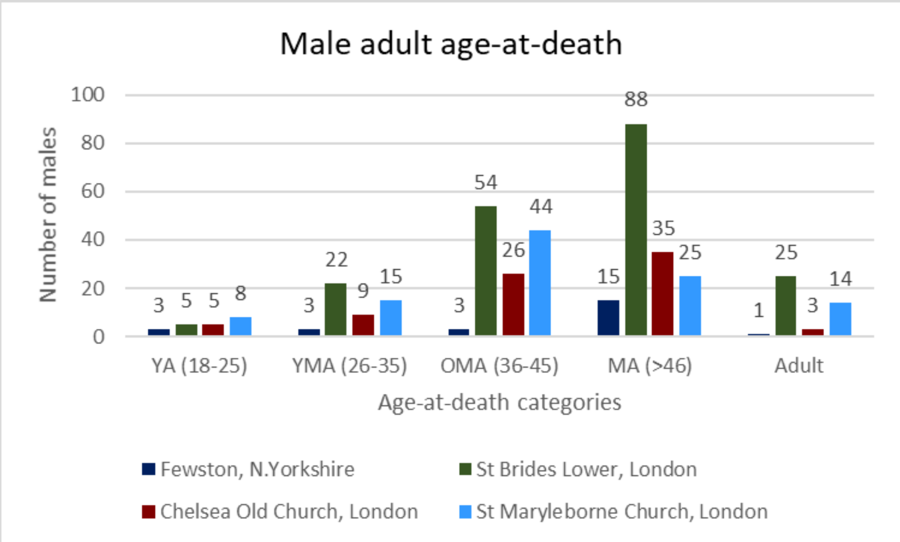


Figure 10: Male age at death. Authors own, table populated with results referenced in Appendix I.

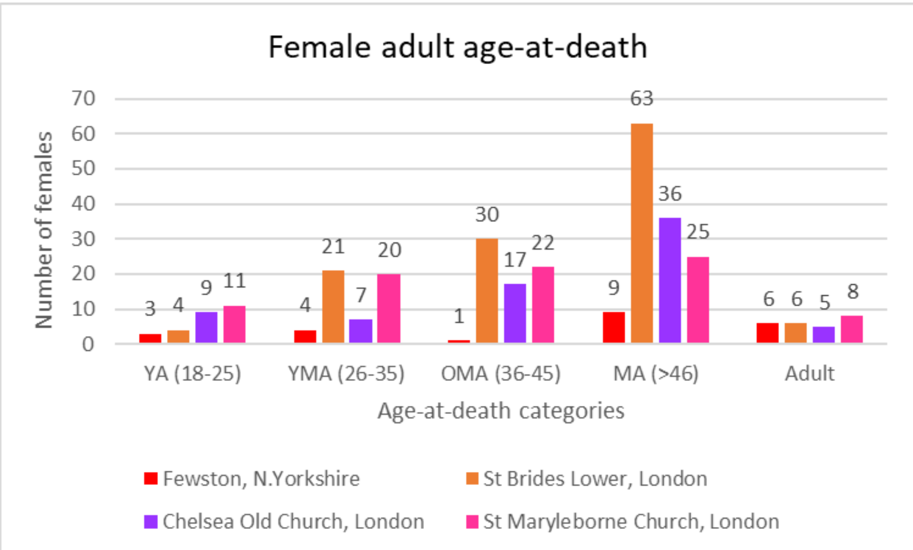
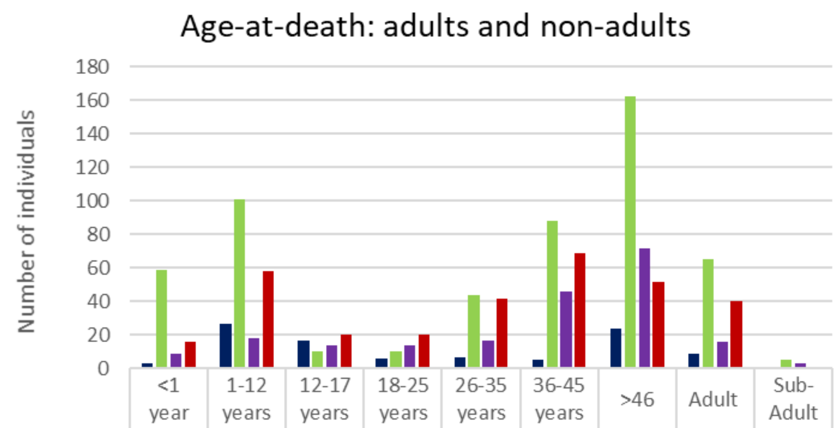


Figure 11: Female age at death. Authors own, table populated with results referenced in Appendix I.



	<1 year	1-12 years	12-17 years	18-25 years	26-35 years	36-45 years	>46	Adult	Sub-Adult
Fewston, N.Yorkshire	3	27	17	6	7	5	24	9	1
St Brides Lower, London	59	101	10	10	44	88	162	65	5
Chelsea Old Church, London	9	18	14	14	17	46	72	16	3
St Marylebone Church, London	16	58	20	20	42	69	52	40	1

Figure 12: Age at death all individuals. Authors own, table populated with results referenced in Appendix I.

4.0 Discussion

4.1 Rural versus Urban Environment

As Industrialisation lead to rapid migrations of families to major cities due to the increase in jobs and wages; this period of transition lead to a parallel increase in vulnerability to the exposure of new pathogens, particularly affecting those already susceptible or experiencing illness' attributed to dietary deficiencies (Roberts and Cox 2003, 299).
Therefore to an extent individuals who lived in major trading urban centres such London, were less likely to maintain sound health and diet due to the pollution. However, the lower classes were at a greater risk, as a result of the issues that arise with overcrowding and subsequent poor sanitation (Mays *et al.* 2008, 87).

Furthermore, an important factor that affected the health of both social classes was the regional accessibility to food, in addition to the cost of fuel. Roberts and Cox (2003, 308) noted that socioeconomic status can often be translated into stature, however for many post-medieval individuals, arguably, the type of environment inhabited would have been more of an influential factor than status alone. For instance, significant use of fresh milk was suggested to have been nearly absent in southern and eastern English counties; or certainly largely adulterated by the time that milk had reached the consumer (Horrell and Oxley 2012b, 17; Roberts and Cox 2003, 310).

On the whole, individuals from a rural background were more likely to prepare home-baked foods than purchase shop-bought food which contained chemical traces, which would have had adverse effects on nutrition and health for all social classes (Gowland *et al.* 2018, 23; Roberts and Manchester 2010, 21; Roberts and Cox 2003, 312).
As seen in Figure 13, the regional nutritional values demonstrate vast variability between neighbouring counties; which supports the positive correlation in figure 14 between adult stature and regionality. Noticeably, the average height (cm) for adult males in London remained within a 2cm bracket, which is a stark contrast to males from urban north Yorkshire who were at least 6.3cm taller than their urban counterparts.

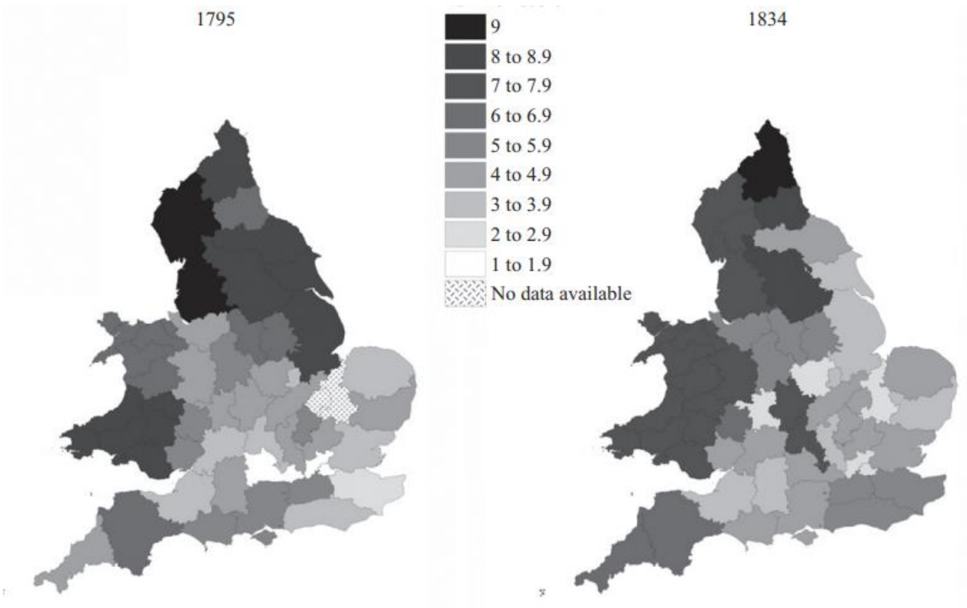


Figure 13: Map of nutritional values during the Industrial Revolution (Horrell and Oxley 2012a).

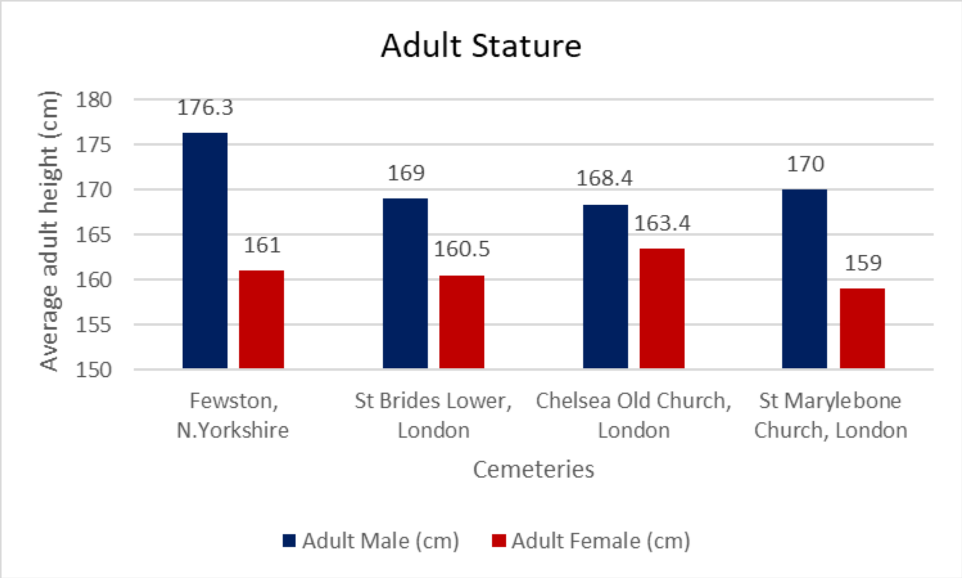


Figure 14: Average adult stature, Authors own. Table populated with data referenced in Appendix I.

4.2 Age and survivability

To an extent, it is expected that adults are more likely to display evidence of poor health, due to longer exposure to disease and possible hazards, in addition to the overall disadvantages of ageing on male and female bones (Willson *et al*. 2015, 65; Weaver 1998, 39). However, an important point that has yet to be discussed is the impact of work-related trauma on the remains of lower-class children who were forced into labour. Factories and mills would have been highly hazardous work places, and working in such environments would have increased the risk of accidental fractures, or amputations, as a result of smaller children operating heavy machinery (Gowland 2018, 153).

Fractures and amputations were not the only types of injuries sustained in this working environment; over-exposure to toxic chemicals has been shown to have caused respiratory-induced trauma in some non-adults from other poor-status cemeteries. An extreme case of respiratory-induced trauma was discovered on the remains of a 12-14-year-old from Coach Lane cemetery near Newcastle (Figure 15). Osteologists concluded that this was an example of over-exposure to phosphorous fumes from creating strike-anywhere matches in poorly ventilated factories (Roberts *et al.* 2016, 44). This type of work was noted to have attracted only “the poorest labourers”, with the condition itself creating necrosis of the jaw, which would have been highly stigmatised due to the odour (Gowland 2018, 150).

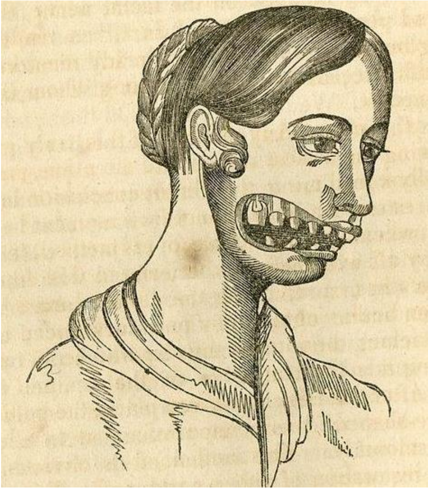


Figure 15: Phosphorous exposure. Image is taken from http://lateralscience.blogspot.com/2017/09/phossy-jaw-white-phosphorus-causes.html. Extracted 18.10.19.

Arguably, conditions caused by the dire work environments aforementioned would have been for the most part absent in non-adults and adults from higher classes. It has been suggested that the impact of poverty and working conditions was multi-generational; therefore, the status of the lower-classes was imprinted on the DNA, which would have negatively influenced the health before birth (Gowland 2018, 158).

A final point to be considered is that the recorded number of individuals with diseases resulting from either poverty or high-status indulgence and choice may be greater. It is possible that many individuals died before being able to manifest conditions skeletally; a concept which is referred to as the osteological paradox (Wood *et al*. 1992, 345). However, this does not detract from the argument displayed throughout this essay, which suggests that social status played a large part in influencing health and diet of post-medieval populations.

5.0 Conclusion

It can be argued that social status was a substantial influential factor in determining the diet, and subsequent health, of post-medieval adults and non-adults. However, it was not the catalyst for poor health as a whole. Arguably, the impact of urbanisation and industrialisation would have been detrimental for all social classes who lived and worked in an overpopulated urban centre. Arguably, the risk of lower-class individuals from urban cities was greater. This is based largely on the lack of nutrition and dire living and working conditions in which poorer families endured daily. A contemporary writer observed that even the most skilled labourers were "constantly exposed to loss of food", which consequently resulted in "death by starvation" (Engels 2009, 85). This can be confirmed skeletally by the presence of conditions aforementioned, however it is worth considering the number of individuals who may have died before skeletal manifestations took place (Wood *et al*. 1992, 345).

In conclusion, the impact of poverty and socio-economic status negatively influenced the health and diet of individuals across England. However, there was a slight regional bias to the extent of food and nutrition accessibility which would have played a part in maintaining health. Health and diet were thus, to an extent, governed by regionalism more specifically relating to the cost of fuel to prepare food, raw resources, and the quantity of common land available.

6.0 Appendix I: Prevalence References

Cemetery	Sub-adults CPR% (n/N)	Adults CPR% (n/N)	Total Scurvy CPR% (n/N)	Reference
Fewston, N.Yorkshire (Rural mixed)	38.4% (15/39)	0.0% (0/104)	10.5% (15/143)	Gowland et al 2018; Caffell and Holst 2010
St Brides Lower, London (Urban poor)	6.9% (12/175)	0.0% (0/369)	7.8% (12/544	WORD Database Museum of London, 2019
Chelsea Old Church, London (Rural rich)	6.06% (2/33)	0.0% (0/168)	2.0% (2/201)	WORD Database Museum of London, 2019
St Marylebone Church, London (Urban rich)	6.4% (5/78)	0.0% (0/223)	1.7% (5/301)	WORD Database Museum of London, 2019

Cemetery	Sub-adults CPR% (n/N)	Adults CPR% (n/N)	Total Rickets CPR% (n/N)	Reference

Fewston, N.Yorkshire (Rural mixed)	44.8% (13/29)	0.0% (0/104)	9.8% (13/133)	Gowland et al 2018; Caffell and Holst 2010
St Brides Lower, London (Urban poor)	14.87% (26/175)	0.0% (0/104)	6.4% (35/544)	WORD Database Museum of London, 2019
Chelsea Old Church, London (Rural rich)	12.1% (4/33)	6.0% (10/168)	7.0% (14/201)	WORD Database Museum of London, 2019
St Marylebone Church, London (Urban rich)	27.0% (21/78)	4.0% (9/223)	10.0% (30/301)	WORD Database Museum of London, 2019

Cemetery	Sub-adults CPR% (n/N)	Adults CPR% (n/N)	Total DISH CPR% (n/N)	Reference
Fewston, N.Yorkshire (Rural mixed)	0.0% (0/50)	0.0% (0/104)	0.0% (0/154)	Gowland et al 2018; Caffell and Holst 2010
St Brides Lower, London (Urban poor)	0.0% (0/175)	2.4% (9/369)	1.7% (9/544)	WORD Database Museum of London, 2019
Chelsea Old Church, London (Rural rich)	0.0% (0/33)	6.5% (11/168)	5.5% (11/201)	WORD Database Museum of London, 2019
St Marylebone Church, London (Urban rich)	0.0% (0/78)	2.7% (6/223)	2.0% (6/301)	WORD Database Museum of London, 2019

Cemetery	Sub-adults CPR% (n/N)	Adults CPR% (n/N)	Total GOUT CPR% (n/N)	Reference
Fewston, N.Yorkshire (Rural mixed)	0.0% (0/50)	0.0% (0/104)	0.0% (0/154)	Gowland et al 2018; Caffell and Holst 2010
St Brides Lower, London (Urban poor)	0.0% (0/175)	1.6% (6/369)	1.1% (6/544)	WORD Database Museum of London, 2019
Chelsea Old Church, London (Rural rich)	0.0% (0/33)	2.4% (4/168)	2.0% (4/201)	WORD Database Museum of London, 2019
St Marylebone Church, London (Urban rich)	0.0% (0/78)	0.9% (2/223)	0.7% (2/301)	WORD Database Museum of London, 2019

Cemetery	Age-at-death reference
Fewston, N.Yorkshire (Rural mixed)	Gowland et al 2018; Caffell and Holst 2010
St Brides Lower, London (Urban poor)	WORD Database Museum of London, 2019
Chelsea Old Church, London (Rural rich)	WORD Database Museum of London, 2019
St Marylebone Church, London (Urban rich)	WORD Database Museum of London, 2019

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Identifying and Assessing Candidates for De-Extinction and Reintroduction to the UK: A Conversation for Conservation

James Osborne

Introduction

The limited reintroduction of extant species into the UK has been successful. Beaver populations have been reintroduced across the country, and public support for the reintroduction of other fauna such as: wild cats, moose, and wading birds is in the majority (YouGov 2020).

The Pyrenean ibex, woolly mammoth, thylacine, gastric brooding frog, passenger pigeon and many other extinct species have all been the focus of de-extinction projects (Zimmer 2013; Zimov 2005; Yong 2013; Waters 2019). As the science of de-extinction the pro’s and con’s of which have been well explored (Pimm 2013; Brand 2014) edges closer towards success, the prospect of de-extinct fauna returning to their (pre)historic environments to roam, graze, and hunt again grows.

Discussion

Once the technical problems with de-extinction have been surmounted (Shapiro 2016) and extinct species can successfully be made de-extinct, one overarching question looms: “Now what?”. Are de-extinct species (an inaccurate but useful term) destined to be confined in cages and enclosures in zoos and safari parks - brought back from the dead to be stared at by paying visitors? Or can they serve some greater purpose - one that goes beyond human entertainment and sheer spectacle?

When considering candidates for de-extinction, the aim is to restore lost ecological balance to a suitable environment (Seddon 2017). The reintroduction of grey wolves into Yellowstone National Park provides a low resolution road-map for how the return of native species can trigger a trophic cascade and positively impact local biodiversity to a significant extent (Smith 2003). In 2016 the International Union for Conservation of Nature (IUCN) published the report, ‘IUCN SSC Guiding Principles on Creating Proxies of Extinct Species for Conservation Benefit.’ (IUCN 2016) detailing, how, when, and why extinct species could be made de-extinct, reintroduced into the wild, and have similarly positive effects. The report suggests that species should only be made de-extinct and reintroduced into environments when: an appropriate species can be found - the species can be appropriately released following the 16 steps described in the report, and when the species will be beneficial to conservation. Once this is satisfied, de-extinction effectively becomes an issue of translocation conservation (Seddon 2014).

Those looking at the UK as a potential home for extinct species must consider the criteria set out in the IUCN report, and must further ask the following questions: was the species once native to the UK? Is the UK's current environment similar to the species' last point of habitation? Was the species' extinction an 'unnatural' phenomenon caused by human activity? If the answer to these questions is 'yes.' then the species could be a suitable candidate for de-extinction and reintroduction. However, the list of known species that fits this criteria is small. The woolly mammoth (Mammuthus Primigenius), aurochs (Bos Primus), woolly rhinoceros (Coelodonta Antiquitatis), and Irish elk (Megaloceros Giganteus) are all extinct species that were native to the UK, lived in similar climatic conditions to the present day, and were, at least in part, made extinct due to human activity (Barnett 2019).

However, whilst these species might all encourage biodiversity, none of them fill the UK's main ecological problem: the lack of a non-human apex predator (Morris and Letnic 2017). The UK's deer population is protected from hunting through strict laws and the lack of large carnivores, and as this deer population of over 2 million grows, so too does the need for ecological balance. The overgrazing of water-sides, forests, and the habitats of large herbivores has both substantial and negative effects on local biodiversity (Morris and Letnic 2017), and was the main reason for the reintroduction of grey wolves into Yellowstone.

These candidate species are all also considered to be megafauna, and though this doesn't limit the potential for positive ecological impacts, it does come with logistical problems: where is there enough space in the UK for a herd of woolly mammoths to freely roam and graze, which is also far enough away from human settlement as to not cause substantial problems? Factors like this must be considered, and though tourism based solutions might appear in the form of gated mammoth-conservation zones (Whittle 2015), this limits the ability for the species to have significant and positive impact on the ecology, thus undermining the aim of their de-extinction and reintroduction. Extinct carnivores that could fulfil the role of apex predator also encounter this problem; cave bears and cave lions would have to be restricted to captivity, even if that captivity was in a large scale reserve.

Moreover, these species don't fill a niche that extant species couldn't already fill. The Eurasian wolf (Canis Lupus Lupus), Eurasian brown bear (Ursus Arctos Arctos), and

Eurasian lynx (Lynx Lynx) are once-native large carnivores that could fill the role of apex predator within the UK's ecology. They do not carry the ethical and financial baggage of de-extinct species. and having lived in the UK within the past 2000 years and currently in wider Europe, their reintroduction would pose lower levels of risk to the existing ecology (Wood 2016).

The Eurasian lynx is a particularly compelling and well suited candidate for the role of apex predator. Public support for the reintroduction of the lynx is currently in the minority at 45%, (YouGov 2020), however this number is higher than for wolves and bears. The lynx would have a positive ecological impact on its woodland habitat by helping to reduce the deer population which could potentially trigger a trophic cascade (Breitenmoser and Haller 1993). The reduced numbers of deer could bring a new biodiversity of local flora - in turn providing habitats for small mammals which feed smaller carnivores. Logistically, the reintroduction of the lynx is far less complex than an extinct species. The Eurasian lynx is non-aggressive towards humans, and lives in the shelter of woodland - only posing a low threat to livestock and farmers (Basille 2009). Unlike extinct species, a road-map for the reintroduction of the Eurasian Lynx and the possible problems along the way has already been created, with Switzerland having successfully reintroduced the species.

Conclusion

While the idea of a woolly mammoth wandering the Yorkshire moors is exciting, the UK does not currently offer potential as a home for de-extinct species. Logistical problems are plenty when considering the reintroduction of de-extinct species, and the candidates fail to solve the UK's biggest ecological problem: the lack of an apex predator. Instead, the restoration of ecological balance in the UK relies upon the reintroduction and rewilding of extant carnivores: the Eurasian lynx, Eurasian wolf, and Eurasian brown bear are three examples of predators that live in Europe currently, lived in the UK during the

Figure 1: Mammoth Skull Art (author's own)

Holocene, and that could live here again. The reintroduction of the Eurasian lynx seems to have the most merit: it effectively navigates the logistical problems of size, habitat, aggression, impact on humans, and has higher levels of support among the public than alternative options.

When looking for a solution to the UK's ecological problems, the answer lies in extant species, not extinct ones. The suggestion is not that the de-extinction and reintroduction of extinct species cannot occur under the right circumstances, but that those circumstances are not currently applicable to the UK.

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Origins and migrations: how aDNA analysis is not necessarily the answer

Alfie Talks

1 Introduction

Ancient DNA (aDNA) offers Bioarchaeologists fresh opportunities to tackle some of the biggest archaeological debates to date. But with all the excitement about what this field of study could reveal, it is easy to overlook some core problems in using aDNA. This essay will therefore critically assess the contribution and potential of aDNA analysis to increase our understanding of both the origins and migrations of *Homo sapiens*, and discuss how aDNA does not necessarily provide the answers.

1.1 Origins

Questions about the origin of our species have been much debated, and in particularly regarding whether humans originate “Out of Africa” or if a “Multiregional Theory” is more likely. aDNA has been able to contribute to this debate through its ability to identify Mitochondrial Eve, as well as showing that the genetic history of Homo sapiens involves a mixture of other hominins. However the potential of aDNA for understanding the origin of Homo sapiens will always be limited. This is due to the reliance on: sex chromosomes to create genetic lineages, genetic sexing, phylogenetic trees, using molecular clocks, and most importantly the preservation of genetic data.

1.2 Migration

Migration is another fascinating phenomenon in which aDNA has attempted to gain an insight. This can be seen in the neolithization of Europe, through evidence of Lactose Persistency, and animal genetics (Itan et al. 2009, 7; Karimi et al. 2016). However, as the research examines the DNA of individuals, thus recognising the high sequencing costs and the destruction of samples due to the invasive process, it may not be representative of society as a whole. The genotyping of animals also cannot necessarily guarantee there has been a migration of people.

2 Origins

2.1 Why use aDNA?

2.1.1 mtDNA and Y chromosome

The process of evolution takes millions of years, with offspring being nearly identical to parents (Darwin 1859, Dawkins 1989). It can be argued that the first human was not human at all but an ape. It has also been argued that the first human was similar to a fish, or a single-celled organism (Dawkins 2012, 50). One method used to understand these origins is aDNA. Genetic lines such as mitochondrial DNA (mtDNA) (inherited maternally), and Y chromosomes (inherited paternally), enable an understanding of the location from which the first humans originate. However, significantly, the mitochondria in both offspring sexes will only be inherited from the mother.

There are two conflicting hypotheses on the origins of Homo sapiens: the “Out of Africa” hypothesis and the “Multiregional Theory”. The first suggests that Homo sapiens originated principally in one location, Africa, before migrating throughout the globe, whilst the latter suggests that there was a level of gene flow in different locations from Homo erectus, as shown by figure 1 (Satta and Takahata 2002, 872). To be able to answer this question, through analysis of the genetic lines, a most recent common ancestor must be established. If the ancestor appears to have originated in Africa, this would provide evidence for the “Out of Africa” hypothesis. Finding this ancestor requires the tracing of all modern DNA to “Mitochondrial Eve” and “Y Chromosome Adam”, and this is the approach upon which many studies have been based (e.g. Ke et al. 2001; Pakendorf and Stoneking 2005). The origins of both Mitochondrial Eve and Adam are estimated to be out of Africa, as the genetics are more divergent in Africa than elsewhere, supporting the claim of “Out of Africa” (Vigilant et al. 1991, 253). It is clear that the contribution of aDNA is that not only is it able to identify the species of Homo sapiens, but also provide answers as to where it originates from. Thus, using aDNA shows that Homo sapiens originate from Africa.

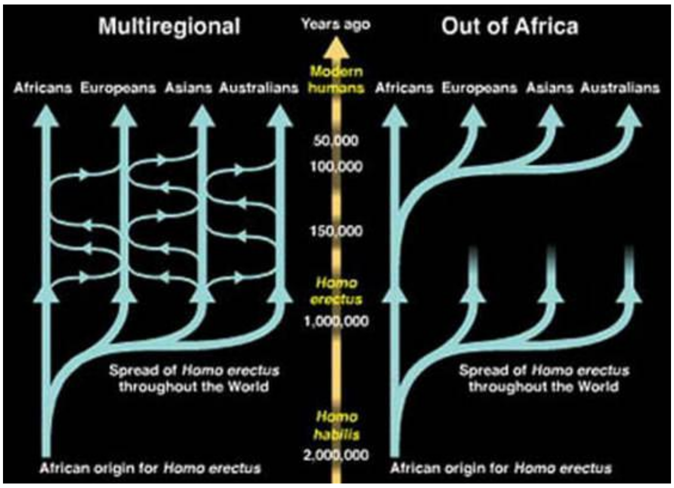

Figure 1 The "Out of Africa" hypothesis and the "multiregional theory". By following the relatedness of modern humans the most common recent ancestor can be assessed (electrobleme 2017).

2.1.2 Admixture

aDNA has also contributed to the debates on the origins of humans, as it has been able to give us more of an understanding of which species Homo sapiens comes from. Through the analysis of the aDNA of anatomically modern humans, Neanderthals and Denisovans, a level of admixture was discovered, meaning that there are genes in modern humans, which originated from these archaic hominins, as shown by figure 2 (Browning et al. 2018, 53). To truly understand the origins of humans, it is necessary to consider Homo sapiens, Neanderthals and Denisovans as being the genetic origins. As a result, it is clear that aDNA has truly revolutionised bioarchaeological understanding of humans as a species. Consequently, aDNA has contributed to the question of origin, as it has been able to show that the genetic history of modern humans involves other Hominin species.

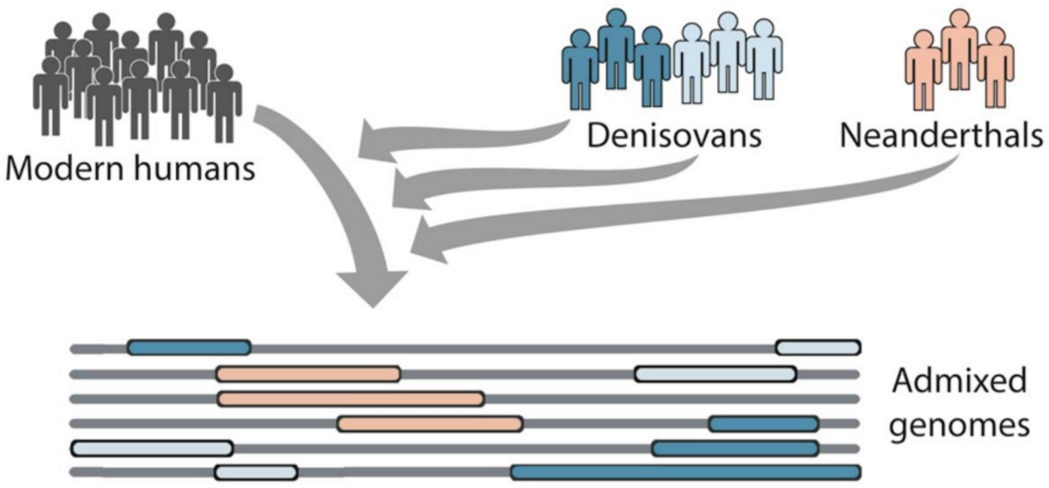

Figure 2 Admixture between *Homo sapiens*, Denisovans and Neanderthals (Browning *et al.* 2018, 52). To define the origin of *Homo sapiens,* one must also consider the origin of Denisovan and Neanderthals.

2.2 The issues

2.2.1 Mitochondria

Opinions on the reliability of Mitochondrial Eve have been fluctuating since its first conception (Gibbons 1992, 873). There are many reasons for this, however, this essay will focus on the misunderstanding of Mitochondrial Eve and the recent discovery of male line mitochondria inheritance. Firstly, being able to identify the origin of Mitochondrial Eve does not mean the identification of the first human (Learn, 2016). As shown by figure 3, sex of offspring and genus origin yields a complex and extensive genetic lineage that ultimately obscures the culminated admixture. This is due to the individual lineages being inherited from a particular sex, so if the offspring are of the same sex, or there is no offspring, the genetic lineages will stop. As a result, this study does not lead to the first human; rather it leads to the survival of one genetic line through gene flow (ibid). Consequently, it is apparent that arguments using Mitochondrial Eve to locate the origin of Homo sapiens are inaccurate, and thus the potential of aDNA to understand the origin is simply too unreliable. Secondly, recent studies have revealed that Mitochondria can also be inherited by the father (Luo et al. 2018, 13044). As this research has been published after much research into Mitochondrial Eve, it paints uncertainty thus showing that aDNA may not have such a great potential as first thought.

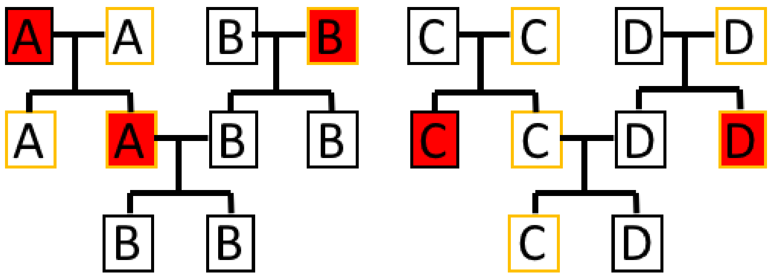

Figure 3 Sex chromosomes in a fictional population. The black outline indicates Y chromosome whereas the yellow indicates mitochondrial DNA. Red squares indicate extinct lineages at this particular point (Authors own).

2.2.2 Y chromosome

2.2.2.1 Biological sexing

There are similarly a range of issues associated with the Y chromosome. The first of these is the identification of genetic sex. To be able to work out the sex chromosome to test, identification of the genetic sex of the individual is needed. Seeing as the Y chromosome is only present in males, by identifying the presence or the difference between AMELX and AMELY can determine the sex. These are relatively inaccurate, however, as the absence of Y chromosome can be caused by a female sample, DNA degradation or an inhibitor in the sample. Amelogenin also has its issues in that allelic dropout, in which the longer chain, i.e. the Y chromosome, is not detectable using PCR techniques. Further issues arise from chromosomal anomalies in which the individual may have phenotypic differences to the chromosomal presence (Brown and Brown 2011, 158-161). A final difficulty in using genetic sex is that despite genetically it may be typed for a particular sex, phenotypically gender cannot be determined entirely. Henceforth, it may be difficult to infer the life that the individual had (Short et al. 2016, S93).

2.2.2.2 Ambiguity

Issues with the inability to identify the individual's sex, creates issues due to the ambiguity of which genetic line is to be tested. Tests themselves are expensive and this may cause possible samples to be discarded as they cannot be certain of the sex. Although the mitochondria will be inherited in both males and females from the mother, the Y chromosome will not be typed due to the difficulty in determining its presence as well as the fragility of the long chains. These elements should certainly be reconsidered before conducting future investigations into aDNA, lest we continue to provide data with inaccuracies and increase misrepresentative interpretations of individuals regarding sex demographic versus potential complex gender social constructs

2.2.2.3 Mutations

Mutations also play their role. Mutations mainly happen in the production of gametes for sexual reproduction. The rate of mutation is higher for male gametes due to the rapid transcription and translation of the parent DNA strand to the male gamete from one initial strand thousands of times, increasing the chance of mutation (Wilson Sayres and Makova 2011, 939). It is therefore hypothetically possible that the mutations will mean that the identification of genetic lineages using Y chromosome is more open to inaccuracies due to this increase in mutations.

2.2.3 Phylogenetic trees

A final issue in finding the origin of Homo sapiens is the use of phylogenetic trees. This process works by investigating the diversity of different samples based on different genetic morphometrics. Molecular clocks are needed for this study to take place. Several controls must be put in place, such as consistent demography, mutation rate and reproduction (Moorjani et al. 2016, 10607–10608). These controls are not reliable in reality. This is because demographics change throughout time and, as there is no accurate measure to estimate population, the rate of mutation relies on generalisations which oposes against the nature of mutations. Also, reproductive ages have been changing throughout time, particularly in the last 100 years, within the time in which DNA sequencing has taken place (Hassan 1978, 49; Lynch 2010, 345; Toulemon 1988, 6). The reliance on controls to be able to use molecular clocks shows that aDNA in conjunction with phylogenetic trees is simply not viable, accordingly the potential and contribution of these studies is limited.

2.1.4 Preservation

However, the above discussion relies on the discovery of samples. As is often said in archaeology; absence of evidence is not evidence of absence. Seeing as the current understanding of “Out of Africa” implies the origins coming from an area of hot climates, the chances of organic remains containing aDNA preservation is less than 0.1 in Africa, as shown by figure 4. Accordingly, it could be possible that the full understanding of the origins of Homo sapiens will never be fully understood. An example of this is Adcock et al. (2001 538), who proposed that a different mtDNA group was the most divergent, based on the findings of Lake Mungo. This claim was later dismissed by Heupink et al. (2016, 6893) who stated there was no Aboriginal Australian DNA but rather it came from modern European contamination, disproving this research. This research demonstrates that there may now be samples which would revolutionise the understanding of the origins of Homo sapiens. When combined with new discoveries such as Jebel Irhoud, Morocco, which pushed the date of Homo sapiens' origin further back, it poses the possibility that there are human remains that are yet to be discovered (Richter et al. 2017, 296). Due to the lack of preservation, the contribution of aDNA may never give a full understanding as to the origin of Homo sapiens. With oxidation preventing the full transcription of genetic coding combined with the scarcity of samples fit for testing, it becomes explicit that human origin will never be fully understood.

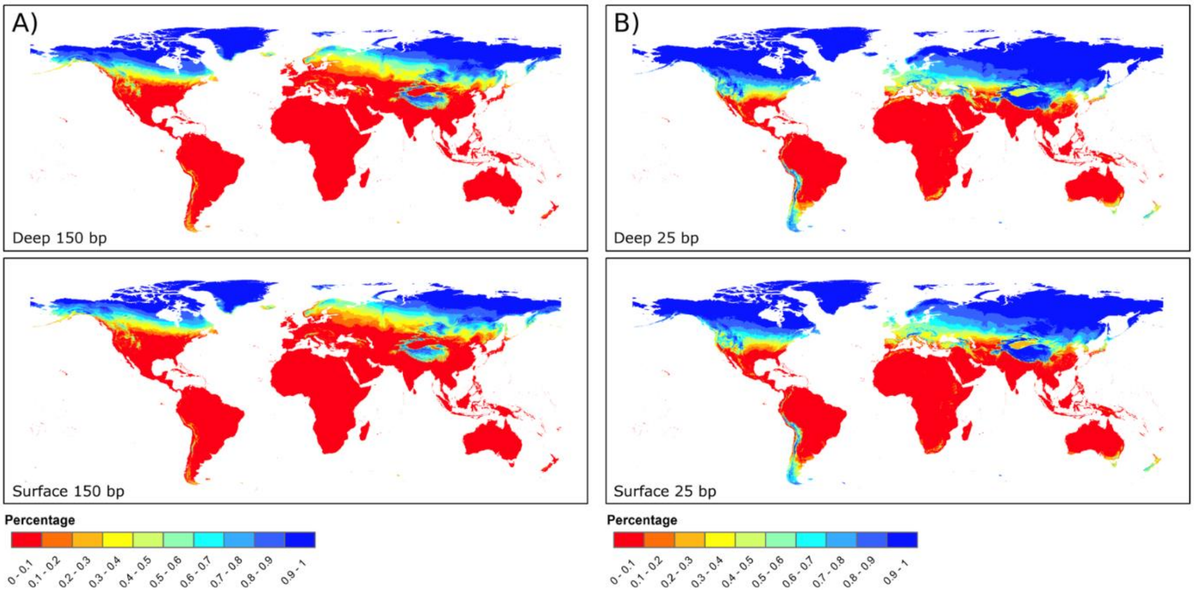

Figure 4 Chances of DNA survival from 10,000 years ago (Holfreiter *et al.* 2015, 286).

3 Migrations

3.1 Case study: Lactase persistence

Since the origin of Homo sapiens, migrations have enabled humans to occupy six of the seven continents. These have happened in a range of significant events. Figure 5 shows the current understanding of how these spreads took place. To be able to show the limitations of aDNA research in relation to migration case studies of lactase persistence, the populating of America, and the process of Neolithization will be used to illustrate the points.

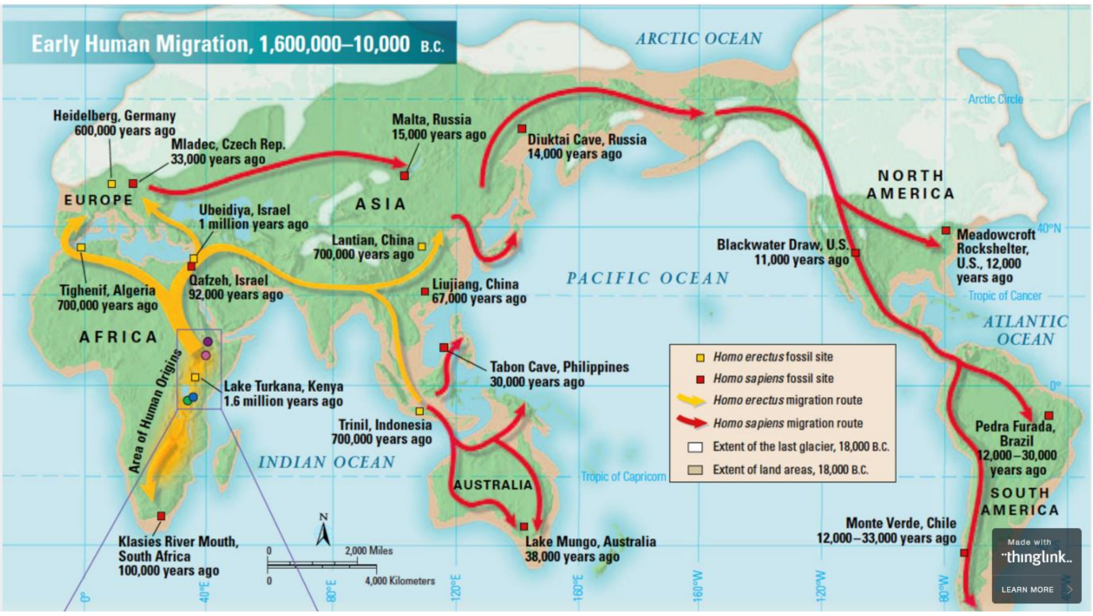

Figure 5 Map showing the earliest migrations of *Homo sapiens* as well as their interactions with Homo erectus. It also shows the extent of ice sheets and dates of particular sites (Calum 2016).

3.2 Why use aDNA?

Lactase persistence is a haplogroup that has arisen in five different ways, reaching 35% of people. In Europe, it has been proposed to have arisen around 6256 to 8683 BP in North Balkans and Central Europe, probably at the same time as the development of dairying (Itan et al. 2009, 7). Figure 6 shows the percentage of people with lactase persistence in different locations. As this is a genetic trait, it is possible to deduce the spread, thus migrations, of people using aDNA techniques. A paper by Krüttli et al. (2014 e86251) suggests that by Medieval times, the spread of lactase persistence (LP) had encompassed the whole of Europe. This was discovered by sequencing a range of samples, of which 70% of the sample was LP (2014, 3). This paper shows the potential of aDNA for archaeological questions it is able to show the level of migrations of people and the interactions of different groups in a way which is inaccessible by different methods. Consequently, aDNA has the potential to contribute to the understandings of migrations.

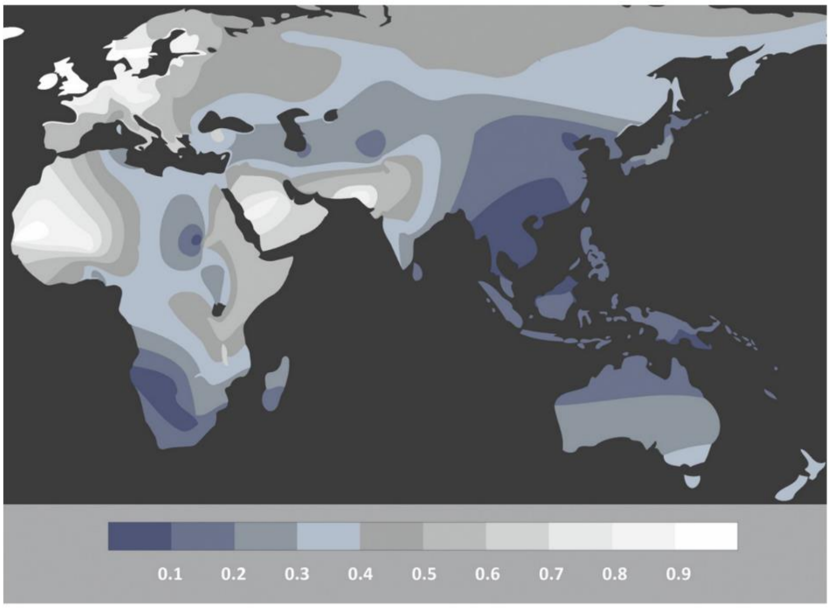

Figure 6 The lactose persistency haplogroup spread across the globe. The scale represents the percentage of that area with that particular haplogroup. (Malmström *et al.* 2010, 2)

3.3 The issues

3.3.1 Individuality

To be able to evaluate the migrations, aDNA analysis studies rely on individuals. As a result, the first question is, are these individuals representative of society? If these individuals are anomalous to the society at the time, the results will present a different analogy to the actual trend. In regards to LP, this can be shown in a paper by Malmström et al. (2010, 3), which used four different sites all located on one island off the coast of Sweden, with ten results, to show that the modern distribution of LP in Scandinavia is not due to the haplogroup originating in this area. Seeing as LP is a single polymorphism, which is dominant and can be caused by a mutation, it is theoretically possible that these results were caused by other factors rather than the spread of LP to this region, for example, it may be a regional anomaly (Swallow 2003, 197). The uncertainty as to whether the sample is representative of a society is made more of an issue due to the high costs and destructive nature of aDNA analysis. As a result, it is not feasible to carry out analysis on more samples. Through these examples of individuality, the overall contribution potential of aDNA to understand migrations is therefore limited by accessibility to analyse more results, to counteract the individuality of results.

3.3.2 Trading domestication

By using the DNA changes between domesticated and wild populations, it is proposed that the spread of neolithization across Europe will be further understood. Many studies have been based on understanding the genetic changes between local wild and introduced domesticated animals and plants, trying to understand the interactions and the level of admixture (e.g. Karimi et al. 2016). Through studying the domesticated relationships, this can be argued to represent the movement of people throughout Europe at this time (Larson and Burger 2013, 198). This should, however, not be claimed as the case. The movement of animals and varieties of crops do not necessarily mean the movement of people. This is as "the spread of agriculture involved a variety of mechanisms and cannot be merely explained by a simple model of migration or acculturation" (Divišováa 2012, 149). To give an example, it may be possible that livestock or products of crops were traded between neighbouring groups, which would argue the spread of the Neolithic "package" instead of people. This clearly points out that following the genetics of animals alone cannot guarantee a reliable method of tracking the migration of people themselves.

4 Analysis

aDNA analysis has developed a lot in the last few years in terms of its capabilities and use for ground-breaking discoveries. There are, however, many complications which arise which renders the capability and potential of such research techniques not as clear cut and decisive.

4.1 Origins

aDNA has contributed to the debates on origins by first defining what being human is as well as discovering Homo sapiens are part Neanderthal and Denisovan. Despite this contribution, factors such as misunderstandings of Mitochondrial Eve not being the first human, mitochondria being inherited paternally, difficulties in sexing, use of controls for molecular clocks which are factually inaccurate, and preservation of genetic material all mean that the potential for using aDNA to understand the origins of Homo sapiens will always be limited. Consequently, it could be argued that aDNA can never reliably contribute to the understanding of Homo sapiens origins.

4.2 Migration

aDNA can contribute to the debates of migrations as not only can aDNA discover information which is inaccessible through alternative methods, but also allows the discoveries to be tested in terms of the reliability of the results. Despite this, contamination, issues of individuality, and the use of animals to understand human relationships, means that studies using aDNA will never escape the clutches of scepticism.

4.3 Conclusion

It is through these case studies that an understanding of the limitations of aDNA to the large debates in archaeology can be accessed, and through time, it will be possible to develop new techniques with new genetic material to understand the lives of our ancestors.

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Bad to the Bone:

A study of class and diet in urban, post-medieval London via statistical analysis of cribra orbitalia and scurvy.

Ian Noble

Introduction

A variety of skeletal pathologies indicative of dietary stress are evident across past and present populations, recognised primarily through their subsequent and distinct osteological markers. Difficulty interpreting these pathologies is compounded in archaeological contexts by the lack of soft tissues to observe, and by the fact that skeletal manifestations of disease require chronic, long-term affliction on the part of individuals suffering from them (Temple and Goodman 2014, 186-191). Not to mention, the nature of many diseases is such that their victims are often likely to die before any skeletal changes occur, especially in the eras preceding modern medical advances such as antibiotic, antiparasitic, and symptom-mitigating medications, as well as an understanding of their microbiological origins and histological presentations. One such time period is the Post-Medieval period, wherein countries like England saw the Industrial Revolution introduce advanced agricultural and industrial processes (Lewis 2002, 211; Mant and Roberts 2005, 190).

However, there may have been certain cultural practices that made their practitioners equally or more susceptible to such diseases and deficiencies, or provided a buffer for those with greater access to rare and expensive resources (Lewis 2002, 212). The purpose of this essay is to analyse the effects of socioeconomic status on the diet and health of Post-Medieval urban populations by comparing the prevalence of cribra orbitalia and scurvy in the St. Benet Sherehog and St. Bride's Lower cemeteries. This will entail an overview of the pathologies and their aetiologies, as well as a brief review of prominent literature surrounding the likely contributors, both cultural and physiological, and effects of the diseases on their victims and those they might interact with. Furthermore, data from the Wellcome Osteological Research Database will be analysed to determine whether and to what extent any differences in the occurrence of Cribra Orbitalia and Scurvy might exist.

Background

The effects of socioeconomic status on health have been well documented in the literature, showing increased susceptibility to chronic diseases for economically disadvantaged people, especially those who experienced multiple stresses early in life (Fagundes *et al.* 2013, 8-12;

Scott and Hoppa 2018, 699). However, the notion that poorer populations were more susceptible to all pathological conditions is not entirely accurate. Mant and Roberts (2015, 188-207) showed that dental caries affected both rich and poor equally in Post-Medieval London, differentiating only between urban and rural populations. They were joined by Lewis (2002, 216-221) who noted that popular nursing substitutes are often the reason for poor health in non-adults in Post-Medieval England. While individuals in the upper class may have had more access to fruits and vegetables containing Vitamin-C, it is suggested that popular nursing and weaning strategies, such as, likely subjected Post-Medieval infants to increased susceptibility to these diseases (Lewis 2002, 216; Walker *et al.* 2009, 114). The use of wet nursing and the use of unsanitary or nutrient-poor weaning methods would exacerbate their nutrient deficiency, both by the lack of vital nutrients in their food, and exposure them to unsanitary conditions, subsequently increasing their vulnerability to diarrheal diseases (Lewis 2002, 216; Walker *et al*. 2009, 115).

Health itself is a complex, relative, subjective phenomenon not constrained to biological effects; it is felt psychologically and socially (Temple and Goodman 2014, 186). Therefore, care must be taken to include considerations of how one might feel the pathologies investigated. To that point, the psychological effects associated with scurvy (Vitamin-C) and iron-deficient anaemia are known to include lethargy, whereas Vitamin-B deficiency may lead to a suite of psychological problems (Still 1935, 213; Walker *et al.* 2009, 120). The psychological and soporific effects of these pathologies make them prime candidates for consideration of overall health.

Cribra Orbitalia is commonly described as a thinning of the cortical bone of the orbital roof and subsequent macroporotic lesions there (Brickley 2018, 897; Rivera and Lahr 2017, 76; Wapler *et al.* 2004, 333). Of the several potential causes of cribra orbitalia, anaemia has stood out as a likely principal source of the biological stresses required to produce such lesions (Brickley 2018, 896-902; Rivera and Lahr 2017, 76-96; Walker *et al.* 2009, 109-125; Wapler *et al.* 2004, 333-339). Specific emphasis has been placed on iron-deficient anaemia being the most prevalent cause of cribra orbitalia archaeological contexts (Brickley 2018, 896-902; Rivera and Lahr 2017, 76-96; Walker 2009, 109-125). However, due to the constraints iron deficiency places on the body's ability to expand red marrow spaces to produce red blood cells (RBCs), Walker *et al.* (2009, 109-125) suggest instead that megaloblastic anaemia (deficiency in B-Vitamins) is much more likely to produce the expansion of red marrow, which causes the orbital lesions characteristic of cribra orbitalia. Regardless, of its convoluted aetiology it is clear from the literature that cribra orbitalia may be considered a sign of biological stress related to diet (Brickley 2018, 896-902; Rivera and Lahr 2017, 76-96; Walker *et al.* 2009, 109-125; Wapler *et al.* 2004, 333-339).

Scurvy has a long legacy of study in the medical and archaeological communities going back to the 16th century (Still 1935, 211-218). While early literature focused on adult populations, it is apparent that children are affected by the disease at disproportionate rates (Brickley and Ives 2006, 163-172; Ortner and Ericksen 1997, 212-220; Still 1935, 211-218). Scurvy is caused by a deficiency in Vitamin-C, impacting an individual's ability to synthesize collagen and to absorb ferrous iron, which would not only produce the lesions characteristic of scurvy, but may exacerbate or induce a state of iron-deficient anaemia (Brickley and Ives 2006, 163-172; Ortner and Ericksen 1997, 212-220; Still 1935, 211-218; Walker *et al.* 2009, 109-125). The hinderance of collagen synthesis affects small capillaries and cartilaginous structures, causing haemorrhaging and producing marked porosity in highly vascular areas, such as the connective tissue by the orbital roof (Brickley and Ives 2006, 163-172; Ortner and Ericksen 1997, 212-220; Walker et al. 2009, 109-125).

Materials and Methods

The Post-Medieval cemetery populations from St. Bride's Lower (SBL) and St. Benet Sherehog (SBS) churches were analysed so that urban lower-class and middle/upper-class populations, respectively, might be compared (Bekvalac and Cowal 2008, Kausmally 2008). The skeletal data for these cemeteries, made available by the Wellcome Osteological Research Database (Museum of London), concerning Cribra Orbitalia, Scurvy, and demographic composition, were entered into Microsoft Excel 16.30 (2019). Irrelevant data were excluded from the pathology tables, namely elements not involved in the presentation of Cribra Orbitalia or Scurvy, and individuals in whom the conditions were absent or unobservable. Individuals who displayed incomplete data for Cribra Orbitalia were retained in the data set and considered as showing the presence of the condition only if the presence of Cribra Orbitalia was confirmed on at least one side.

Demographics tables (Table 1 and Table 2) organized by biological age and biological sex were made, and charts were produced from those data (Fig.1 and Fig.2). Those tables were also expanded upon to include considerations of the prevalence and absence of Cribra Orbitalia and Scurvy and the respective proportions of the sample comprised by each group. However, in order to apply due scrutiny to the data, more than a simple comparison of percentages was necessary.

Cemetery	Total Population	Unsexed Children	Females	Females?	Males	Males?	Undetermined	Intermediate
St. Benet Sherehog	231	64	34	12	65	16	37	3
St. Bride's Lower	544	175	99	26	161	33	36	14

Cemetery	Total Population	Non-adult Perinatal	Non-adult 1-6 Months	Non-adult 7-11 Months	Non-adult 1-5 Years	Non-adult 6-11 Years	Non-adult 12-17 Years	Unclassified Non-adult	Adult 18-25 Years	Adult 26-35 Years	Adult 36-45 Years	Adult >46 Years	Unclassified Adult
St. Benet Sherehog	231	11	7	1	17	9	12	7	9	33	50	32	43
St. Bride's Lower	544	36	16	7	85	16	10	5	10	44	88	162	65

Table 2. *(above) Biological Age demographics for St. Benet Sherehog (Upper-Middle Class) and St. Bride's Lower (Lower Class) cemeteries. Note that the differential size of the cemeteries makes direct comparison of demographic categories difficult, thus requiring more comprehensive comparative methods.*

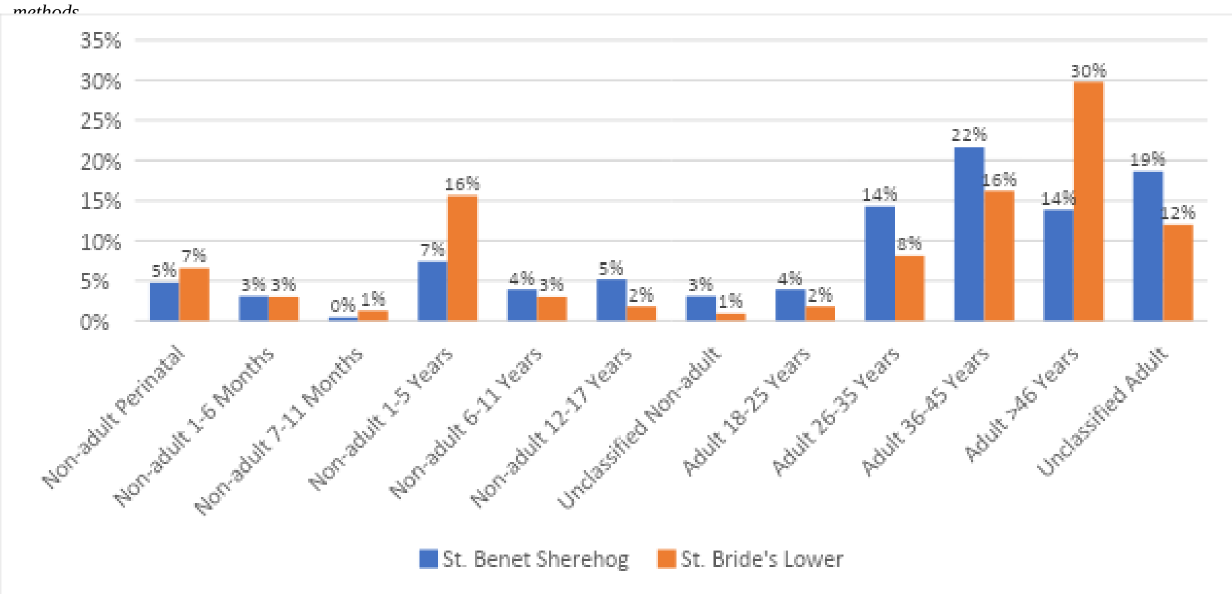

Fig. 1. *Relative percentages of Biological Age demographics for St. Benet Sherehog and St. Bride's Lower cemeteries. While the charts displayed provide context and some information about the longevity of individuals of different classes in Post-Medieval London, they alone are not enough to draw conclusions about the overall health of those individuals. Statistical and clinical analysis of the prevalence of certain pathologies will aid in the critical analysis of the health of our sample.*

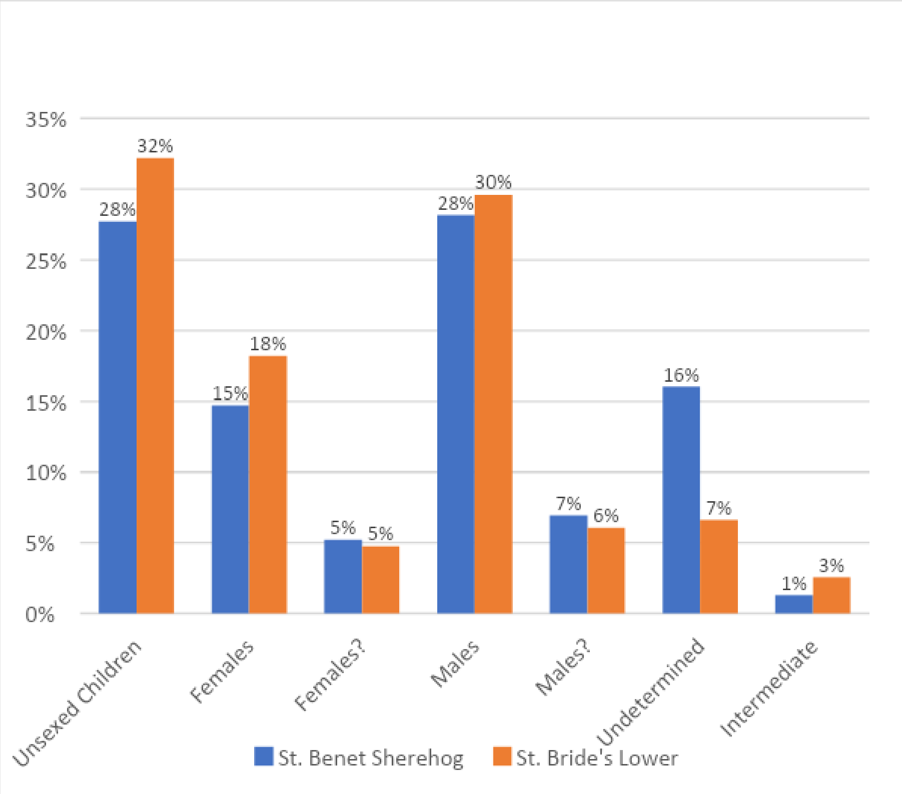

Fig. 2. *Relative percentages of Biological Sex demographics for St. Benet Sherehog and St. Bride's Lower cemeteries. Males comprise the majority of the sample, as do Unsexed Children. It is important to keep in mind, however, that the biological sex of non-adults is rarely, if ever, determined. The skeletal changes used in biological sex determination do not begin to take shape until puberty.*

To compare the significance of the presence of cribra orbitalia and scurvy in two populations, null hypothesis (H_o) and active hypothesis (H_a) were written for scurvy, cribra orbitalia, general affliction with either, and comorbidity of both, respectively, as follows:

H_o1: There is no difference between upper and lower-class populations in the prevalence of scurvy.

H_a1: There is a difference between upper and lower-class populations in the prevalence of scurvy.

H_o2: There is no difference between upper and lower-class populations in the prevalence of cribra orbitalia.

H_a2: There is a difference between upper and lower-class populations in the prevalence of cribra orbitalia.

H_o3: There is no difference between upper and lower-class populations in the prevalence of individuals afflicted with either cribra orbitalia or scurvy.

H_a3: There is a difference between upper and lower-class populations in the prevalence of individuals afflicted with either cribra orbitalia or scurvy.

H_o4: There is no difference between upper and lower-class populations in the prevalence of comorbidity of scurvy and cribra orbitalia.

Health Status	Observed	Expected	O-E	$(O-E)^2$	$(O-E)^2/E$
With Scurvy (SBL)	12	11.93	0.07	0.0049	0.00038
With Scurvy (SBS)	5	5.07	-0.07	0.0049	0.00089
Without Scurvy (SBL)	532	532.07	-0.07	0.0049	0.00001
Without Scurvy (SBS)	226	225.93	0.07	0.0049	0.00002
Total	775	775	0	0.0196	0.00129
				Ho Results:	Failed to Reject

Table 3a. *X^2 test comparing the prevalence of scurvy in each cemetery, as per hypothesis set 1. Failure to reject the null hypothesis (H_o) will be covered in the Results section.*

H_a4: There is a difference between upper and lower-class populations in the prevalence of comorbidity of scurvy and cribra orbitalia.

Health Status	Observed	Expected	O-E	$(O-E)^2$	$(O-E)^2/E$
With CO (SBL)	69	63.17	5.83	33.9889	0.5372
With CO (SBS)	21	26.83	-5.83	33.9889	1.2652
Without CO (SBL)	475	480.83	-5.83	33.9889	0.0706
Without CO (SBS)	210	204.17	5.83	33.9889	0.1662
Total	775	775	0	135.9556	2.0393
				Ho Results:	Failed to Reject

Table 3b. *X^2 test comparing the prevalence of cribra orbitalia (CO) in each cemetery, as per hypothesis set 2. Failure to reject the null hypothesis will be covered in the Results section.*

Since nominal scale data (presence/absence of each condition) was being compared between populations, a Chi Square (X^2) Test was used as per Vanpool and Leonard (2011), who informed the entire statistical analysis process. The data were entered into tables which include the X^2 tests themselves and the mathematical work applied to observed and expected frequencies of each pathological consideration to arrive at X^2 values for each hypothesis set (Table 3a, Table 3b, Table 3c, and Table 3d).

Health Status	Observed	Expected	O-E	$(O-E)^2$	$(O-E)^2/E$
Afflicted (SBL)	81	75.11	5.89	34.6921	0.4624
Afflicted (SBS)	26	31.89	-5.89	34.6921	1.0888
Not Afflicted (SBL)	463	468.89	-5.89	34.6921	0.0741
Not Afflicted (SBS)	205	199.11	5.89	34.6921	0.1744
Total	775	775	0	138.7684	1.7997
				H_o Results:	Failed to Reject

Table 3c. *X^2 test concerning the presence of either cribra orbitalia, or scurvy, related to hypothesis set 3. Failure to reject the null hypothesis will be discussed in the Results section.*

Health Status	Observed	Expected	O-E	$(O-E)^2$	$(O-E)^2/E$
Comorbid (SBL)	9	6.32	2.68	7.1824	1.1391
Comorbid (SBS)	0	2.68	-2.68	7.1824	2.6826
Not Comorbid (SBL)	535	537.68	-2.68	7.1824	0.0134
Not Comorbid (SBS)	231	228.32	2.68	7.1824	0.0315
Total	775	775	0	28.7296	3.8666
				Results:	Rejected

Table 3d. *X^2 test comparing the prevalence of the comorbidity of both cribra orbitalia and scurvy in each cemetery, as per hypothesis set 3. This was the only consideration framework wherein the null hypothesis was rejected, indicating a significant difference within the data. The nature of such significance is still unknown at this stage, requiring a X^2 Residual and Adjusted Residual test to confirm and locate.*

Results

The sums of the X^2 values were compared to the critical value for X^2 matrices with a degree of freedom of 1 and an alpha value of 0.05 (α=.05), which is 3.84 (Vanpool and Leonard 2011, p.242). This resulted in the failure to reject H_o1, H_o2, and H_o3, and the successful rejection of H_o4. Groups that failed to reject their H_o were excluded from further analysis, since such failure meant that there was no significant difference between the populations' observed and expected values, thus indicating that there was no difference between the prevalence of the respective corresponding conditions. A table was made for the calculation of the X^2 residual and adjusted X^2 residual values for the comorbidity X^2 group (Table 3a). Residual and adjusted residual values could not be calculated for SBS's comorbid category, since there were no observed cases in this population, and it is impossible to divide by zero. However, values were calculated for the other three categories and compared to the residual critical value for α=.05 as provided by Vanpool and Leonard (2011, 246), which is $^{+}/_{-}1.96$. X^2 residual values all fell within the "Expected" range, but as stated by Vanpool and Leonard (2011, 246), the X^2 residual "tends to underestimate the significance of differences for small samples," which this (N=9) undoubtedly is. Therefore, adjusted X^2 residuals (Table 4) were calculated to determine significance of differences between observed and expected frequencies for individuals with both cribra orbitalia and scurvy. The adjusted X^2 residual value for "Not Comorbid (SBL)" was the only statistically significant value (d = -1.9694), indicating that the number of people who did not show comorbidity of both cribra orbitalia and scurvy was lower than expected by a statistically significant margin.

Health Status	Observed	Expected	O-E	X^2 Residual (e) (O-E)/√E	Adjusted X^2 Residual e/√(1-[CT/GT])(1-[RT/GT])	Significant/ Not Significant
Comorbid (SBL)	9	6.32	2.68	0.8933	1.6459	Not significant
Comorbid (SBS)	0	2.68	-2.68	N/A	N/A	N/A
Not Comorbid (SBL)	535	537.68	-2.68	-0.1159	-1.9694	Significant
Not Comorbid (SBS)	231	228.32	2.68	0.1763	1.9530	Not significant

Table 4. *X^2 Residual and Adjusted X^2 Residual tests to determine which sample displays a statistically significant difference between the observed and expected values. It was shown that the "Not Comorbid" group's observed value was significantly lower than the expected value.*

Discussion

The results of the statistical analysis show that it may be possible that lower socioeconomic status puts one at greater risk of multiple dietary deficiencies, thus increasing the risk of infection later in life as per Scott and Hoppa (2018, 699). However, to draw such a conclusion definitively based on such a small sample would be ill-advised. It was shown that there is no difference between lower-class and upper middle-class urban populations in Post-Medieval London regarding the prevalence of cribra orbitalia and scurvy. As it was aptly suggested by Mant and Roberts (2015, 202) and by Lewis (2002, 222), in spite of their relative wealth, upper class individuals would be subject to the same overcrowding, poor sanitation, and early life dietary nutritional inadequacy as the lower class. Another possibility is that cribra orbitalia and scurvy lesions were the result of different factors culminating in the same skeletal effect. The statistical results are congruous with the literature stating that the industrialization and differences between an urban and rural environment are a greater influence on peoples' well-being than socioeconomic status itself (Lewis 2002, 222; Mant and Roberts 2015, 202).

The fact that scurvy and cribra orbitalia are observed in skeletal material points to the idea that there were likely a greater number of people suffering from these conditions to a lesser degree. This is important because the deficiencies associated with cribra orbitalia and scurvy are known to impact one's physiological as well as psychological well-being (Walker et al. 2009, 109-125). The psychological impact of these diseases may have had a radiating effect, since it likely would have affected the people around those with the diseases. With over 13% of the population suffering from either one or the other, the proportion of people who knew or took care of someone with scurvy, cribra orbitalia, or both was likely significant. Furthermore, if Walker et al. (2009, 120) are correct, and megaloblastic anaemia is the prime culprit of orbital lesions diagnosed as cribra orbitalia, the effect on caretakers and community members may have been even more dire, due to the paranoia, depression, and dementia (among others) that are associated with B-Vitamin deficiency.

Individuals may present different skeletal indicators for the same condition, and conversely, present the same indicators due to different conditions. In this case, the author proposes that such skeletal indicators point to the idea that individuals suffering such skeletal changes likely suffered dietary stress or were in more advanced stages of disease than those without. Such skeletal lesions, however, indicate that those afflicted would have had to survive long enough for them to appear. This is not to say that the absence of lesions indicates a "healthy" individual. Health is a multifactorial phenomenon and relies on homeostasis of physiological, psychological, cultural, and societal stimuli (Temple and Goodman 2014, 186-191). However, these conditions are known to have an impact on one's energy and psychological well-being; the presence of skeletal lesions suggests that these pathologies persisted for long enough to affect the psychological status of those exhibiting them.

Conclusion

Despite finding little statistical significance in the data chosen, this essay shows that there was little difference in the nutritional hardships faced by individuals in Post-Medieval urban areas. The author, therefore, provides the answer to the question in saying that socioeconomic status likely played a nominal role in the dietary health of Post-Medieval populations on its own. However, the facts that these diseases affected over 10% of the population, and likely impacted the people around those suffering shows that the psychosocial conditions of urban areas in this period were likely as poor as the sanitation. Further research should include a wider array of cemeteries to expand the sample of individuals who display comorbid pathologies and to compare rural environments to urban as well, since the urban wealthy likely had greater access to the countryside than the poor.

Considerations of age of death, morbidity rates, and other pathologies would contribute to creating a more complete perspective on overall health of subject populations.

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