REVIEW ARTICLE

Bogged Down: A Case Study of Tollund Man Using Bioarchaeological Techniques

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ABSTRACT
This paper explores the bioarchaeological methods employed to investigate bog bodies, which are human remains preserved in peat bogs. The distinctive preservation conditions of bogs have facilitated the remarkable survival of soft tissues, hair, and even textiles, dating back thousands of years. Commencing with a concise historical overview of bog bodies and the associated cultural beliefs, this section elucidates how bogs foster preservation. Bioarchaeological techniques for studying of bog bodies encompass note-taking, photography, radiocarbon dating, isotopic analysis, and medical imaging. Subsequent application of these methods to the case study of Tollund Man, a renowned bog body unearthed in the 1950s, allows researchers to reconstruct Tollund Man's dietary habits, lifestyle, and cause of death, thereby providing fresh insights into the lives of individuals during the Iron Age. The study of bog bodies grants a unique glimpse into the past, and the evolving bioarchaeological methods utilized in their analysis continue to enhance our comprehension of human history.

Keywords: Bioarchaeology, Bog Bodies, Soft Tissue Preservation, Radiocarbon Dating, Isotopic Analysis, Medical Imaging, Tollund Man

INTRODUCTION

Harvesting peat from peat bogs has been done for centuries, usually by hand, to obtain a reliable fuel resource to heat homes (Chapman et al. 2019). Throughout the years, peat cutters have gotten quite the scare when human body parts began to surface during their work. Today, the trade is mechanized, dramatically reducing the likelihood of discovering bodies in the peat bogs (Chapman et al. 2019). Cutting peat by hand significantly increases the chances of unearthing bodies, whereas machinery reduces close contact with the bodies and can easily cut through them. Local Northern European police often received calls to investigate possible homicide cases due to the remarkably well-preserved nature of these bodies, appropriately referred to as 'bog bodies' (Nielsen et al. 2018). The peculiar truth is that these bodies quietly reside in bogs under excellent preservation conditions for millennia before being discovered. What puzzles many onlookers is how someone so ancient can look like they died only days earlier. Bioarchaeologists who study these bodies aim to answer these questions and discover who these people were when they were alive.

While bogs are not the fountain of youth, they have unique circumstances that allow for exceptional preservation of soft tissues. This environment forms with an accumulation of moss in low areas of the landscape, preventing nutrients and oxygen from cycling in the soil due to it being fully saturated with water (Lobell & Patel 2010). Over time, moss grows and accumulates until it creates a wet, swampy environment. During this process, the moss decomposes slightly and releases acidic chemicals, which aid in preserving bog bodies. Sphagnum moss produces one of these chemicals called tannic acid, which is often used to tan animal hides and gives the bog bodies their characteristic darkened skin and orange hair (Lobell & Patel 2010). The combination of anoxic conditions prevents bacteria from decaying the body and the dark, cool environment creates the perfect set of circumstances for preserving soft tissues (Lobell & Patel 2010). Unfortunately for bioarchaeologists, these acidic conditions are not favourable for preserving bone and clothing as they frequently dissolve.

Most bog bodies have been dated to the Pre-Roman Iron Age (500 – 1 BCE) and often met very violent deaths by strangulation, cut throats, decapitation, and execution (Bahn 1997). It has been theorized that either these killings were a form of capital punishment for crimes, or they were sacrifices to the gods to ensure their relationship with the community continues to be profitable (Kelly 2006). The belief in Northern Europe at the time was that bogs were an intermediate space between the earth and the gods, so human sacrifices and other offerings were presented to please the gods (Nielsen et al. 2020). Bogs have also preserved objects which are thought to have been left as offerings, including wood and metal weaponry, leather shields, gold and silver jewelry, large wooden ships, and even butter (Kelly 2006).

In some cases, less acidic bogs have allowed for the preservation of both complete and incomplete skeletons (Nielsen et al. 2020). While maybe not as apparent to the viewer when compared to soft tissue preservation, signs of trauma can still be found on the skeleton and attributed to their death (Nielsen et al. 2020). Although most bog bodies are thought to have died in violent ways, some taphonomic processes can appear similar to trauma, leading to misinterpretations surrounding the cause of death (Lobell & Patel 2010). Whether these bodies truly met violent ends or died of natural causes, these seemingly "socially sanctioned killings" contain many skeletal pathologies suggesting physical deformities that would have affected how the individual looked (Nielsen et al. 2020). People may have regarded an individual who was physically different from their peers as being favoured by the gods, making them a sacrifice of great value (Nielsen et al. 2020). Similarly, sacrifices of parts of a body may have also been viewed as equal to or greater than the value of a whole body being offered (Moen & Walsh 2022).

With a brief history of bog bodies and the conditions that lead to their preservation now established, the discussion will shift towards the bioarchaeological methods most commonly employed to study them: notes and photographs, radiocarbon dating, isotopic ratios, and medical imaging. Each method will be examined regarding its procedure and the data it provides about the individual under study. After describing each method, each one will be applied to the most well-known and best-preserved bog body: Tollund Man.

METHODOLOGIES

NOTES AND PHOTOGRAPHS

Within any branch of archaeology, taking detailed field notes and photographing everything within its original context provides a significant quantity of information (Archaeology Canada – Keeping a Record n.d.). Upon discovering bog bodies, a race against the clock begins to excavate them as safely and quickly as possible to prevent further deterioration of the remains (Glob 1965). Once removed from the homeostasis provided by the bog, the soft tissue begins to dry out, and the body becomes exposed to decaying bacteria (Nielsen et al. 2020). The bodies are quickly transferred into a refrigeration unit for transportation to the place of study, maintaining conditions similar to those found in the bog to aid in preservation. Between the moment of uncovering the body to excavation to preservation in a lab, there is a very narrow window of time for bioarchaeologists to gather crucial contextual evidence (Nielsen et al. 2020). Detailed notes and photographs assist in retaining information that would otherwise be lost when excavating the body, including its orientation and position within the bog (Archaeology Canada - Keeping a Record n.d.). These field notes frequently encompass measurements, descriptions of soil layers and features, artifact catalogues, descriptions of the work conducted at the site, events within each section, and records of any tests performed along with their results (Archaeology Canada - Keeping a Record n.d.).

RADIOCARBON DATING

Once the bog bodies have arrived at the laboratory, one of the first procedures is establishing a date range utilizing radiocarbon dating (Nielsen et al. 2020). Establishing a timeline of when the bodies were interred is crucial, as it offers clues about the cultural background (Moen et al. 2022). These clues can encompass information such as cultural beliefs, diets, gender roles, societal patterns, and mortuary practices, which can be inferred from written and oral histories, as well as other archaeological finds dating to the same time period (Moen et al. 2022). Northern European bog bodies such as Yde Girl have almost all been dated exclusively to the Iron Age (Kelly 2006).

Before the body can be dated, a sample needs to be taken and processed into a material that can be radiocarbon dated (Nielsen et al. 2018). Since bone constitutes the most prevalent type of human remains in the archaeological record, it is typically chosen as the sample (Nielsen et al. 2018). Nevertheless, skin and muscle may also be collected when they are available (Nielsen et al. 2018). Regrettably, this necessitates the removal of a piece of bone, often taken from the best-preserved bones of the individual (Nielsen et al. 2018). The bone pieces are cleaned with a scalpel to remove any large chunks of debris that may be attached before immersing them in hydrochloric acid for several days to dissolve the mineral component of the bone (Nielsen et al. 2018). Subsequently, sodium hydroxide is added to suspend the organic component of the bone, which is then turned into a gelatin-like substance (Nielsen et al. 2018). This substance undergoes a specialized filtration process in a centrifuge to purify the sample (Nielsen et al. 2018). After purification, the sample is freeze-dried and sealed into a tube subjected to combustion, turning the sample into carbon dioxide (Nielsen et al. 2018). By introducing hydrogen and a metal catalyst, they reduce the carbon dioxide to graphite, which can undergo radiocarbon dating (Nielsen et al. 2018).

ISOTOPIC RATIOS

Researchers may also conduct isotopic analysis after transforming the samples into testable material. This process involves comparing the proportions of the stable isotope with the decaying isotope, and the ratio between isotopes can provide various types of information depending on the element under study (van der Pilcht et al. 2004). For example, data on carbon isotopes provides insights into the long-term dietary sources of the individual and how much of their diet was composed of protein (Nielsen et al. 2018). In comparison, nitrogen isotopes provide information on whether the plants and animals in the individual's diet came from marine or terrestrial sources (Nielsen et al. 2018). Lastly, while not commonplace, strontium isotopes may be used to determine the individual's locality when compared with values found in the surrounding landscape (Nielsen et al. 2020).

MEDICAL IMAGING

In contrast to the previously mentioned methods, which can be applied to both osteological and soft tissue specimens, most of the medical imaging techniques in this discussion are relevant exclusively to soft tissues (Zanello et al. 2017). In other bioarchaeological contexts, medical imaging may be employed even when only bone is present (Villa & Lynnerup 2012). In the context of bog bodies, it is a non-invasive means of examining the body's interior (Nielsen et al. 2020). Imaging techniques vary depending on what researchers want to observe and the detail they capture, ranging from X-ray to computed tomography (CT) and magnetic resonance imaging (MRI). X-rays are beneficial for looking at bones and their associated changes but may also be used to view internal organs.

CT scans are similar, except they take more detailed cross-sectional images of the body that are combined using computer software (Zanello et al. 2017). MRI is the most detailed imaging process of the three discussed here, which creates images of organs and tissues such as tumours. Zanello and colleagues (2017) successfully utilized another imaging technique called endogenous fluorescence for non-invasive means of examining remains, including bog bodies. This process employs a laser to stimulate fluorescent particles naturally present within soft tissue, causing them to emit light from areas where they absorb the laser's energy (Zanello et al. 2017). Additionally, this method can differentiate between healthy tissue and tissue containing abnormalities such as warts, as observed on the feet of Tollund Man.

CASE STUDY: TOLLUND MAN

On a spring day in 1950, two peat cutters were working in the Tollund Fen of Bjældskovdal, Denmark, when they suddenly uncovered a face in the peat bog (Glob 1965). Terrified by the possibility of a homicide, local police received a call to investigate the scene (Glob 1965). The officers knew ancient discoveries were somewhat frequent in peat bogs, given that Elling Woman had been found in the same bog in 1938, and intricately carved golden discs and glass beads had also been discovered (Glob 1965). Due to the area's historical significance, museum officials were also called to attend. They included archaeologist P.V. Glob, who later published a book on these findings titled *The Bog People: Iron Age Man Preserved*. They swiftly established that the body belonged to a man who had died centuries earlier, and he was subsequently nicknamed the Tollund Man (Glob 1965). Today, he is known as one of the best-preserved bog bodies found to date and has undergone extensive study to uncover his past.

Upon further excavation, photographs of Tollund Man were taken *in situ*, depicting him lying curled up on his right side, oriented with his head to the west and feet to the east (Glob 1965). They found him in the center of the bog, positioned near the bottom with approximately eight to nine feet of peat covering him (Glob 1965). Glob also made detailed field notes about the body's appearance, which were later analyzed once he could be thoroughly examined in a lab (Glob 1965). Glob observed that Tollund Man had a securely fastened leather cap under his chin, a leather belt around his waist, and a braided leather cord tied into a noose encircling his neck (Glob 1965). The remaining cord length extended over his shoulder and down his back, where the end appeared to be cut from when he was hung at the gallows (Glob 1965). Clothing was otherwise absent from the body due to the acidic bog dissolving away traces of textiles (Lobell et al. 2010).

Since the soil was too soft to bring in machinery to remove Tollund Man from the bog, the excavation team built a wooden box around him, which was attached to horses that pulled him out of the bog (Glob 1965). Tollund

Man and the peat bed beneath him were then sealed and transported to Copenhagen, where he was extensively studied. Upon his arrival at the University of Copenhagen, X-rays were taken of his head and neck to determine the cause of death since the leading theory was that he was hung rather than strangled (Glob 1965). This theory finds support in the indentations on the skin around his neck where the noose was wrapped, except for the back where the knot was positioned (Glob 1965). Through the X-rays, researchers hoped to see dislocation and fractures in the cervical vertebrae, commonly seen in individuals who died by hanging. Unfortunately, due to the acidity of the bog seeping into the tissues, the bone was degraded, and the results of the X-rays were inconclusive (Nielsen et al. 2020). However, the X-rays were still informative since his wisdom teeth were visible and fully erupted, indicating that he had to be older than twenty (Glob 1965). Further examination of tooth wear narrowed his age range to between thirty and forty years old (Giles 2020).

Tollund Man also underwent an autopsy during which his internal organs were examined, and his stomach was dissected to observe the contents of his last meal (Glob 1965). The contents were a mix of boiled grains collectively called gruel and contained seasonal grains available in the winter, such as barley, flax, *Camelina* seeds, and knotweed (Nielsen et al. 2020). By assessing the degree of digestion of the gruel found in his stomach, it was concluded that Tollund Man died approximately twelve to twenty-four hours after consuming his last meal (Glob 1965). After the autopsy, Tollund Man's head and right foot were chemically preserved so that they could be displayed in a museum, making them unsuitable for most bioarchaeological analysis techniques (Nielsen et al. 2018). The remainder of his body was left undisturbed and allowed to dry, enabling examination and further testing to be conducted (Nielsen et al. 2018).

Radiocarbon dating of Tollund Man has been attempted multiple times with variable results (van der Pilcht et al. 2004; Nielsen et al., 2018). Since none of the obtained dates agree, Nielsen and colleagues recalibrated them in 2018 by extracting four samples from various locations on the body, including bone, skin, and muscle (Nielsen et al. 2018). These dates were all close and averaged around 2330 years BP, meaning that he died between 405 and 380 BCE during the Iron Age (Nielsen et al. 2018). Radiocarbon dates were also acquired from the surrounding peat and the wooden track leading into the bog. These structures existed at least two hundred years before Tollund Man's deposition (van der Plicht et al. 2004).

While his last meal was directly observed during the autopsy, it did not provide information about Tollund Man's long-term diet. Carbon isotopic analysis was conducted to compare his diet during adolescence to adulthood (Nielsen et al. 2018). This comparison could provide insights into changes in social status or a shift in reliance on different food sources. A sample was taken to obtain carbon isotope values representing adolescence from the femur since the bone tissue is slower to regenerate (Nielsen et al. 2018). A sample was taken from the ribs for adulthood values since they have a faster bone tissue regeneration time (Nielsen et al. 2018). The analysis revealed no significant difference in diet between the two stages of Tollund Man's life. Nitrogen isotopic analysis indicated that Tollund Man's diet consisted of terrestrial plants and animals (Nielsen et al. 2018). This analysis suggests that he did not reside near water sources. Finally, Nielsen and her colleagues analyzed strontium isotopes to ascertain if Tollund Man originated from the area where his body was discovered. They concluded that he most likely lived within a forty-kilometre radius of the bog.

There has been minimal medical imaging performed on Tollund Man, likely due to his autopsy in 1950 (Zanello et al. 2017). In recent years, he underwent examination using endogenous fluorescence. His chemically preserved foot and dried foot were both analyzed for comparison, which resulted in the identification of several warts on both feet and a scar (Zanello et al. 2017). In 2012, a CT scan was taken of his body for comparative purposes to other wet and dry mummies, and he was observed to have a more radiodense head and right foot than the rest of his body since those areas had a higher water content (Villa & Lynnerup 2012). It is important to note that with desiccated tissues, there can be an overlap in the radiographic ranges of various tissue types (Villa & Lynnerup 2012). This overlap may pose challenges in distinguishing between them, potentially leading to inaccurate results (Villa & Lynnerup 2012).

To conduct further studies, it would be advantageous to perform further CT and MRI scans on Tollund Man's remains to better understand his physical characteristics. These imaging methodologies could provide information from his remaining bones including any pathological conditions he may have suffered from such as osteoarthritis and other degenerative joint diseases (Nielsen et al. 2020). Since his muscles do not reflect what they looked like while he was alive, CT and MRI could show entheseal changes related to repetitive motions. Due to the absence of grave goods accompanying him, it has been challenging to assess Tollund Man's social status and gender identity (van der Pilcht et al. 2004). Medical imaging has the potential to provide insight into craft specialization and Tollund Man's social status within his community. While his social identity may remain a mystery, his genetic identity can be unveiled through ancient DNA (aDNA) analysis. Scholarly articles have yet to mention investigating Tollund Man for viable DNA since the acidity of the bog often degrades DNA, but may be possible to find. If there is any surviving DNA, then there is potential for sequencing his genome to discover his ancestry and medical conditions that are otherwise invisible to the bioarchaeological study methods.

CONCLUSION

Tollund Man is a fascinating case study in bioarchaeology, offering insights into the life and death of an individual from the prehistoric past. Various bioarchaeological methods have provided information on his last meal, age, geographic origin, and pathological lesions. His well-preserved body has provided a unique opportunity to study the health conditions and dietary habits of people who lived over two thousand years ago. Although many questions about Tollund Man's life and identity remain unanswered, the ongoing development of new technologies and bioarchaeological approaches provides hope that researchers can uncover even more about this exceptional individual.

In the continued study of Tollund Man, it would be beneficial to use medical imaging techniques such as CT and MRI scans to provide further insight into his physical condition. At the same time, aDNA analysis may reveal his ancestry and any hidden medical conditions. Furthermore, with the ever-evolving field of bioarchaeology, Tollund Man's story may offer new information that researchers have yet to uncover. Ultimately, Tollund Man's legacy has expanded the understanding of prehistoric societies and serves as a reminder of the value of studying the past to understand the present.

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