Introduction to Human Taphonomy – Human Taphonomy Begins when Life Ends

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The term "taphonomy", which was introduced earlier in the last century by the palaeontologist Ivan Efremov, is based on the Greek terms "taphos" meaning "grave / burial" and "nomos" referring to "law". Taphonomy as a scientific discipline focuses on the decomposition of organic material from the cessation of vital functions (death) to the fossilization and the discovery of the remains[1].

Human taphonomy, in particular, refers to the study of the human body decomposition through the ages. Generally, forensic institutions in Switzerland consider human remains with a postmortem interval (PMI) of more than 70 years (approx. two generations) as archaeological remains. If the time since death is estimated as more recent (< 30 years in Switzerland), the case has to be investigated from a forensic point of view as legal actions can be taken and responsibilities can be prosecuted in a court of law.

Consequently, the interpretation of taphonomical signs as interpreted by the first analyses of the taphonomical status help the specialists to prepare and choose the correct methodological and instrumental skills to investigate the case(s). Indeed, according to the category of the case(s), i.e. forensic or archaeological, the methodologies and technologies applied are not the same – mostly due to their costs and the quality of expected results.

1 Schotsmans et al. 2017.

M. A. Guggisberg, M. Billo-Imbach (eds.), Burial Taphonomy and Post-Funeral Practices in Pre-Roman Italy. Problems and Perspectives (Heidelberg 2023) 11–18.

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Early and forensic human taphonomy

Analysis and research in forensic human taphonomy aims to investigate and document the cause and circumstances of death. This investigation is known as early taphonomy, also called thanatology. Depending on the state of preservation of the remains, the forensic examiners and pathologists mainly assess the cause and circumstances of death. The estimation of the postmortem interval is based on macroscopic external examination, thermal approach, and postmortem body reactions. Depending on the possibilities, internal examinations can be completed by imaging methods and radiological examinations (Multi Dimensional Computed Tomography – MDCT, Magnetic Resonance Imaging – MRI, 3D-scanning, etc.). A full autopsy is necessary in order to finalize the conclusions on the estimation of the time, the cause and the circumstances of death.

The various decomposition processes of a human corpse cannot be identified as specific steps but must rather be understood as continuums, as they may sometimes occur simultaneously (Fig. 1).

Decomposition processes are very well known and details of the different stages are described in the literature[2]. The decomposition stages include pallor mortis as the first stage of death, which is a paleness that occurs shortly after death[3].

Livor mortis refers to the settling of the blood in the lower portion of the body, causing a purplish red discoloration of the skin[4]. This postmortem characteristic is important for forensic specialists, as a potential indicator that the dead body was moved, since these lividities are mobile until six hours postmortem but are

2 e.g. Madea 2016.
3 Schäfer 2000.
4 Madea 2016.

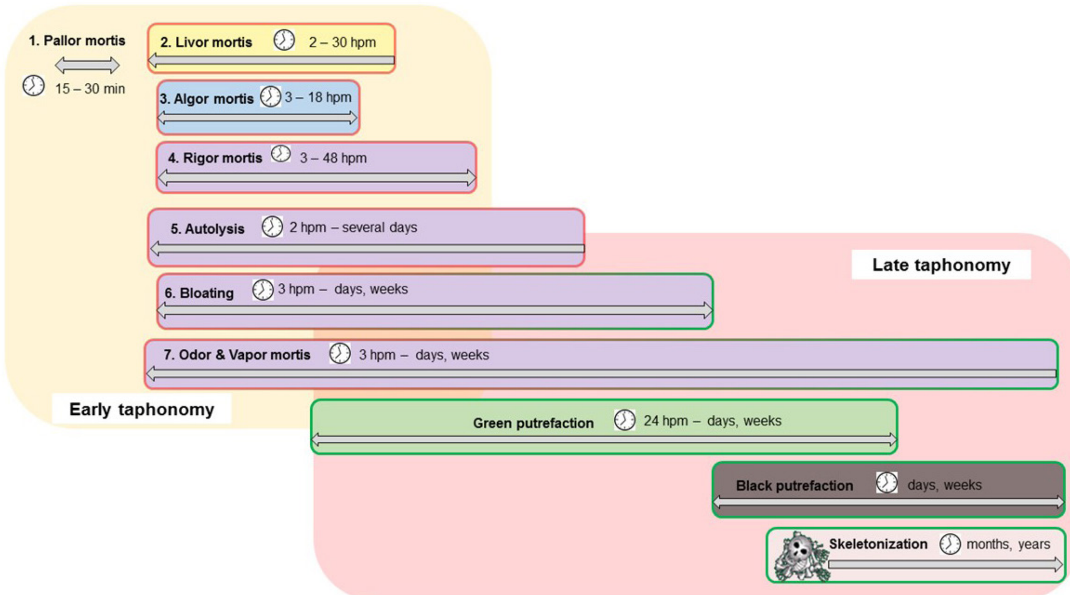

Fig. 1 – Human decomposition processes from early to late taphonomy.

considered fixed after 10 to 12 hours postmortem.

Furthermore, thermal measurements of dead bodies are taken and reported into diagrams to assess a PMI, by relying on the process of algor mortis. This is the change of the body temperature until its alignment to the environment[5].

Rigor mortis is characterized by stiffening of the limbs of the corpse caused by postmortem chemical changes in the muscles[6]. After death, calcium in the organism accumulates, causing a general stiffening of muscular fibers. This postmortem rigidity can last until two days after death. The rigidity decreases gradually as time goes by with autolysis, which corresponds to a cellular breakdown. To estimate a PMI within the first two days after death, thermal methods are therefore mainly used, completed by other observations based on the skeletal muscle electrical and mechanical excitability and pharmacological excitability of the iris[7].

Hospitals and forensic institutes are nowadays able to use additional innovative methods, requiring advanced technologies, such as modern imaging tools. Thanks to Magnetic Resonance Spectroscopy, it is possible to perform thanatometabolomics[8]. The generation of compounds after death could be correlated to a PMI. Various scientists have proposed to analyse the composition of vitreous humor as it is relatively well protected in the eye[9]. However, these approaches are only valid for early taphonomy because these compounds can also be produced by external microorganisms.

As the postmortem interval grows, cellular integrity is lost, and the endogenous cellular content is no longer organized. Additionally, enzymes may attack body cells. This process is called the endogenous biochemical autolysis[10]. Similarly, the endogenous microorganisms begin to "eat" the body internally as they no longer receive sufficient substrates through the usual living human metabolism. This invasion

5 Wardak – Cina 2011.
6 Krompecher 1994.
7 Balci et al. 2010; Larpkrajang et al. 2016.
8 Ith et al. 2002.
9 Girela et al. 2008.
10 Shimizu et al. 1990.

is referred to as endogenous biological autolysis and rapidly leads to the so-called bloating and green putrefaction.

The bloating of the body is caused by an accumulation of intracadaveric gases due to microbial development. The intracadaveric gaseous composition can be measured, leading to the vapor mortis stage[11]. By the start of putrefaction, the body releases a volatile profile composed by odorant or non-odorant volatile compounds. This is called the odor mortis[12]. Odor and vapor mortis can start shortly after death and last a long time. Changes in their composition can inform us on taphonomical stages, because green and black putrefaction do not release the same compounds.

Due to the above-described characteristics, early taphonomy is mostly investigated by forensic examiners and pathologists. The cause and circumstances of death are studied through "cadaveric sciences", including forensic medicine, imaging, anatomy, anthropology, ballistics, etc., i.e. sciences focused on the dead human body.

Late human taphonomy

With an increasing postmortem interval, the thanatological signs vanish. Green and later black putrefaction appear on the bloating body, and then eventually proceed until skeletonization (Fig. 1), which mostly starts with the head and face[13]. These processes are also described as late human taphonomy.

Simultaneously with bloating, microbial ecology begins to grow in the right flank of the intestines. This area turns green after one or two days[14]. The greenish discoloration gradually spreads to the abdomen until it involves the entire body in later stages, and marbling occurs (outlining of the superficial blood vessels). Bacteria generate hydrogen sulfide, which reacts with the hemoglobin and forms sulphhaemoglobin, giving a marbling aspect to the skin.

Once the bloating reaches its maximum stage, the pressure becomes too important and cadaveric fluids are drained through body weaknesses, openings, wounds, and lesions caused by animal scavenging or microbial processes[15]. This is called the cadaveric purge.

Depending on the ambient parameters and individual factors, the body skeletonizes more or less rapidly[16]. Furthermore, depending on the environment where the body is found, desiccation and mummification may occur. In peat bog, the acidity can promote hard tissue destruction and skin tanning. In badly aerated soil with high moisture, the soft tissue may turn into adipocere. In this case, fat turns into a "soap" of sorts, giving the body a waxy appearance[17].

With an increase in PMI, analyses of the body become more and more difficult and specialized examiners are consulted. When dealing with highly decomposed bodies, such as skeletonized remains, forensic anthropologists get involved.

Cadaveric Decomposition Island (CDI)

However, the environment surrounding the cadaver is full of important contextual evidence. This so-called Cadaveric Decomposition Island (CDI) includes the volume of air, water and soil surrounding the body in decomposition[18]. The CDI is investigated through various disciplines, and these analyses can be used to characterize the CDI or the body itself. Investigations of the CDI includes toxicological, genetical (human, vegetal, animal and environmental), macro- and microbiological analyses (Fig. 2). Indeed, cadaveric fluids are released into the CDI, whose biochemical and physical properties eventually change completely. It results in physicochemical and ecological changes, which can be monitored to document the time, cause and circumstances of death.

11 Varlet et al. 2015.
12 Vass 2012.
13 Damann – Carter 2014.
14 Pinheiro 2006.
15 Prahlow – Byard 2012.
16 Bell et al. 1996.
17 Pokines – Baker 2014.
18 Fancher et al. 2017.

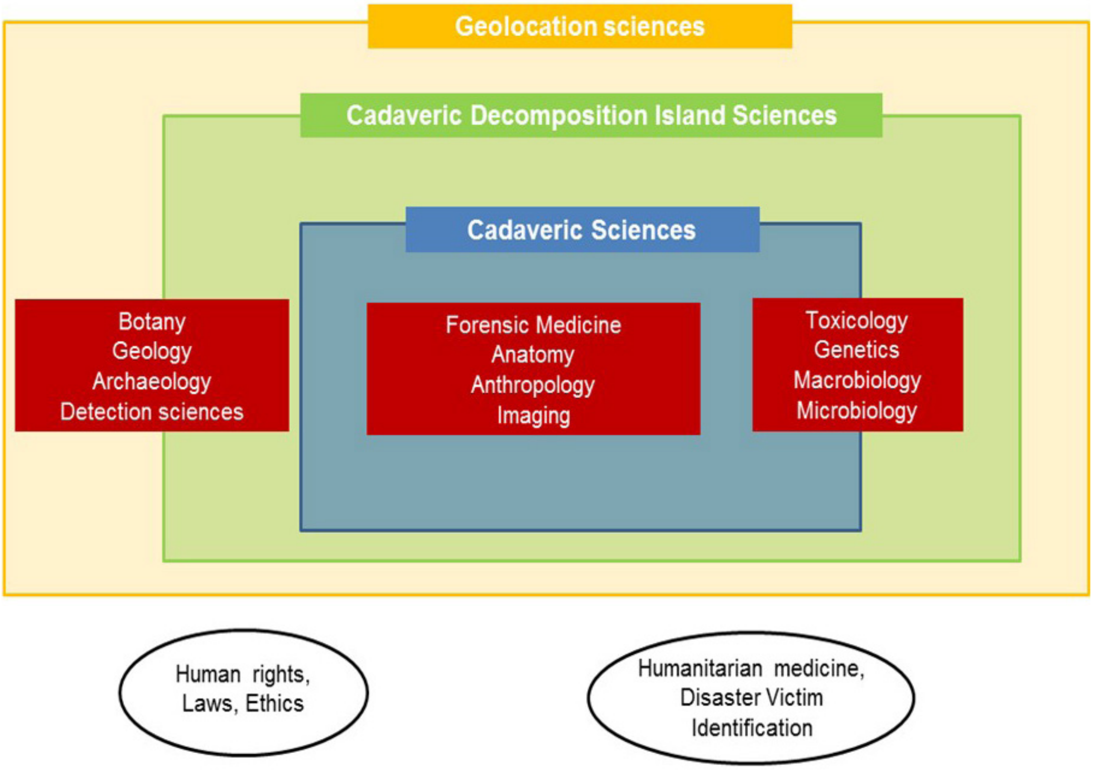

Fig. 2 – The tridimensionality and interdisciplinarity of taphonomy.

Finally, according to the geopolitical and historical context of the case(s), it is sometimes necessary to localize the CDI with remote technologies. This is the case for clandestine individual or mass graves related to war conflicts or homicides. CDIs can be identified thanks to geolocation (drones), aerial photogrammetry, forensic botany and geology, and finally archaeological research.

Human taphonomy must be understood as concentric spatial volumes, which must be carefully investigated beginning from the center, i.e. the human cadaver, thanks to cadaveric sciences, then to the CDI thanks to environmental sciences and finally to the place of the CDI in its environment thanks to geolocation sciences (Fig. 2). This tridimensional structure of techniques must also integrate the human dimension of taphonomy. Indeed, the study of the human body is ruled by specific judicial, ethical and social frames as well as operational emergencies (in specific disaster and humanitarian cases), which must be respected at all time.

As it stands, cadaver sciences are part of CDI sciences, which themselves are embedded in localisation sciences. This multi-layered tridimensional structure evolves with the PMI, and as time goes by evidence might be collected away from the cadaver as its surroundings becomes loaded with forensic interest thanks to cadaveric fluid soaking into the soil. Human taphonomy, however, is also subjected to other external and intrinsic parameters. Indeed, each taphonomy is different as it is influenced by external environmental and climatic conditions[19]. The taphonomic processes will not progress similarly under different climatic conditions (rain, snow, sun, etc.). Moreover,

19 Carter et al. 2007; Cockle – Bell 2015.

the taphonomy of every individual is different due to internal and external intervariability. According to the initial body composition (proportion of fat, etc.), medication, pathologies, habits (smoking, etc.), sex, and age, the taphonomic processes will be intrinsically different among humans.

Every human taphonomy, however, needs to be investigated with the same methodological approaches and tools. To estimate and document the circumstances and the cause of death, several methods related to various disciplines can be applied. Some of them are related to body analysis with cadaveric sciences, and others are focused on the environment and CDI.

Taphonomy in an archaeological context

Within the last decade, taphonomy has become more and more important to forensic and physical anthropologists[20]. However, for both archaeologist and anthropologist, understanding the differences in environmental settings and its impact on the preservation of the body is crucial to obtain a clear picture of the depositional context and the taphonomic changes[21]. As stated by Haglund and Sorg "It is only when viewed through the interdisciplinary lens that the full value of forensic taphonomy can be realized"[22].

Taphonomy plays a major role in archaeological research, however its study within the archaeological realm is a challenge. As mentioned for example by Mickleburgh and Wescott, archaeological remains represent a snapshot of the final stage of the taphonomical processes, deriving from a great number of factors[23]. Archaeological remains, such as findings dating to the Iron Age Europe (such as the burial sites discussed within this special issue), mostly present a very advanced taphonomic stage. Archaeologists, anthropologists, and archaeozoologists are mainly confronted with skeletonized human and animal remains. Depending on burial environment (especially soil characteristics and climatic factors), the state of preservation of the skeletal remains may vary from excellent to bad, and sometimes diagenetic changes may lead to bone dust as the only trace left of human remains within a grave. A large number of human decomposition processes can no longer be detected in archaeological findings. Hence, analyses of human bones dating to prehistoric times, for example, can be extremely challenging. Furthermore, as described by Forbes, the recovering of faunal and human remains may sometimes be biased, and researchers may apply different methods for sampling and recording the archaeological data based on their personal expertise[24]. Research concerning burials of historic and prehistoric populations is indispensable in order to gain knowledge on the past. Understanding human decomposition processes is fundamental when studying human remains in archaeological context. It is correctly noted by Allison and Bottjer that extensive laboratory and field-based research in the last decades has helped to expand our knowledge of taphonomic processes[25]. This knowledge includes a better interpretation of bioarchaeological data in order to understand past populations, as demonstrated by various specialists in that field[26].

The presence of anthropology specialists at archaeological burial sites is therefore vital to ensure that the potential of the site in terms of taphonomic processes is correctly asserted, and that their determination and analysis can proceed. This in turn will lead to a better understanding of the past from a holistic point of view, englobing all information that can be derived from taphonomic, archaeological, and anthropological evidence.

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20 Pokines – Symes 2014.

21 Baxter 2004; Dirkmaat – Cabo 2016; Surabian 2012.

22 Haglund – Sorg 2002.

23 Mickleburgh – Wescott 2018.

24 Forbes 2014.

25 Allison and Bottjer 2011.

26 e.g. Hoogland and Hofman 2013; Knüsel and Robb 2016; Mickleburgh and Wescott 2018; Moreno-Ibanez et al. 2022.

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