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TAPHONOMICAL INVESTIGATION APPLIED TO CLANDESTINE GRAVES

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ABSTRACT. Taphonomy originates as a branch of palaeontology addressed to the study of processes occurring from the pre-agonic stages of an organism to the recovery of the fossilized palaeontological record. The rigorous methodology in recording data and the analysis accuracy allows application in forensic science. The use of taphonomical procedures in studying and searching for clandestine graves is described here. In the search for clandestine graves, taphonomy can help in narrowing the area of investigations, finding sites with adequate diggability and topography, and detecting anomalies on the ground. In the study of clandestine graves, taphonomy in tandem with other disciplines, such as forensic archaeology and anthropology, may contribute to investigation with rigorous excavation methods, stratigraphical survey, environmental reconstructions, sample and evidence records, burial characterization, body positioning and damages, and preservation patterns of human skeletal remains. Applications are also possible in karstic sites where several "*Mafia* cemeteries" may be found in the Italian territory.

1. Introduction

Taphonomy (from the Greek roots *Taphos*=burial and *nomos*=law) is a branch of palaeontology stated by Efremov (1940) as the study of processes occurring from the pre-agonic stages of an organism to the recovery of the fossilized palaeontological record. The subdiscipline had a strong impulse in the '80s of the last century for its applications to vertebrate palaeontology and physical anthropology (Behrensmeyer 1978; Brain 1981; Shipman 1981; R. L. Lyman and C. Lyman 1994; Somma and Costa 2022; Marra, Di Silvestro, and Somma 2023), and later to archaeology (Noe-Nygaard 1987). Recently, applications of taphonomic techniques in forensics increased, giving rise to the sub-branch of "Forensic Taphonomy" (Nawrocki 1996; Bristow, Simms, and Randolph-Quinney 2010; Nawrocki 2016; Pokines, L'Abbe, and Symes 2021; Marra, Di Silvestro, and Somma 2023). Taphonomic procedures and techniques can be applied for search strategies (Donnelly *et al.* 2021) and for the study

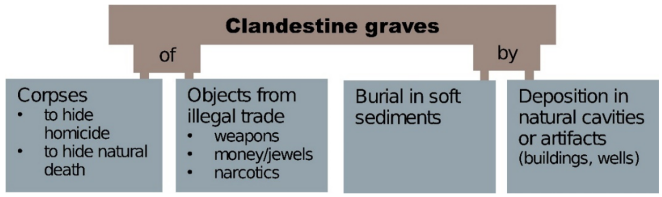

FIGURE 1. Scheme showing the main types of buried items and *substratum* in clandestine graves. Source: Author.

of criminal burials used to conceal underground illicitly drugs, money, weapons, or human remains (homicide graves) (Figure 1).

Using the taphonomic methodology in the recovery of evidence may improve sampling for analysis, by the individuation of the appropriate digging tools, depositional patterns, and biotic bias (roots, scavengers, fungi, bioturbation). According to Nawrocki (1996), Forensic Taphonomy includes Biotaphonomy and Geotaphonomy. Biotaphonomy deals with the human remains, their completeness, and their decomposition *status* and can be biased by environmental (climate and animals), individual (body size and age), and cultural/behavioural factors (*pre-mortem trauma*, embalming, autopsy; Nawrocki (1996) (Figure 2). Geotaphonomy studies the geological context where the corpses were buried, searching for traces left during both digging and deposition, disturbance in vegetal cover after digging, changes in soil pH, erosion, and drainage biases (Nawrocki 1996) (Figure 2).

2. Taphonomy in the search for clandestine graves

Due to the potential for investigating times and modalities of burial, taphonomy may be applied in searching for clandestine graves and concealments (*i.e.*, Geoforensic Search Strategy, hereafter GSS, *sensu* Donnelly and Harrison 2020 and Donnelly *et al.* 2021). Every intentional burial in the soft ground produces a bias and implicates the reworking and repositioning of the removed sediment. Moreover, natural and artificial cavities, abandoned buildings, wells and irrigation channels may be used for the concealment of a corpse. After the delimitation of an investigation area, taphonomy can help to refine the area addressing the search where the substrate is easily diggable or where ruined buildings, caves, rock fissures, wells, and channels are present. A detailed geological and topographic survey, based on both remote sensing activities, supported by GIS-based applications and 3D laser scanner surveys, and field surveying, is also required (Somma *et al.* 2018; Donnelly and Harrison 2020). A clandestine grave in soft sediment/soil is usually refilled with the removed material, which, because of the presence of buried items, produces a more or less pronounced relief on the top of the burial (Salsarola and Cattaneo 2009). Moreover, in the first stages of decomposition, organic gas developed in the abdomen enhances the convexity of the grave (Salsarola and Cattaneo 2009; Caccianiga *et al.* 2021). Later, the surface convexity can change into a depression due to sediment compaction and the chest sagging (Salsarola and Cattaneo 2009). Excavation activities remove the vegetation cover, and differences in the growth of plants or their absence are also expected (Salsarola and Cattaneo 2009). The presence of caves, fissures, dolines, and ravines in karst environments

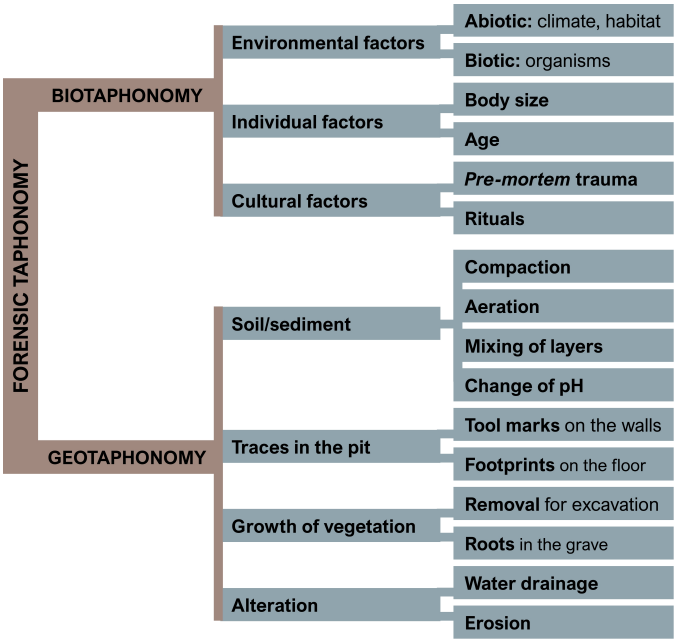

FIGURE 2. Framework of Biotaphonomy and Geotaphonomy fields within Forensic Taphonomy (Source: Author).

and other natural cavities (*i.e.*, cavities in volcanic or sedimentary rocks) is relevant in GSS for their potential use to conceal crime evidence.

3. Taphonomy in the study of clandestine graves

Methods and procedures of taphonomy may help to collect evidence and data from a clandestine grave to recover them and reconstruct processes occurred during and after the burial, as well as in case of concealment of a corpse without burial.

3.1. Excavation methods. The area identified as a possible clandestine grave must be cordoned and excavated with taphonomic *criteria* (Donnelly and Harrison 2020) (Figure 3). Positioning a reference grid is highly recommended to record the exact localization of every evidence and sample (Figure 3b,c). Using taphonomic methods, the excavation proceeds by cutting layers of determinate thickness based on ground characteristics (example: cuts from 1 to 9 in Figure 3). The thickness can be determined based on the granulometry of filling material, or adapted if layers of different materials are encountered (*i.e.* large stones or wood planks, or, items capping the body). Planimetry and photographic documentation should produced for every "cut". This methodology, borrowed by palaeontological and archaeological excavations, is addressed to record precise location and quote of collected evidence and samples in order to obtain the burial stratigraphy, and to distinguish the removed and re-positioned soil from the undisturbed one.

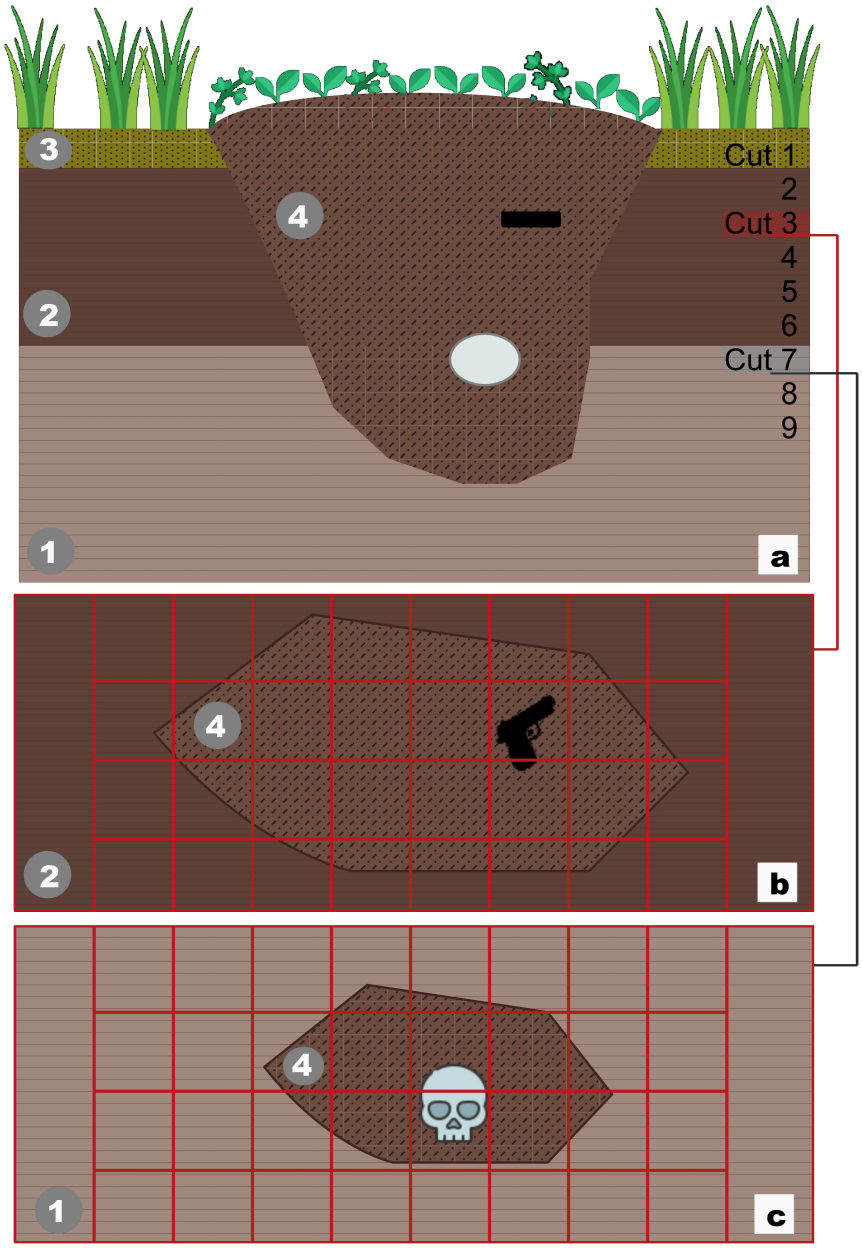

FIGURE 3. Excavation of a clandestine grave: a) stratigraphy; b) planimetry at cut 3 showing a concealed item (firearm); c) planimetry at cut 7 with an emerging skeletal remain (a skull). Legend: stratigraphic layers 1-2-3 of undisturbed stratigraphic succession or pedological profile; stratigraphic layer 4 of reworked sediments; red lines: reference grid; plant, gun, and skull icons from www.Icon8.com. Source: Author.

3.2. Stratigraphy. The burial depth and stratigraphy of a clandestine grave provides information on the time and modalities of digging of the clandestine grave (Figure 3). The burial depth depends on factors such as the diggability, the time available to dig, and the digger's skill. Moreover, the disposition of the re-filling material can be indicative of the accuracy of the burial, in addition to the possible inclusion of physical and biological evidence and traces. Bioturbations consist of sediment disturbance due to the biological activities of roots, small invertebrates and vertebrates, which can move and replace small items or skeletal parts. Walls and bottom of the embedding ground have to be investigated in the search for displaced evidence (Salsarola and Cattaneo 2009; Donnelly and Harrison 2020). Roots do not produce only bioturbation but, when passing through the corpse, they can be used to determine the *Post-Mortem Interval* (PMI) on the basis of dendrochronology (Salsarola and Cattaneo 2009; Pokines 2018; Donnelly and Harrison 2020). When all the filling material is removed, the walls and the bottom can show signs left by the tools used to dig, cracks, and desiccation traces indicating a possible preparation of the pit days before the burial, as well as shoe imprints (Salsarola and Cattaneo 2009; Donnelly and Harrison 2020). The stratigraphy of the filling material may indicate the level of organization of the offender and the time to realize the burial. A shallow burial with a chaotic filling may be indicative of a short time spent for the concealment of the corpse, the use of inadequate instruments, or unskilled diggers; on the contrary, a deep burial or the presence of layers of heavy stone blocks covering the body may be indicative of premeditation and the use of a mechanical excavator (Salsarola and Cattaneo 2009; Donnelly and Harrison 2020; Somma and Costa 2022).

3.3. Data from the buried human remains. A taphonomical excavation provides evidence of the precise position of the corpse in the grave. The decomposition degree of the corpse can be evaluated in *situ* and later during the autopsy, helping to assess the PMI by coroners with the assistance of forensic entomologists. The positioning of the body in the grave can be careful, messy, or can follow a pattern, giving information on the criminal behavior and psychology of the digger, and also helping to understand whether the digger is also the killer or the death was accidental and followed by the concealment of the corpse. The position of the corpse can indicate some rituals, as in the case of natural burials due to religious or ethnographic reasons, or criminal practices, as in the case of *incaprettamento*, a self-strangling induced by a peculiar rope ligature used by the *mafia* criminal organizations to warn and kill traitors (Fineschi *et al.* 1998). It is worth noting the possibility of non-intentional burial of an abandoned corpse or an accidental death by natural events (*i.e.* flooding, landslides, rockfalls) or falls in natural traps (*i.e.* canyons, rock fissures, artificial cavities).

3.4. Environment and decomposition rate. The decomposition of human remains occurs in almost four stages: fresh, early, advanced, skeletonization (Alfsdotter and Petaros 2021). Some environmental variables bias the decomposition (Janaway, Percival, and Wilson 2009; Alfsdotter and Petaros 2021) and can be investigated by means of a taphonomical approach in order to ascertain several features and parameters, such as the presence of clothes/wrapping, soil moisture, Eh, pH, soil type, presence of *humus* and related bacterial community, biological agents (Byrd and Sutton 2020) (roots, decomposer *bacteria*, insects, vertebrates in the ground and scavenging), and climate (possibly indicated by pollen and

other floristic remains). Coroners can use these environmental and chemical-physical data to determine the PMI and consider conditions that can accelerate or delay the decomposition rate, such as freezing, thawing, desiccation, and saponification phenomena (Alfsdotter and Petaros 2021). Soil features and microbial communities in the soil must also be considered in the decomposition process (Carter and Tibbett 2008; Emmons *et al.* 2020; Alfsdotter and Petaros 2021).

3.5. Clandestine graves without burial. The territorial availability of natural caves, especially in karst areas, is often an opportunity exploited by organized crime (in particular *Mafia* and similar criminal associations such as *SacraCorona Unita*, *Camorra*, and *'Ndrangheta*) to conceal their victims. The use of caves, fissures, and ravines is quite common in the cases of *lupara bianca*, consisting in concealing victims of *Mafia* executions. Karstic caves, ravines, and cavities in volcanic and sedimentary rocks are documented as "*Mafia* cemeteries" for releasing a certain number of corpses showing gunshots to the head, typical of an execution[1] (Pomara *et al.* 2015). In these cases, the taphonomic survey consists in reporting the relative position of the corpses and the presence of ligatures or wrapping. In most cases, the site of the murder does not coincide with the place of the concealment and discovery, and corpses were dismembered *post-mortem* and wrapped in plastic bags (Pomara *et al.* 2015), suitcases or carpets to be transported. Cases of dismembered and wrapped corpses thrown in deep ravines inside vehicles were also documented (Pomara *et al.* 2015). Recovery is often carried out by speleologists, being the cavities sites of difficult access, often developed hundreds of meters underground. Accidental death in caves, possibly due to voluntary disappearance, is also known. In the latter cases, corpses lie intact without signs of violence associated with personal belongings. Because of the inaccessibility of these places, the skeletonized remains in natural cavities may be discovered several years later, even decades.

3.6. Skeletonized remains. Experts in taphonomy and anthropology may give a decisive contribution to the analysis of skeletonized remains, helping the direct evaluation of damages to bones, environmental conditions, the original position of the corpeses, eventual bioturbations, and scavenging. The involvement of forensic veterinaries may be also required to ascertain the human origin of the bones. Bones may show evidence of gunshot or knife wounds related to the possible causes of death; they may have fractures caused by aggression before death or fractures already healed. The general *status* of the skeleton may indicate pre-existing pathologies helping the identification or hardship and deprivation suffered by the victim, indicating a possible period of abduction and imprisonment. Bones can also be damaged by exposure to meteoric agents (weathering, *sensu* Behrensmeyer 1978, by transport, fire (thermal alterations, Symes *et al.* 2013), animal predation, and scavenging (Behrensmeyer 1978), which can be highly indicative in reconstructing *peri-* and *post-mortem* events. Weathering on bones accurately buried may indicate a repositioning of the skeleton. Weathering can also occur in case of shallow burials and subsequent exposition to meteoric agents of the skeleton. In other cases, scattered remains can be found unburied, and the taphonomic analysis of the bone can conduct to the death causes.

[1] I resti nella Grotta dell'Etna sono di un uomo che zoppicava. Continuano le indagini per dare un'identità a mister Omega di Silvestre M. (2022). https://catania.meridionews.it/articolo/98793/

Moreover, a taphonomist with experience in mammal palaeontology can support anthropologists and coroners in the determination of sex, age, and pathologies detectable in the skeleton. The extraction of DNA is essential to identify human and skeletonized remains. The DNA comparison of unknown people with that of the missing persons disappeared in the supposed time of the burial may provide information on potential matches. It is worth noting that DNA preservation depends on burial and soil characteristics, physical and chemical conditions, and the microbial community (Emmons *et al.* 2020). Bones are in a continuous exchange with the surrounding environment, and their organic and bioapatite fractions decay, due to the presence of a *microbiota*, leading to a significant DNA decay (Lega *et al.* 2017; Emmons *et al.* 2020). Demineralization of the bone and moisture can accelerate DNA decay (Emmons *et al.* 2020).

4. Discussion and conclusions

Forensic taphonomy represents a powerful tool for experts in forensic sciences and geology. Applications in the study of gravesites may improve the evidence record and contribute to a reliable reconstruction of *peri-* and *post-mortem* events. Unfortunately, in Italy, the involvement of taphonomists, forensic archaeologists, and physical anthropologists is still infrequent. A recent case highlighted the limitations due to the lack of a GSS and taphonomic *criteria*. At Novellara (RE, Italy), there was the suspect that a missing person was killed and buried underground nearby the house, in a cultivated area. Despite the wide employment of law enforcements and cadaver dog handlers for the surface search, the body was found 575 days later, following the indications of one of the concealers. The ruined country house where the body was buried was inspected by the searchers almost twice without positive results. After the first inspection, a reporter of a popular television program focused on the country house, describing to the TV public some site conditions consistent with a clandestine grave (dry vegetation and brick *cumulus*). Shots reported in TV programs showed as under a few bricks, the ground was still soft, as proved by tests with a metal T-bar. Excavations began immediately and were stopped when part of the corpse was encountered. It seems that a forensic archaeologist was called in only a few days after the finding of the gravesite and it was not completely evident if the removed soil infilling the illicit grave was sorted under the supervision of the forensic archaeologist or stratigrapher. Another criticism in applicating the forensic taphonomy relies in the recovering methods. Too many are yet the cases where the skeletonized remains are damaged by not appropriate procedures of excavation, such as the use of mechanical excavators or digging by hand instruments (picks, shovels) used by not specialized personnel. These elements should be considered, and education and training activities (Somma 2022) should be addressed to the achievement of awareness of the consequences due to inadequate investigation methodologies.

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References

Alfsdotter, C. and Petaros, A. (2021). "Outdoor human decomposition in Sweden: A retrospective quantitative study of forensic-taphonomic changes and postmortem interval in terrestrial and aquatic settings". *Journal of Forensic Sciences* **66**. DOI: 10.1111/1556-4029.14719.

Behrensmeyer, A. (1978). "Taphonomic and ecologic information from bone weathering: Paleobiology". *Palaeobiology* **4**. DOI: 10.1017/S0094837300005820.

Brain, C. K. (1981). *The Hunters or the Hunted? An Introduction to African Cave Taphonomy*. University of Chicago Press. DOI: 10.1017/S0016756800025103.

Bristow, J., Simms, Z., and Randolph-Quinney, P. (2010). "Taphonomy". In: pp. 279–318. DOI: 10.1201/b10727-10.

Byrd, J. and Sutton, L. (2020). "Forensic entomology for the investigator". *Wiley Interdisciplinary Reviews: Forensic Science* **2**, e1370. DOI: 10.1002/wfs2.1370.

Caccianiga, M., Caccia, G., Mazzarelli, D., Salsarola, D., Poppa, P., Gaudio, D., Cappella, A., Franceschetti, L., Tambuzzi, S., Maggioni, L., and Cattaneo, C. (2021). "Common and much less common scenarios in which botany is crucial for forensic pathologist and anthropologists: a series of eight case studies". *International Journal of Legal Medicine* **135**, 1–11. DOI: 10.1007/s00414-020-02456-0.

Carter, D. and Tibbett, M. (2008). "Cadaver Decomposition and Soil". In: pp. 29–51. DOI: 10.1201/9781420069921.ch2.

Donnelly, L. and Harrison, M. (2020). "The geoforensic search strategy: A high assurance search method to assist law enforcement locate graves and contraband associated with homicide, counter terrorism and serious and organised crime". *The Journal of the Geological Society of Japan* **126**, 443–458. DOI: 10.5575/geosoc.2020.0029.

Donnelly, L., Pirrie, D., Harrison, M., Ruffell, A., and Dawson, L. (2021). *A Guide to Forensic Geology*. Geological Society Publishing House. URL: https://books.google.it/books?id=kI1DEAAAQBAJ.

Efremov, J. (1940). "Taphomony: a new branch of geology." *Pan-Am. Geologist* **74**, 81–93.

Emmons, A. L., Mundorff, A. Z., Keenan, S. W., Davoren, J., Andronowski, J., Carter, D. O., and DeBruyn, J. M. (2020). "Characterizing the postmortem human bone microbiome from surface-decomposed remains". *PloS one* **15**(7), e0218636. DOI: 10.1371/journal.pone.0218636.

Fineschi, V., Dell'Erba, A. S., Di Paolo, M., and Procaccianti, P. (1998). "Typical homicide ritual of the Italian Mafia (incaprettamento)". *The American journal of forensic medicine and pathology* **19**(1), 87–92. DOI: 10.1097/00000433-199803000-00017.

Janaway, R., Percival, S., and Wilson, A. (2009). *Decomposition of human remains in Microbiology and Aging. Clinical Manifestations*. DOI: 10.1007/978-1-59745-327-1_14.

Lega, C., Fulgione, D., Genovese, A., Rook, L., Masseti, M., Meiri, M., Cinzia Marra, A., Carotenuto, F., and Raia, P. (2017). "Like a pig out of water: Seaborne spread of domestic pigs in Southern Italy and Sardinia during the Bronze and iron ages". *Heredity* **118**(2), 154–159. DOI: 10.1038/hdy.2016.74.

Lyman, R. L. and Lyman, C. (1994). *Vertebrate taphonomy*. Cambridge University Press. DOI: 10.1017/cbo9781139878302.

Marra, A. C., Di Silvestro, G., and Somma, R. (2023). "Palaeontology applied to criminal investigation". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A4. DOI: 10.1478/AAPP.101S1A4.

Nawrocki, S. (1996). "An outline of forensic taphonomy". *University of Indianapolis Archeology & Forensics Laboratory (http://archlab. uindy. edu)*.

Nawrocki, S. (2016). "Forensic taphonomy". In: *Handbook of forensic anthropology and archaeology*. Routledge, pp. 415–432.

Noe-Nygaard, N. (1987). "Taphonomy in archaeology: with special emphasis on man as a biasing factor". *Journal of Danish Archaeology* **6**(1), 7–52. DOI: 10.1080/0108464x.1987.10589975.

Pokines, J. T. (2018). "Two cases of dendrochronology used to corroborate a forensic postmortem interval". *Journal of Forensic Identification* **68**(4), 457–465.

Pokines, J. T., L'Abbe, E. N., and Symes, S. A. (2021). *Manual of forensic taphonomy*. CRC Press. DOI: 10.4324/9781003171492.

Pomara, C., Monica, S., Maglietta, F., Sessa, F., Guglielmi, G., Turillazzi, E., *et al.* (2015). ""Lupara Bianca" a way to hide cadavers after Mafia homicides. A cemetery of Italian Mafia. A case study". *Legal Medicine* **17**(3), 192–197. DOI: 10.1016/j.legalmed.2014.12.008.

Salsarola, D. and Cattaneo, C. (2009). "Archeologia forense". In: *Scienze Forensi – Teoria e prassi dell'investigazione scientifica*. Ed. by A. Intini and M. Picozzi. Milano: UTET Giuridica Publisher, pp. 207–226.

Shipman, P. (1981). *Life history of a fossil: an introduction to taphonomy and paleoecology*. Harvard University Press, Cambridge, Mass. DOI: 10.2307/2802289.

Somma, R. (2022). "Advances in Flipped Classrooms for Teaching and Learning Forensic Geology". *Education Sciences* **12**(6), 403. DOI: 10.3390/educsci12060403.

Somma, R., Cascio, M., Silvestro, M., and Torre, E. (2018). "A GIS-based quantitative approach for the search of clandestine graves, Italy". *Journal of forensic sciences* **63**(3), 882–898. DOI: 10.1111/1556-4029.13677.

Somma, R. and Costa, N. (2022). "Unraveling Crimes with Geology: As Geological and Geographical Evidence Related to Clandestine Graves May Assist the Judicial System". *Geosciences* **12**(9), 339. DOI: 10.3390/geosciences12090339.

Symes, S. A., L'abbé, E. N., Pokines, J. T., Yuzwa, T., Messer, D., Stromquist, A., and Keough, N. (2013). "Thermal alteration to bone". In: *Manual of forensic taphonomy*. CRC Press, pp. 382–417. DOI: 10.4324/9781003171492-14.

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