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Review Article

The concept of forensic taphonomy: understanding the postmortem processes of dead remains

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Abstract

Taphonomy is the discipline that investigates and interprets all activities that occur to remains after death. Postmortem Interval (PMI) is a critical concept in forensic science and refers to the time elapsed between the death of an individual and the discovery and examination of their remains. Estimating the PMI is often one of the primary objectives in forensic investigations, as it can provide crucial information to investigators, such as the approximate time of death, which is vital in narrowing down potential suspects and reconstructing the events leading to the demise of an individual. By gaining insights into the PMI and the conditions surrounding a body after death, forensic taphonomy can aid law enforcement in solving crime by providing a scientific foundation for estimating when a crime might have occurred. The concept of forensic taphonomy is a dynamic and indispensable aspect of forensic science. It sheds light on the intricate processes that occur after death and helps solve mysteries, bring perpetrators to justice, and offer solace to those affected by the tragedy. As forensic science continues to evolve, so does our understanding of taphonomy, making it an ever-relevant field in the realm of criminal investigations and human identification. The accuracy and dependability of PMI estimates have been substantially improved globally by improvements in methodologies and the incorporation of advanced Systems. However, difficulties still exist, such as differences in insect behavior across geographical regions and the requirement for thorough databases for documented data. Forensic taphonomy is a critical aspect of modern forensic science and as such requires development and research in developing countries hence the purpose of this study.

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INTRODUCTION

Taphonomy is field that studies and evaluates all processes that take place to remains after death. It was first described as the study of burial regulations and death assemblages (Efremov, 1940). Numerous changes have been made to the term, such as Bonnichsen's (1989) definition, which defines taphonomy as the accumulation and alteration of osteological assemblages from the standpoint of site development. Early research on taphonomy came from the fields of archaeology and paleontology, which paid little attention to biological decomposition processes and instead concentrated on the fossil record (Milroy, 1999).

Postmortem Interval (PMI) is a critical concept in forensic science. It refers to the time elapsed between the death of an individual and the discovery and examination of their remains (Cockle and Bell, 2015). Estimating the PMI is often one of the primary objectives in forensic investigations, as it can provide crucial information to investigators, such as the approximate time of death, which is vital in narrowing down potential suspects and reconstructing the events leading to the demise of an individual. However, determining the PMI accurately is a complex task, as it involves the integration of various scientific disciplines, including forensic entomology, forensic anthropology, and forensic pathology (Sutton and Byrd, 2020). Each discipline contributes unique insights and data, making the estimation process a meticulous and multidisciplinary endeavour (Spitz and Diaz, 2020).

PMI estimation plays a pivotal role in criminal investigations and civil cases, disasters, and mass fatalities. Forensic entomology, which studies the colonization of insect species on decomposing remains, is one of the most reliable methods for estimating the PMI during the early stages of decomposition (Siva-Prasad and Aneesh, 2022). The integration of various techniques and expert opinions from different forensic disciplines is essential to ensure the accuracy and reliability of time since death estimations, enabling the legal system to deliver fair and just outcomes. As technology and research in forensic sciences continue

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to advance, the precision of PMI estimations is expected to improve, further solidifying its position as a crucial component of modern forensic investigations (Iqbal et al., 2020).

DECOMPOSITION

Decomposition can be described as the process where a cadaver becomes a skeleton, through the destruction of the soft tissue, is quite complex (Kõrgesaar et al., 2022). In discussing the decomposition process, it is important to put into perspective that, there are no two individuals alike, nor any two decomposition processes that are exactly alike. A body's breakdown is a complex process that ranges from tissue autolysis caused by enzyme release or external processes, such as bacteria and fungus in the bowels or outside, to cellular autolysis caused by endogenous chemical destruction (Knight, 1996). Insects and mammals are examples of predators that take part in and may even speed up the process. Therefore, it may be said that putrefaction (caused by bacteria and fermentation) and autolysis (the aseptic chemical death of cells and organs) are both components of decomposition. In the forensic context, decomposition has a far broader meaning, encompassing all stages from the moment of death to the dissolution of all body parts, but in common understanding, it is synonymous with putrefaction (Cockle and Bell, 2015; Kõrgesaar et al. 2022).

It is a process that varies greatly from body to body, environment to environment, according to whether the body is clothed or naked. The circumstances of the death and the place where the body is found, the climate, and so forth. For example, it is known that putrefaction occurs much faster in bodies that are left in the open air than those immersed in water, whereas buried bodies decay at a much slower rate (Prieto et al., 2004; Cobaugh et al*.,* 2015 DeBruyn et al., 2021).

Decomposition may also vary within the same cadaver, with some parts of the body showing adipocere, other parts mummified, and still others only putrefied (Metcalf et al., 2016). This will be contingent upon the distinct "microenvironments" that arise in the vicinity of their location. The date of death is also challenging to estimate due to the numerous potential interconnections between these conditions. In cases of decomposition, the calculation of the postmortem interval (PMI), one of the most controversial and challenging issues in legal medicine, becomes more acute (Buikstra and Beck, 2006; Márquez-Grant and Roberts, 2021). The interval has been calculated using a variety of methods, with the subjective nature of the individual assessment being taken into account, with the exception of the valuable assistance provided by forensic entomology (a separate discipline that is not addressed in this report). Decomposition is influenced by a variety of factors, including the extent of DNA deterioration, the changes sustained by microanatomical skeletal structure, the persistence of blood remnants in bone tissue, biomarkers such as lipids, nitrogen, amino acid content, neurotransmitters, decompositional by-products, and carbon. Some authors have attempted to investigate the variations of factors that influence decomposition in specific cases, either prospectively through the formation of adipocere (Forbes et al., 2004; Gomes et al., 2020; Mickleburgh et al., 2021) or retrospectively (by analysing cases that have already been solved in order to study particularly extrinsic factors that affect it (Kahana, et al., 1999; Gomes et al., 2020).

Decomposition provides resources for the habitats and also plays a large role in recycling nutrients and organic matter in ecosystems (Swarzenszki et al, 2008). Necrophagous insects are the predominant eukaryotes that contribute to vertebrate carrion decomposition (Payne 1967; Benecke 2001; Archer 2003, Matuszewski et al*.,* 2010) other organisms such as bacteria and fungi also play a significant role in decomposition ecology, they account for up to 99% of organic matter on earth (Matuszewski et al*.,* 2010). As soon as dead cells begin autolysis, they release enzymes during this period, microbes utilize the nutrients produced, this process is known as putrefaction (Vass et al, 2002). (Matuszewski et al, 2010) conducted research and noticed that species like diptera: calliphoridae consume the carrion organic matter directly. While some like coleopteran: silphidae use the carrion as a location to find prey (Gibbs and Stanton 2001).

STAGES OF DECOMPOSITION

Fresh Stage

This is where the decomposition usually starts, immediately after death with some of its major features being greenish discoloration of the abdomen, livor and tache noir; insect activity starts with the orifices and fissures present in the body and autolysis is evident (Megyesi et al., 2005; Goff, 2009; Pittner et al., 2020). The fresh stage usually starts after the heart stops beating. Although the body appears fresh from outside, the bacteria that is found within the carrion begins to eat away at the soft tissues. Few hours after death, colonization of the corpse by extrinsic organisms may begin within few hours of death, especially by insects like blow flies (Calliphoridae) which may be attracted to the body within few minutes of exposure (Janaway, et al 2009). After death, the body temperature begins to decrease in order to align with the temperature of the surrounding environment, and the blood is drawn downward by gravity to the lowest point in the body. Calcium accumulates in the muscles of the carrion after 3-4 hours, causing them to become inflexible. This rigidity will reach its maximum at 12 hours and will dissipate by 48 hours following the individual's demise. At this juncture, cell walls lose their integrity thereby releasing enzymes to process the tissues in the body and bacteria already present break down the intestinal walls (Almulhim and Menezes, 2023).

Bloat Stage

The bloating stage is where putrefaction begins. Anaerobic bacteria in the abdomen begin to digest the tissue; this causes gases to be released thereby inflating the abdomen (Goff, 2009).

As bacteria process the body, gases are produced as by-products (Pimentel et al., 2013). Bacteria undergo anaerobic respiration and produce gases as by-products such as hydrogen sulphide, methane, cadaverine, and putrescine. The build-up of resulting gas inflates the cadaver and eventually forces fluids out (Hyde et al*,* 2013). Maggots hatched from flies' eggs feed on the surrounding body tissues where there is usually a shift in aerobic bacteria (*Staphylococcus* and Enterobacteriaceae) to anaerobic bacteria (*Clostridia* and *Bacteroides*). Janaway et al. (2009) noted that the initial breakdown of tissue is due to autolysis as well as the action of bacteria present in the tissues.

Active Decay Stage

This is featured by skin breakage, deflation of the carrion and strong putrid smell at the end of the stage (the insects would have eaten up most of the soft tissues (Goff, 2009; Gomes et al., 2020). During this stage of decay, the skin breaks due to putrefaction and the action of maggots, allowing the accumulated gases to escape. Partly for this reason, the body emanates strong, distinctive odours (Dawson et al., 2020). At this point, the tissues begin to liquefy and the skin will start to blacken. Blowflies target decomposing corpses early on, using specialized smell receptors, and lay their eggs in orifices and open wounds. The carrion may start to have adipocere and wax formation on some parts.

Advanced Decay Stage

During the advanced stage of decay, the body starts to dry out and loses majority of its bulk. At this point, the body's fluids have either evaporated or drained and entomological activity has significantly decreased (Martinez et al., 2007) because of the discontinuities in the skin which will for oxygen to enter the body and cause deterioration by aerobic organisms like fungi. At this point, there is a noticeable rise in several chemicals found in the soil of the Carrion decomposition island (CDI), including calcium, magnesium, salt, potassium, and nitrogen. A rise in vegetative growth on the CDI's border has also been proposed (Carter et al., 2007) as one such discrete point, even though it can be challenging to identify when one stage of decomposition stops and the next begins. In this stage, the body is usually reduced to just skin, cartilage and bones and the coleoptera replaces the dipteral colonists. The remains may become completely skeletonized with little odor or grease present. The skeleton may show early signs of exfoliation either by sun bleaching or weathering. There may be signs of carnivore scavenging or rodent gnawing. Mice, wasps or other animals may utilize the skull as a nest (Goff, 2009).

Dry remains/Skeletonisation Stage

At the dry stage only bones, dry skin and hair are left, by this time, the insects have completed their task. The PH of the soil may return back to its original level, as well as the soil fauna (Goff, 2009). Of of the characteristic feature of this stage is that, the bone surfaces break down and have an exfoliated appearance due to the harsh effects of the weather and scavengers. Longitudinal cracks occur, and the external cortex may flake away leaving the bone to appear significantly weathered and continue to show evidence of fragmentation over time (Dupras et al., 2012).

CADAVER MASS

Several studies revealed the high importance of cadaver mass for pattern and rate of decomposition (Parmenter & MacMahon, 2009; Matuszewski et al. 2014; Matuszewski et al. 2016). Estimates of PMI based on development and succession may be confused by the potential importance of carcass bulk for carrion entomofauna. A single, unrepeated experiment comparing the carrion fauna of two pig corpses weighing 8.4 and 15.1 kg was conducted to investigate its effects (Matuszewski et al. 2020). Because of the limited range of body mass covered in the study, there were no reported size-related changes in the composition of carrion fauna or patterns of its succession (Matuszewski et al. 2020). The carcass bulk may have a variety of effects on carrion entomofauna. First, the makeup of the carrion insect assemblage may be structured by body mass (Hewadikaram & Goff, 1991; Matuszewski et al. 2014, Sutherland et al. 2013; Matuszewski et al. 2020).

Different-sized carcasses signify various amounts and types of insect succession. In comparison to smaller corpses, larger carcasses include more fat and number of muscles (Matuszewski et al. 2016, Bruns et al. 2004). Additionally, active decomposition in larger corpses have been found to be less effective and leaves behind significantly more biomass (Matuszewski et al. 2014). As a result, insect assemblages on larger carcasses may be more complex and comprise more larval taxa. It has been shown that larger corpses exhibit longer bloating and active decay (Matuszewski et al. 2014). Insect abundance may also be influenced by carcass mass. Hewadikaram and Goff (1991) found that a larger pig attracted more arthropods. Matuszewski et al. (2014) found that larger carcasses are inhabited by more larvae. Carrion insect pre-appearance intervals (PAI) may also be affected by corpse mass or size. Larger carcasses lose heat at a slower rate (Madea, 2009), which may increase the development of bacteria quickly after death and, in the long run, reduce the time required to produce insect attractants. Carcasses of various masses signify varied amounts and types of resources available to insects. Larger corpses include more muscle and fat than smaller carcasses (Wilson et al. 2007). Furthermore, active decomposition in larger carcasses is less effective, leaving substantially more biomass after its conclusion (Matuszewski et al. 2010).

PIGS AS HUMAN ANALOGUES

In facilities where human donors are not available, pigs make an excellent model to get a general sense of the tendencies that might be observed in humans in later validation trials. Donated human bodies quickly replaced animal counterparts as the favored model for decomposition research with the development of human taphonomic facilities. Compared to data obtained from studies on non-human models, the outcomes of such studies are more immediately applicable to forensic situations (Miles et al. 2020). Since there are a number of problems with this argument, which were most recently compiled by Matuszewski et al. (2020), it has yet to be established. The experiment's donor population and the general population to whom the results are intended to be extrapolated differ in a number of biographical aspects, including age, body mass, and underlying medical disorders that may affect decomposition cycles. This is associated with the inability to regulate donor sample biographics, which results in an unreliable experimental sample and lowers statistical rigor and inferential power (Simmons et al. 2010). For actualistic research, uneven supply creates logistical challenges, chief among them being the creation of a suitable sample size and the requirement for a significant investment in storage capacity. The most obvious, nevertheless, are the ethical and legal issues that forbid most nations from doing taphonomic research on donated human remains (Spicka et al. 2011). When feasible, these facilities are subject to rigorously regulated and open ethical agreements with the donor or the donor's family (Sutherland et al. 2013). These factors make it difficult to gather data that may be used in forensic investigations because there aren't many research institutes that can handle human cadavers. Only ten anthropological research facilities worldwide—located in the United States, Australia, Canada, and the Netherlands—permit the use of donated human remains for taphonomic analysis. Therefore, the majority of forensic taphonomists are limited by the requirement to employ animal analogs rather than human cadavers as research specimens (Miles et al. 2020).

ADVANTAGES OF USING PIGS AS HUMAN ANALOGUES

Pig cadavers can be copied in huge quantities and at a minimal cost, whereas human corpses must be obtained through taphonomic institutions or medical examiner's offices, both of which have inherent challenges. Pig use allows you control over the timing and cause of death. Some noteworthy similarities with human cadavers include body mass range, anatomy, body composition, hair coverage on the skin, and gut microbiome (Matuszewski et al. 2020). Waiting durations in taphonomic institutions for receiving replicate bodies on several donation days are variable and uncontrollable (Schoenly et al. 2005). The difficulty in obtaining replicate human cadavers provides for limited experimental control over major decomposition drivers such as cadaver mass. The unpredictable and uncontrollable variation inherent in cadaver availability may limit the value of human observations and invalidate the experiment, resulting in statistically underpowered comparisons insufficient to detect significant differences and increasing the risk of confounding effects.

Pigs have inspired current theoretical breakthroughs in carrion and succession ecology, as well as our understanding of how vertebrate cadavers decompose in a variety of contexts such as indoor, suspended, buried, intertidal, marine, and freshwater (Miles et al. 2020). At least five general decomposition patterns can currently be identified: decay driven by vertebrate scavengers, bacteria, burying beetles, blow flies, or blow flies with silphid beetles, each with separate key factors of decomposition rate (Schoenly et al. 2005). Human cadavers have many characteristics that influence decomposition, the majority of which have been studied using pigs. Pre- or post-mortem modifications such as wounds, burning, wrapping, dismemberment, contamination, concealment, and clothing may affect the colonisation process and, eventually, decomposition to varying degrees, depending on their intensity and context of action. Some modifications do not affect the entire cadaver, allowing insects to colonize it as usual, whereas others, such as clothing, have effects on insect colonization or succession that are too small or too variable to have practical implications for PMI estimates (Henssge, 2016).

ALTERNATIVE MODEL ORGANISMS

Pigs are not a viable option in some areas due to religious beliefs, hence alternative animal models are required. Rabbits have been widely utilized by forensic entomologists, as documented by Stokes et al. (2013), however they are obviously too small to be useful for most forensic studies. Carrion insect assemblages are less complex and last less time on smaller cadavers than on larger cadavers (Wang et al. 2017, Matuszewski et al. 2016). Due to their small size, rabbit cadavers decompose significantly faster than pig or human cadavers. As a result, the well-established importance of body size must be recalled when picking alternatives, such as sheep or goats, which are frequently shorn to make bug sampling practicable and to limit the potential impact of the fleece on decomposition, which differs from pig and human circumstances (Miles et al. 2020).

FORENSIC ENTOMOLOGY AND TAPHONOMY

Forensic entomology is a specialized branch of forensic science that deals with the study of insects and other arthropods as they relate to legal investigations. In particular, forensic entomologists use their expertise to estimate the time of death, commonly known as the postmortem interval (PMI), by analyzing the colonization of insects on decomposing remains (Joseph et al. 2011). The science is based on the principle that insect succession patterns follow a predictable sequence as they infest a corpse, with different species being attracted to and colonizing the body at specific stages of decomposition. By carefully studying the presence, development, and behavior of these insects, forensic entomologists can deduce critical information about the timing of death and environmental conditions during the postmortem period (Joseph et al. 2011).

The basics of forensic entomology revolve around understanding the life cycles and behaviors of necrophagous insects, those that feed on dead tissue. The primary group of insects used in forensic investigations are blowflies (Calliphoridae) due to their early arrival at the scene of death and their predictable colonization patterns. Their eggs are laid on or near the decomposing body, and their larvae, commonly known as maggots, hatch and feed on the decaying tissues (Griffiths et al. 2020). The development rate of these insect larvae is highly temperature-dependent, making temperature a crucial factor in calculating the PMI. By establishing the species of insects present, their developmental stages, and the prevailing environmental conditions, forensic entomologists can provide law enforcement and forensic pathologists with valuable insights into the timeline of events surrounding a person's death (Goff, 2009).

THE ROLE OF INSECTS IN THE DECOMPOSITION PROCESS

Insects play a fundamental role in the decomposition process of a dead body, and their activities can significantly impact the postmortem interval (PMI) estimation. As soon as a body becomes available for colonization, insects, particularly necrophagous species, are attracted to it by emission of volatile organic compounds emitted during the early stages of decomposition (Campobasso et al. 2001). The hatching larvae of blowflies for instance, commonly referred to as maggots, swiftly begin to consume the decaying tissues, accelerating the breakdown of organic matter. Through this process of consumption, they create a distinct pattern of tissue removal and modification, which can be studied by forensic entomologists to estimate the elapsed time since death. Other insects, such as beetles and certain fly species, are classified as secondary colonizers and typically arrive at a later stage of decomposition, further contributing to the decomposition process and altering the insect succession patterns (Abajue & Ewin, 2016).

Insect succession patterns in decomposition refer to the predictable and sequential colonization of a dead body by various insect species at different stages of decay. As soon as a body becomes available, it starts to undergo a series of complex changes, releasing a combination of volatile compounds and gases that act as potent attractants for a variety of necrophagous insects (Voss et al. 2009). The first insects to arrive at the scene are typically blowflies (Calliphoridae), which are highly specialized in detecting these chemical cues. Female blowflies lay their eggs on or near the corpse, and the hatching larvae, known as maggots, begin to feed on the decaying tissues. As decomposition progresses, different insect species join the scene, each with its preferences for specific stages of decomposition. Beetles (Coleoptera), for example, are often considered secondary colonizers, arriving at a later stage to feed on dried and decaying tissues (Castro et al.2019).

The process of insect succession in decomposition can be divided into several stages, each corresponding to specific ecological changes that occur on and around the body. (Tembe & Mukaratirwa, 2021). Each stage of insect succession leaves a distinctive pattern of colonization and decay, offering valuable clues to forensic entomologists as they piece together the timeline of events surrounding the death of an individual (Matuszewski et al. 2020).

One of the most critical factors that influences the colonisation of insects on a decomposing body is temperature, as it directly affects the development rate of insects and the speed of decomposition. Warmer temperatures accelerate the life cycle of insects, leading to faster colonization and progression through different developmental stages. In contrast, colder temperatures can slow down insect activity and delay the decomposition process (Tembe & Mukaratirwa, 2021; Wang et al. 2019). Humidity is another crucial factor, as it affects the moisture levels of the corpse, which, in turn, influences the growth and survival of insect larvae. High humidity can promote the proliferation of certain insect species, while low humidity may hinder their development. Additionally, climatic conditions, such as rainfall and seasonal variations, can impact insect colonization by altering the availability of resources and modifying the microenvironment around the body (Campobasso et al. 2001; Defilippo et al. 2023).

The presence of vegetation and other natural habitats also significantly influences insect colonization. Bodies located near water bodies, forests, or grasslands may attract different insect species compared to those found in urban environments (Zeariya & Kabadaia, 2019). Vegetation can serve as a shelter and a food source for certain insect populations, affecting their abundance and distribution (Wang et al. 2019). Moreover, the accessibility of the corpse to insects plays a vital role in colonization patterns. Bodies exposed in open areas are more readily accessible to a wide range of insect species, while those concealed or buried may experience delayed or limited insect activity. Human-made factors, such as the use of pesticides or insecticides in the vicinity of the body, can also alter insect colonization patterns, leading to potential disturbances in the succession process

The analysis of insect colonization patterns and the developmental stages of the collected specimens provides critical information about the timing of death (Wells & LaMotte, 2019). Forensic entomologists use temperature-driven development models, to estimate the insect's accumulated degree-hours or degree-days. These models incorporate temperature data from the crime scene and the known temperature-dependent developmental rates of the relevant insect species (Perez et al. 2014). By calculating the accumulated degree-hours or degree-days, entomologists can approximate the age of the insect specimens, thereby estimating the time elapsed since their colonization on the body (Anderson et al. 2011).

CADAVER DECOMPOSITION ISLAND (CDI)

Cadaver decomposition island is a highly concentrated area of organically rich soil. Cadavers are complex resources that have a heavy microbial inoculum in the form of intestinal and cutaneous microbial communities (Clark, Worrell, and Pless 1997; Wilson 2007). A decomposing body contains a lot of water (60-80%), a lot of lipid and protein (Swift, Heal, and Anderson 1979; Tortora and Grabowski 2000), and a proportion of carbon to nitrogen (C:N) ratio.

A very dense concentration of biologically rich soil can be found on Cadaver Decomposition Island. The cadaver attracts other organic elements like dead insects in addition to releasing nutrients into the greater environment. An intense pulse of water, carbon (C), and nutrients (such as nitrogen and phosphorus [P]) results in the formation of a CDI. The immediate effects of this pulse and the cadaver itself on the vegetation can be seen in the demise of neighboring and beneath ground plants due to leachate and smothering.

The breakdown of cadavers follows a sigmoidal pattern, according to numerous studies on cadaver decomposition (Anderson and VanLaerhoven 1996; Carter 2007; Kocárek 2003; Payne 1965). Cadaver decomposition is also frequently linked to a variety of stages. We use the six stages outlined by Payne (1965) consistently: fresh, bloated, active decay, advanced decay, dried, and remnants. It is frequently believed that temperature affects how rapidly a corpse decays. In order to account for temperature variations, accumulated degree days (ADDs, the total of average daily temperature), might be utilized (Megyesi et al. 2005; Vass et al. 1992).

Several factors can influence the breakdown of a cadaver and the formation of a CDI. These include temperature, moisture, soil type, associated materials, decomposer adaptation, and trauma. Furthermore, these factors may be more or less influential depending on whether a cadaver has been placed on the soil surface (exposed) or buried in the soil (Rodriguez and Bass 1983; Vass et al. 1992; Janaway 2009).

CHALLENGES IN HUMAN DECOMPOSITION RESEARCH

If taphonomic facilities are to regain scientific credibility then they need to focus relentlessly and entirely on rigor, repeatability, accuracy, reliability and scientific experimentation that is underpinned by large sample sizes, multiple black box testing and robust statistical validity (Sue, 2017). The existence of only 10 forensic research facilities that can use human cadavers for decomposition research, presents this problem for researchers.

Many cultures have specific rituals and practices associated with burial. Using cadavers for research may be seen as a violation of these practices, leading to concerns about desecration or disrespect. Some cultures emphasize the intactness of the body after death, making the dissection of cadavers a sensitive issue (Knüsel et al. 2016). Religious beliefs about bodily integrity and respect for the deceased can conflict with the practices of dissection and manipulation in medical education. Different cultures and religions have varying beliefs about the treatment of the deceased (Caffell and Jakob, 2019). In most countries, taphonomic study on donated human remains is prohibited due to legal and ethical concerns. In areas where it is possible, these facilities must closely adhere to tightly supervised and transparent ethical contracts with the donor or the donor's family (Williams et al. 2019). There are biographic differences between the donor population for experimentation and the general population to whom results are intended to be generalized, including age, body mass, and underlying medical disorders that may affect decomposition cycles (Matuszewski et al. 2020). Uneven supply causes logistical issues for actualistic research, particularly the development of a suitable sample size, demanding significant investment in storage capacities.

CONCLUSION

By gaining insights into the PMI and the conditions surrounding a body after death, forensic taphonomy can aid law enforcement in solving crime by providing a scientific foundation for estimating when a crime might have occurred. The concept of forensic taphonomy is a dynamic and indispensable aspect of forensic science. It sheds light on the intricate processes that occur after death and helps solve mysteries, bring perpetrators to justice, and offer solace to those affected by the tragedy. As forensic science continues to evolve, so does our understanding of taphonomy, making it an ever-relevant field in the realm of criminal investigations and human identification. The accuracy and dependability of PMI estimates have been substantially improved globally by improvements in methodologies and the incorporation of advanced Systems. However, difficulties still exist, such as differences in insect behavior across geographical regions and the requirement for thorough databases for documented data. Forensic taphonomy is a critical aspect of modern forensic science and as such requires development and research in developing countries

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