



Case report

The bodies of two missing children in an enclosed underground environment

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ABSTRACT

Two young children, respectively 11 and 13 years old, originally from a small town of Southern Italy, were missing on 5 June 2006 (06:30 p.m.). Soon after their disappearance, the search for the missing children began. Broadcasters promptly transmitted a description of the missing children, pushing the entire community to assist in the search and safe recovery of the children. However, every effort was in vain, and the search went on for more than 1 year. During the missing-child search, the investigators collected enough evidence against the father, who was arrested 17 months after the children's disappearance. He was indicted for kidnapping, homicide and concealment of the two bodies. He never confessed to the crimes and claimed to be innocent.

Three months after the conviction, a fireman found the two corpses in a subterranean, dry cistern next to a well over 20 m deep. The bodies were well preserved, almost mummified, with only few body-parts skeletonised. Based on dental records, they were identified as those of the two children, who had gone missing 1.5 years before. Signs of a very low insect activity were present, reasonably consistent with a rapid skin dehydration. The autopsy showed no signs of defence injuries or ligature consistent with strangulation or captivation, except for fractures of the axial skeleton at a number of points consistent with a fall from a low-medium height. The body of the elder brother presented major injuries with signs of recent haemorrhages and gut content analysis consistent with the last meal, which provided enough evidence to ascertain a very short survival time. The younger child showed minor injuries, signs of old haemorrhages and gastric- and intestine-emptying time consistent with a longer survival time of approximately 3–4 days, spent alone in the dark and cold cistern. A long post-mortem interval (PMI) of approximately 20 months was estimated, mainly from the pattern of insect succession. Based on such physical evidence, on 4 March 2008, 4 months after conviction and 40 days after the recovery of the two bodies, the father was finally released from prison and exonerated from previous indictment of homicide.

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The words 'missing child' usually bring to mind tragic and frightening kidnappings reported in the national and international news. However, a child can be missing from their caretakers for many reasons, and the problem of missing children is far more complex than the headlines may suggest [1]. Runaways have sometimes been referred to as the "voluntary missing", to distinguish them from abducted and lost children. In fact, it is generally recognised that children, who leave home prematurely, often do so as a result of intense family conflict or even physical or psychological abuse [2]. Children missing involuntarily because they were lost, injured or stranded and those missing for benign

reasons account for another substantial number of missing children [1]. Investigators, police officers and law-enforcement professionals should recognise that children, who become missing involuntarily (because they are lost, injured or stranded), make up a significant part of missing children overall, thus avoiding wrongful conviction and injustice as occurred in the following case.

The article aims to illustrate a little-known but noteworthy case concerning the unhappy story of two missing children found in an enclosed underground environment, approximately 1.5 years after their disappearance. Their father was wrongfully indicted for kidnapping, double homicide and concealment of the bodies. In particular, search operations, methods of investigation and the indictment process will be highlighted and discussed in reference to the autopsy findings and physical evidence collected on the scene and from the bodies. The reconstruction of the events was made possible by the co-operation among the different disciplines

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of forensic sciences, that is, forensic pathology, forensic anthropology, forensic taphonomy, molecular genetics and, last but not least, forensic entomology.

1. Case history

A and B, two young brothers 11 and 13 years old, respectively, were originally from Gravina in Puglia, a small town in the Province of Bari (Southern Italy) located in the so-called 'Alta Murgia'. The peculiarity of this territory is its unique geographical and morphological features caused by the long-term rain and water erosion of the rocks, a phenomenon called 'carsism'. In such an area, there are many canyons and deep carsic caves. In October 1993, some of the oldest human remains found in Europe, the approximately 400,000-year-old calcified 'Altamura man', from the Pleistocene period [3], were discovered in a limestone cave.

A and B were missing on 5 June 2006 at 06:30 p.m. After a lunch consisting of vegetables and some meat (pork and rabbit), they did their homework and, in the afternoon, they went to meet their friends. Some of them said to have seen the two children alive for the last time, playing football close to a fountain in a little square of the old part of the town. Soon after their disappearance, the missing-child search began. Several law-enforcement agencies got involved, but every effort was in vain. The direction the children went in was recorded for a very short time by a video-surveillance camera. The elder brother (A) was wearing a white shirt, grey jacket and white trousers, while the younger (B) was wearing an orange jacket and blue jeans. Because of the carsic area, several speleological teams were also at work searching for the missing children in deep caves, canyons and wells in the area surrounding Gravina.

Broadcasters and the local press promptly aired and printed pictures of the missing children, provided by the parents in television (TV) interviews, urging the public and the entire community to assist in the search and safe recovery of the children. But, for more than a year, every effort was in vain. During that period, several different hypotheses were proposed, ranging from child abuse, kidnapping by paedophiles or Satanists, a runaway episode or even a voluntary escape from the family as a result of intense conflict. In fact, the parents have been divorced since 1997 and the father, a truck driver, was severe and violent

with his wife and children. There was a dispute over custody, and the children were assigned to the father because the mother was homeless and unemployed. After the divorce, the father of the boys married again, and he had a baby girl; but the two children were not happy in this new family and, sometimes, they ran away back to their mother.

During the missing-child search, the investigators collected enough evidence for this case from environmental evidence and phone interceptions and an eyewitness, a friend of the boys who had seen the two brothers alive for the last time. The eyewitness said that he had been playing football with A and B next to the fountain, in the old part of the town, when the father had stopped them playing. He had picked the two brothers up and driven away in his car reproaching and beating them hard because they were already in punishment for some reason. Mainly based on this evidence, 17 months after their disappearance, on 27 November 2007, the father was arrested. He was indicted for kidnapping, homicide and the concealment of the two bodies. He never confessed to the crimes, and he always claimed to be innocent.

After 3 months' imprisonment, on 25 February 2008, in Gravina, a young 11-year-old boy fell into a dry well over 20 m deep, while playing with friends. At first, one of his playmates tried to get him out but in vain; hence, the child decided to call for help. A fireman climbed down the well where he found two additional bodies close to the young boy, who was still alive but whose right leg was fractured. The dry water well was located in a very old and abandoned house (so-called "100-rooms house" or the "mystery house") in the centre of the old town, very close to the fountain where A and B have been seen alive for the last time. Even though the house was abandoned and surrounded by 3-m-high brick walls, the local children said they often used to go there because it was the ideal place to play hide-and-seek, being very big with several rooms on different floors, below and above the ground floor, with no adults around.

The access to the 22-m-deep well was located at the second floor of the house at the top of a short stairway, originally closed by a small brick wall (Fig. 1). The fireman was able to get down the well, rescue the young injured boy and climb back up using some rungs meant for service inspection located on the front wall. The same rungs were also used by the young injured boy's playmate. At

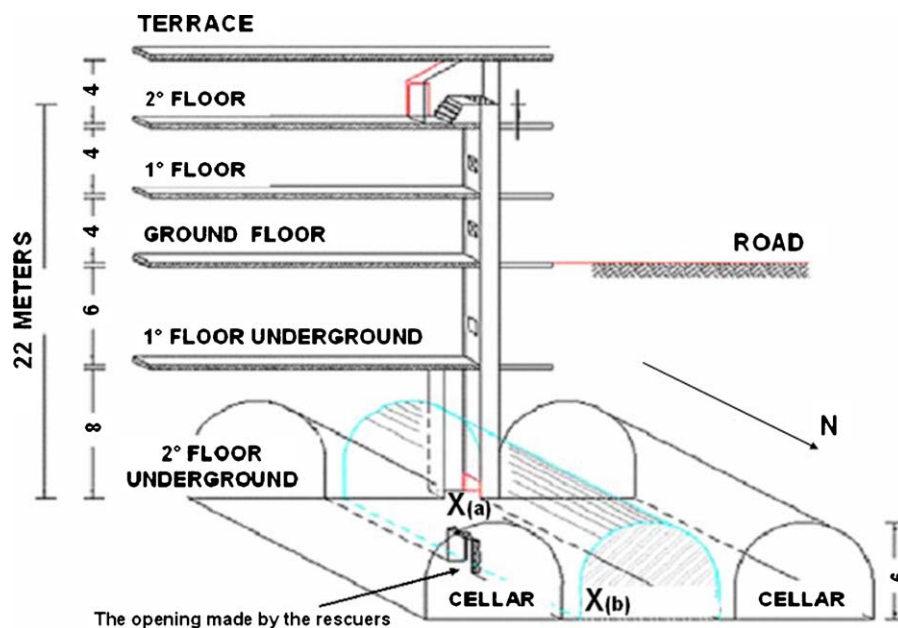


Fig. 1. The 22-m deep well and the cistern where the two bodies were found: (a) location in the cellar where the body of the elder brother A was found and (b) location in the cellar where the body of the younger kid B was found. N: North direction.

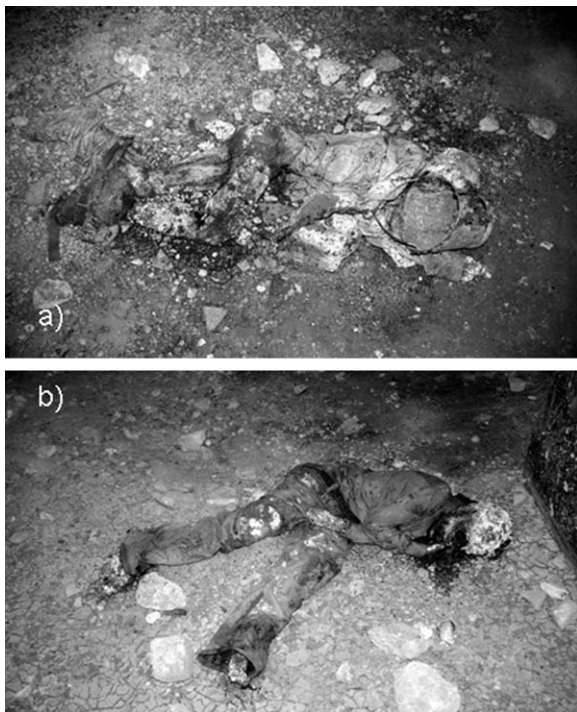


Fig. 2. The two bodies found in the dry cellar: (a) the elder brother, was found just in front of the opening access to the 22-m deep well and (b) the younger kid, was found a few metres far from his brother in North direction.

the bottom of the well, the fireman found also some stone bricks, which had fallen along with the injured boy from the top of the stairway and an opening access (approximately 1.5 m wide) to a 10-m-long dry cistern, an underground basement where the two additional bodies were located (Fig. 1). The subterranean basement was a totally closed environment where the only escape route was to climb to the top of the well. To get into the cistern, the rescuers made an opening through the wall of an adjacent cellar. The environment was totally dark except for a very faint light coming from the northern part of the basement on sunny days. The temperature in the basement was 7 °C below the temperature recorded outside (13 °C) at surface level. The human remains were later positively identified as those belonging to the missing brothers, mainly based on dental records.

The body of the elder brother A was found just in front of the opening access to the 22-m-deep well, close to an old bucket. A was lying on his left side, still wearing his white shirt and trousers, partially removed. The body was almost mummified, with the face and neck partially skeletonised, as well as the right foot, disarticulated. A few metres to the north of A was the body of his younger brother B (Fig. 2). B was still wearing his orange jacket and the blue jeans, exactly as filmed by the video-surveillance camera on the day of his disappearance. The body was also lying on its left side, well preserved, almost totally mummified. Signs of a very low insect activity were present on both bodies, reasonably consistent with a rapid skin dehydration, typical of dry and windy conditions. The clothing was partially covered by puparia.

2. Autopsy findings, physical evidence and reconstruction of events

During the autopsy, the bodies did not emit any smell as they were reduced almost to skeletons covered by a thick leathery skin. Evidence of mummification was clearly displayed by desiccation and brittleness of the skin, which was stretched tightly across anatomic prominences such as the cheekbones, the long bones of

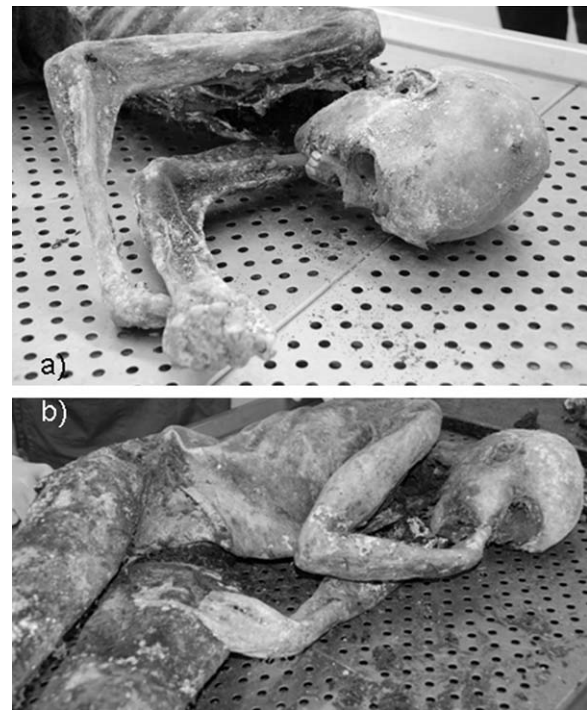


Fig. 3. The two mummified bodies, still fixed in their supine position, after clothing removal: (a) the elder brother and (b) the younger brother.

the limbs, the costal margins and the hips. The bodies were fixed in a supine position by the brittle dehydrated tissues, both lying on their left sides (Fig. 3). The internal organs were grossly identifiable but, in some cases (e.g., brain and lungs), partially putrefied and reduced to a blackish, dry material, while the abdominal viscera were partially dried up. No signs of ligature around the neck or wrists consistent with strangulation or captivity were found. No signs of defence injuries, child abuse or sexual assault were observed on the bodies.

Previous full-body computed tomography (CT) scans, autopsy findings revealed no fatal injuries for the younger child B as represented by some minor hip bone and foot fractures of the metatarsals and phalanges, while for the elder brother A, major injuries as represented by fractures of two lumbar vertebrae, a right femur fracture, right tibia and fibula fractures at the distal end with disarticulated right foot and exposed fractures of metatarsal bones and phalanges (Fig. 4). The severity of injuries (minor for A and moderate for B) was the factor most significantly predictive of different survival times for the two young boys suggesting that the trauma occurred while the boys were alive. Haemorrhagic infiltration was not so evident macroscopically in mummified skeletal muscles still present around the lower leg fractures. However, microscopic analyses were performed using routine haematoxylin and eosin (H&E) staining together with Perl's iron protocol for haemosiderin and Weigert stain for fibrin. Histological examination showed severe post-mortem deterioration with normal tissue components not readily and always recognisable. Although the material was degraded, in some areas, the histological and histochemical stains were suggestive of haemorrhages based on the appearance of still-preserved erythrocytes and granulocytes as well as fibrin and haemosiderin deposits (Fig. 5). No clear evidence of inflammatory reaction was found in human skin still covering the bone injuries or in skeletal muscles close to fractures. Unfortunately, no immunohistochemical reactions were performed. However, if the presence of blood cells and fibrin did not prove the vitality of the haemorrhages,

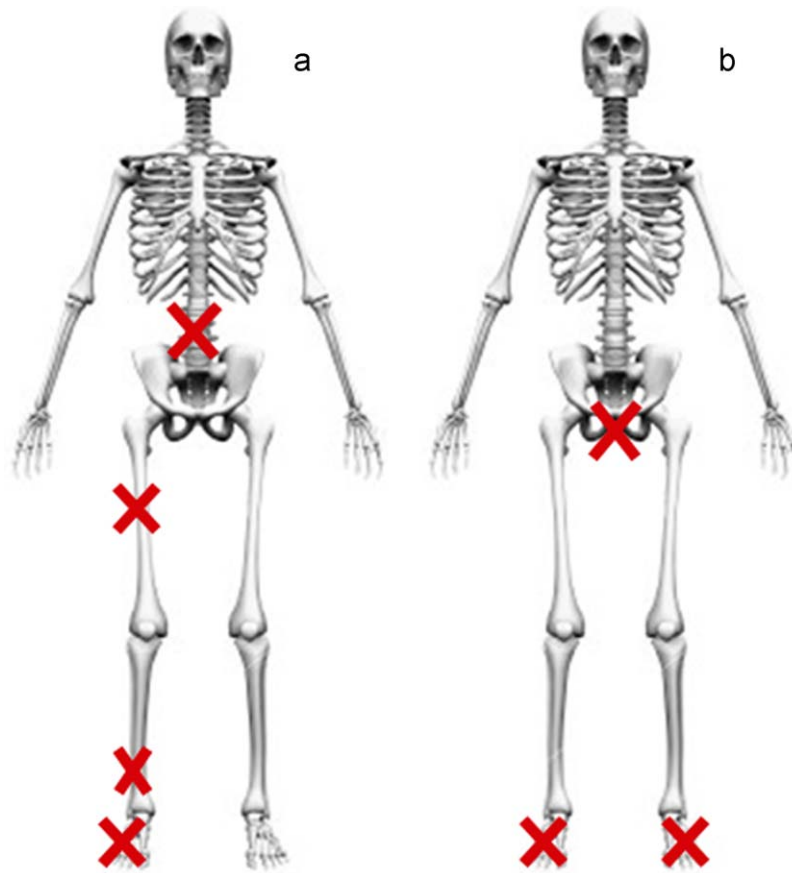


Fig. 4. The distribution of skeletal injuries in the two bodies: (a) the elder brother: Column: L2 and L4 fractures: R femur: mid-shaft fracture, R tibia and fibula: fractured at the distal end, R foot disarticulated: midfoot luxation with exposed fractures of distal phalanges (1, 2 and 3 fingers). (b) the younger brother: L hip bone: displaced ischiopubic fracture, L foot: fracture of the proximal phalanges (1, 2, 3 and 4 fingers), R foot: hindfoot and forefoot luxation with displaced metatarsal fractures (2, 3, 4 and 5).

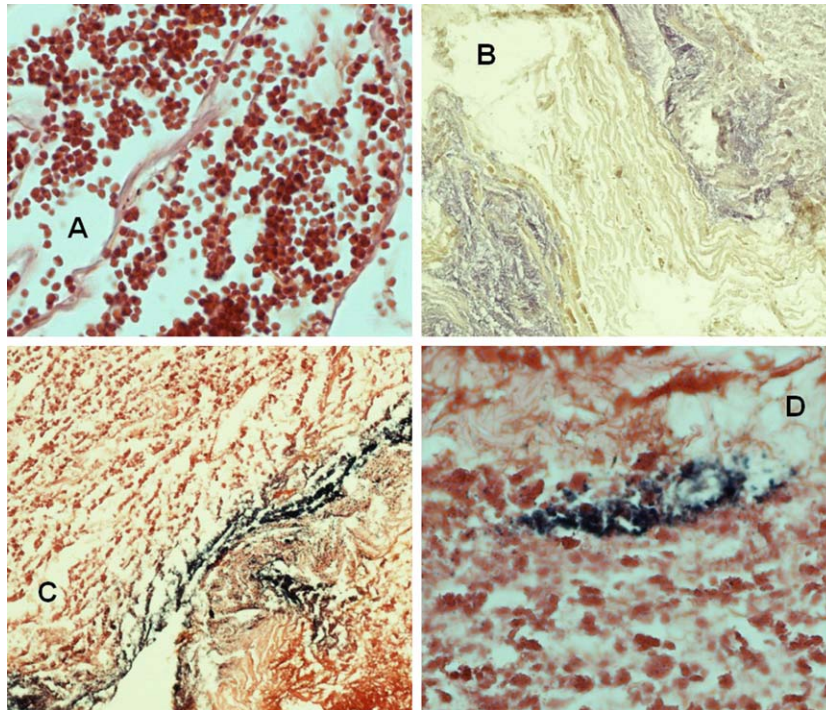


Fig. 5. Signs of haemorrhages in mummified soft tissues. (A) Haemorrhagic infiltration with red and white blood cells still preserved into subcutaneous layer of mummified human skin close to femur fracture of the elder brother (H&E stain). (B) Fibrin stained in dark blue into mummified soft tissues with severe post-mortem deterioration close to leg fracture of the younger brother (Weigert stain). (C and D) Signs of haemorrhagic infiltration with severe post-mortem deterioration and haemosiderin deposits into mummified soft tissues close to ischiopubic fracture of the younger kid (Perls stain).

especially in deteriorated material, their detectability in the quite intact form observed in some areas of the mummified soft tissues was worthy of consideration. In particular, the histological examination was indicative of a recent haemorrhage for the elder brother A and an old haemorrhage of approximately 3–4 days for the younger B, according to data provided by previous studies on the earliest appearance of the haemosiderin pigment after wounding [4–6]. No evidence of other internal haemorrhages was found in the thorax and abdomen.

Therefore, the microscopical results along with the severity of bone injuries supported the hypothesis of the vitality of the trauma in both bodies but also of a different survival period to be confirmed by further studies on gastric and intestine emptying time. The autopsy findings were consistent with the fall of the two boys from a low–medium height. As the primary impact is usually the site of the most severe injury, the older brother A probably fell from the top of the 22-m-deep well onto his right foot with leg extended. The right foot was the first part of the body to touch the bottom of the well because when the fall is on the feet, the deceleration stress can break the axial skeleton at a number of points [7,8], explaining the multiple fractures observed in A. These were almost exactly the same injuries found on the other boy rescued from the fireman on the day of the bodies' recovery (25 February 2008). On account of the minor severity of the fractures, the younger child B also fell on his feet but from a lower height probably because he was trying to climb down the well to help his older brother A, using the rungs meant for service inspection located on the front wall. The younger child's minor injuries that matched with histological findings were also indicative of a longer survival period compared with the older brother A. During that period, the child B was exposed to a low ambient temperature. Unfortunately, the experts were not allowed to collect temperature data for any period of time as commonly suggested; [9] however, it was quite clear from the beginning that the general conditions in the basement were remarkably unvaried without distinction of day and night and, in particular, the underground temperature was significantly lower than the temperature recorded outside at surface level. Based on such circumstantial evidence, hypothermia was not excluded as the cause of death for B, considering the cooler underground cistern and the non-lethal injuries with signs of old haemorrhages corresponding to the time from trauma to death, which was later confirmed by the negative results of DNA gut content analysis.

In cases when the time of the last meal is known, the state of gastric and intestine emptying may suggest when death occurred in relation to the ingestion of that meal, according with all the factors affecting the digestion process, such as type and volume of meal (light and/or heavy meal), stress, trauma and drugs [10,11]. In these cases, the examination of gastric and intestinal material was provided through mitochondrial DNA (mtDNA) analysis for the identification of type of meat products [12,13]. For the child B, the mtDNA analysis was totally negative from all samples collected at any part of the small and large intestine suggesting that the digestion process had already taken place. For the elder brother A, remnants of food were still found in the large intestine consistent with the last meal. Traces of pork and rabbit were identified by mtDNA analysis of samples collected from the ascending and sigmoid part of the colon as well as from the rectum. Based on the intestinal emptying time, B survived for few days after his minor injuries. The younger boy B also realised being trapped inside the cistern, a closed, cold and totally dark environment with no way of exit apart from the top of the dry well. The autopsy findings and the gut content analysis provided enough physical evidence to support the following reconstruction of events that occurred during the survival time and its estimation (few hours for A and few days for B). Soon after the fall, B probably moved his older brother from the

bottom of the well into the cellar (which explains why the trousers were partially removed) and, in the following days, also tried to find a way out. In fact, B was found at northern side of the cistern, next to the only small opening (few centimetres wide) through which a very faint light filtered through on sunny days, close to traces of human faecal material. These traces were just recovered approximately 2 m away from the body of B, in agreement with the estimated survival time.

Entomological specimens also provided strong evidence consistent with the estimation of a long post-mortem interval (PMI). After body removal, signs of insect activity were more represented on the soil where the corpses had been lying compared with those found on the bodies. Absorbed by the soil, traces of the early putrefactive fluids coming from the corpse were still observed due to the natural fluorescence of dried body fluids under an ordinary ultraviolet (UV) light. The type of soil has always to be taken into account to interpret the decomposition process and thus insect activity in soil [14,15]. The soil was mainly rubble (stones of irregular size and shape) mixed with Diptera puparia, cast pupal skin of clothes moths (Lepidoptera) and Coleoptera larvae. Among the Diptera species, Sarcophagids and Calliphorids like puparia of *Calliphora vicina* and *Muscina stabulans*, on which clothes moths fed, were found (Fig. 6). Among the clothes moths, specimens of *Tinea pellionella* and *Tinea bisseliella* were found. Puparia of Fanniidae (*Fannia scalaris*) and Phoridae (*Megaselia* sp.) were also found, mostly deteriorated by Tineidae specimens among which were the *Monopis obviella* suggesting that such Lepidoptera colonised the body after Diptera. Tineidae usually colonise bodies in the late stages of decomposition when the body is really dry, feeding not only on natural fibres such as hairs but also on clothing that contain human sweat or putrefactive fluids. The life cycle of Tineidae species, even if extremely variable, usually lasts from 6 to 24 months [16,17]. There is also considerable variation in the duration of the immature stages, and it is not clear if there are one or more broods in the year [18]. Finally, some Tenebrionidae larvae and adults were also found in the silt–clay soil layer beneath the bodies, attracted by the nutrients released during decomposition (Fig. 7). Such Coleoptera, also called mealworm, are mostly nocturnal, prefer dark environments and are often found in stored grain and related products. The Tenebrionid life cycle usually lasts from 6 to 10 months for adults, also known as darkening beetles spread worldwide [19].

3. Discussion and PMI

The discovery of mummified bodies in the enclosed environments does not represent an unusual phenomenon for forensic pathologists [20]. Environmental factors, such as temperature, humidity and sunlight, acting with internal factors such as surface area-to-volume ratio (size and weight of the body) and body temperature, largely determine the outcome of the post-mortem changes [21]. They may be viewed essentially as a competition between decomposition (decay and putrefaction) and desiccation [22]. The onset of decomposition and mummification can be faster in human remains found in outdoor environments than those found indoors [23,24]. Most enclosed and deep-underground environments, such as catacombs and subterranean crypts usually associated with churches, are human-created environments conducive to natural desiccation where many mummies have been reported [25]. The general climatic conditions in these environments are remarkably unvaried and without distinction in day and night, as occurred in the basement where the two boys were trapped after their fall. Differences between summer and winter conditions are also greatly moderated in most subterranean environments, such as the cold and dry cistern, approximately



Fig. 6. Diptera puparia and clothes moths case.

15 m below the ground level, an apparently rather unique environment in which the present mummified bodies were found.

It is well known that the depth of burial, even under only few centimetres of soil, can contribute to exclude some groups of forensic flies such as Calliphoridae and Muscidae [18,26,27]. In this case, even if the cistern was 15 m deep and with conditions conducive to preservation through desiccation, the access of the bodies to insects was still possible, achieved mainly through the dry well but also through a small opening in the northern part of the cellar wall. The insect succession and biology was consistent with a long PMI of approximately 20 months and a process of decomposition and mummification realised in the place where the bodies were found inside the basement. As in many forensic cases, it was not entirely possible to determine when the mummification process took place, but it took some few weeks; and the early

stages of mummification were certainly mixed (as is often the case) with a degree of putrefactive change, especially in the internal organs. The smaller body size and lower weight of child remains as well as the greater surface-to-volume ratios facilitate degradation processes in a shorter time interval compared with adult remains [28]. The rapid skin drying was certainly facilitated by absorption by clothing and soil (mainly rubble embedded into a silt-clay matrix) of the early putrefactive fluids as well as by the dry and windy conditions of the underground cistern.

The poor variety of species observed among the insect community was consistent with the subterranean environment where the bodies were found (atypical burial) and the rapid dehydration of the skin surface, which usually hinders larval infestation for all blowfly species. During the dehydration of the skin, only some blow flies (mainly Calliphorids and Sarcophagids) were able to colonise first the bodies, followed by Fanniidae and Phoridae, in accordance with findings on insect succession provided by several previous case studies on human and animal models [29–31]. The insect community was finally enriched by Lepidoptera (clothes moths) and Coleoptera. Therefore, it was possible to recognise at least three different groups or waves of insects occurring in chronological order: Calliphorids and Sarcophagids (1st wave), soon followed by Fanniidae and Phoridae (2nd wave) and later by Lepidoptera (Tineidae) and Coleoptera such as Tenebrionidae (3rd wave). The pattern of insect succession was partially similar to cadavers found on surface. Calliphorids and Sarcophagids are usually the first Diptera species to find a decomposed body, outdoors as well as indoors [30–32]. In some locations, Phoridae and Fanniidae respond to carrion in a similar manner even if they are almost always found in bodies that have somehow been at least partially sheltered from the colonisation by larger flies through burial or usually after butyric or caseic fermentation corresponding approximately to 6 months after death [33]. Dominant taxa in the latter stages of decomposition were species of clothes moths (Tineidae) and Tenebrionidae very common in mummies but less usual in surface bodies and also in buried cadavers [26,27]. The habitat favoured by Tineidae and Tenebrionidae was consistent with the circumstances of decomposition realised inside the underground cistern, a man-made environment that allowed these species to access indoor cadavers.

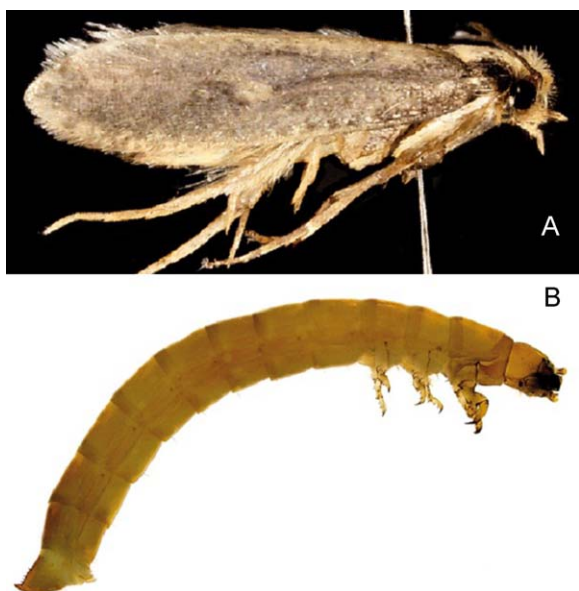


Fig. 7. Tineidae and Tenebrionidae specimens. (A) Female adult of *Tinea pellionella* and (B) Tenebrionidae larva.

Clothes moths and Tenebrionids colonised the bodies later in the late stage of decomposition when their food source was completely dry. They have been recorded approximately 1.5 years after death [18], representing an extremely useful biological marker of the minimum PMI occurring in this case.

Insect evidence was not able to provide more accurate data regarding the PMI because the subterranean environment was quite unique and no previous insect succession reports were available for such environmental conditions. However, the entomological data matched with the results provided by the autopsy examination and molecular genetic analyses enabled the case to be reconstructed as it follows: an accidental fall of the two missing children, trapped in the cold dry well after trauma, with a survival time of approximately few hours for the elder brother A and of 3–4 days for the younger boy B. After death, the bodies started to decay undisturbed, except for the insect colonisation, for approximately 20 months before recovery.

On 4 March 2008, based on such physical evidence and reconstruction of events, 4 months after imprisonment and 40 days after the recovery of the bodies, the father was finally released from prison and exonerated from previous indictment. He was able to participate in the funeral of the two children, and he is claiming a compensation of 500,000 Euro for the wrongful conviction and the damages suffered from the injustice. In fact, it is the opinion of the legal representative of the prosecution that the father at least knew the location of the bodies inside the old house and, for this reason, he is still indicted for a different crime that of the abandonment of minors followed by death. The defence lawyers are actually claiming that some young playmates were probably with the two brothers in the abandoned house and they left the children alone intentionally in the underground basement.

4. Conclusion

Understanding how the environmental conditions (temperature, access to insects, clothing and type of surface on which the body is lying) can impact on the progression of decomposition and/or desiccation, and the pattern of insect succession is mandatory to determine the time since death. The accuracy of a PMI estimation depends on available knowledge of insect biology and behaviour in relation to the use of decomposing remains as a food resource [34], the different environmental preferences of species and their abilities to access corpses indoors [32] as well as on autopsy findings supporting conclusions regarding the timing of wounds and/or survival period of the victims. This case is representative of children, who go missing involuntarily because they are injured and lost. It can also be representative of how the headlines of the local press and TV-media can sometimes force the judicial authority and public opinion into a forensic misadventure because of erroneous testimony (given the young age of the eyewitness) and erroneous interpretations of environmental and phone interceptions (in this case expressed in local dialect). Wrongly conducted, the investigation was far more complex than the events that actually occurred.

The issue of missing children is often both sad and multifaceted, and there is a high risk of wrongful conviction. Investigators, police officers and law-enforcement professionals should be cautious and recognise that children, who go missing voluntarily or involuntarily (because they are lost, injured or stranded) are a significant part of the overall missing children problem. All such cases call for collaboration between law enforcement, local press, TV media and a variety of other agencies, including the medical and public health community as well as civil authorities [1]. Agencies and authorities involved in missing children cases should be prepared to respond to such events, and therefore, should receive training on how to conduct the search and start the investigation. Public education on

ways to avoid miscommunication and using successful search strategies for resolving such episodes may be very helpful. Finally, the co-operation among the different disciplines of forensic sciences, that is, forensic pathology, forensic anthropology, forensic taphonomy, molecular genetics and, last but not least, forensic entomology enables the cases to be reconstructed through a full understanding of the physical evidences. In this respect, the role of the forensic pathologist as coordinator of a multidisciplinary effort can be crucial, as he is often responsible for determining the how (manner), when (time) and why (cause) of any death, which is the result of suspicious or unexplained circumstances [35].

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