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The story of a homicide: The location, exhumation, and multidisciplinary analysis of a clandestine burial

Daniela Alit Mansegosa [a,*], Pablo Sebastián Giannotti [a], Julián Ignacio Marchiori [b], Fernando Nicolás Jofré [c], Fernando Hernán Aballay [c,d], Camila Fernandez Aisa [b]

[a] Instituto de Arqueología y Etnología, Facultad de Filosofía y Letras, Universidad Nacional de Cuyo. Consejo Nacional de Investigaciones Científicas (CONICET), Centro Universitario, s/n., Parque General San Martín, 5500 Mendoza, Argentina
[b] Facultad de Filosofía y Letras, Universidad Nacional de Cuyo, Centro Universitario, s/n., Parque General San Martín, 5500 Mendoza, Argentina
[c] Laboratorio de Entomología, Instituto Argentino de Investigaciones de las Zonas Áridas (IADIZA), CCT-CONICET, Mendoza, Argentina
[d] Departamento de Biología, Instituto y Museo de Ciencias Naturales, Facultad de Ciencias Exactas Físicas y Naturales de la Universidad Nacional de San Juan, Consejo Nacional de Investigaciones Científicas y Técnicas (CCT CONICET San Juan), Av. Libertador Gral. San Martín 1109, J5400ARL San Juan, Argentina

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ABSTRACT

This article presents a case study of a victim murdered in 2008 and found in a clandestine burial. The body was found in 2019 outside a rural residence in the province of Mendoza, Argentina. The article's objective is to demonstrate the relevance of having archaeologists and anthropologists on-site and the importance of multidisciplinary laboratory analysis as part of a continuous process of investigation. The search, location, exhumation, and interpretation of the burial was carried out using archaeological methods. In the laboratory, we reconstructed the biological profile and cause of death using forensic anthropology, dentistry, image diagnosis, and genetics. The postmortem interval and history were reconstructed from the entomological and taphonomic analyses. The individual's identity was confirmed and the evidence made it possible to locate and prosecute those responsible for the murder. Finally, the classic indicators of burial are discussed in relation to those found in the case study presented here. The unsystematic techniques used by the scientific police in cases of buried corpses are also critically assessed. We reflect on the importance of collecting adequate scientific evidence to support a legal case.

Introduction

In Argentina and other countries, documenting and removing skeletonized or partially skeletonized human remains from crime scenes is carried out by police personnel. Rarely are other types of professionals called in such as archaeologists, anthropologists, or entomologists. However, there is extensive literature demonstrating the potential of these specialists to process the complex scenarios involving human skeletal remains [1–5]. This has also been pointed out in numerous studies that include searching for and locating bones in the open, either on the surface [6], buried individually [7], or in multiple graves [8].

Investigating the site in conjunction with multidisciplinary laboratory analysis is an extensive research process that must be addressed holistically. This paradigm shift within the police and legal field is complex but necessary. In Argentina, this methodology has been duly applied by the Argentine Forensic Anthropology Team (*Equipo Argentino de Antropología Forense*) [9], mainly in crimes against humanity committed during the county's last civil-military dictatorship (1976–1983) that are addressed by the federal justice system. However, this approach has rarely been used in forensic contexts for judicial cases since 1983, after the return to democracy [10]. This is mainly because forensic anthropologists and archaeologists do not generally work at forensic laboratories; there is more established tradition of police and firefighters reporting to the scene of a crime or burial.

The objective of this case report is to present the methodological and analytical strategies employed for the search, location, recording, and exhumation of a clandestine burial. It also presents the analysis of the skeleton that was found, its biological profile, cause of death, and postmortem interval from a multidisciplinary approach that articulates contributions from forensic anthropology, dentistry, genetics, taphonomy, image diagnosis, and entomology. It also reflects on the need to strengthen the direct link between anthropologists, archaeologists, and entomologists in criminal investigation to clarify complex crimes.

Case study

In August 2019, personnel from the Unit for Homicides and Institutional Violence (*Unidad Fiscal de Homicidios y Violencia*

* Corresponding author.
E-mail address: alitmansegosa@gmail.com (D.A. Mansegosa).

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Institucional) from the District Attorney of the Province of Mendoza (*Ministerio Público Fiscal*; MPF), began an investigation to locate a clandestine burial near a rural house. The investigation began with a report made by a woman who testified that her father disappeared in August 2008 under strange circumstances when she was a child, eleven years prior to the report. Based on the woman's testimony, the prosecutor hypothesized that it could have been a homicide and that the body of the victim may have been burned or buried behind the house.

Following the report, the prosecutor requested that the scientific police (police specialized in homicides and other crimes) and firefighters begin searching for the bones. They dug a hole, two meters in diameter and one-meter-deep, in an area behind the house (Fig. 1). This area was chosen based exclusively on the testimony of a witness. Shovels were used for the excavation and the dirt was piled up around the hole, which was briefly reviewed without a screen. The area was used to discard domestic waste, so there was glass from bottles, plastic from disposable containers, metal, and bones from animals for household consumption. This intervention had negative results with respect to the discovery of human bone remains. After this initial attempt, legal authorities summoned the anthropologists from the District Attorney's Medical Forensic and Criminalistic Corps (*Cuerpo Médico Forense y Criminalístico*; CMFyC) to continue with the evaluation and the search for human remains.

Methods

Work at the crime scene

The search area comprised a total of 72.5 m^2, delimited to the south, east, and west by vineyards and to the north by the house. It was a horizontal surface of natural soil with low annual vegetation such as bushes that were dry and distributed in patches. During the

Winter, the entire search area was shaded by the house throughout the day. The house is located in the district El Carrizal, Department of Luján de Cuyo, Mendoza, Argentina (33°14.742′S, 68°51.615′W). The site is located in the biogeographical province of the Monte, which is a warm shrub desert extending between the Puna and Patagonia east of the Andes [11]. It has an average annual temperature of 15.6 °C and an average annual rainfall of 200 mm.

Since one of the prosecutor's main hypotheses was that the body of the victim had been burned and buried behind the house, it was decided to search for human remains and evidence of thermal alteration, using the methods and techniques of forensic archaeology [3,12,13].

The strategy involved two simultaneous activities. First, we examined and screened the dirt from the hole dug by the scientific police and firemen, using a 1.4 mm-mesh screen. Second, we carried out a surface inspection of the area with the goal of identifying a clandestine pit. We checked for surface indications of a pit such as topographic depressions, changes in sedimentary composition, variation in vegetation [3], and human remains or thermo-altered sediments. A vegetation patch of the *Salsola kali* species (Caryophyllales: Chenopodiaceae) was identified as having forensic potential because it was higher than most vegetation at the site and was near the area the witness suggested was a burial site. This patch was defined as feature 1 (Fig. 2).

Fig. 2. Feature 1. The yellow box indicates the location of the dead *Salsola kali* (Chenopodiaceae) identified during surface observation.

Next, all vegetation was removed to better observe the ground surface. Two east–west 1 × 10 m trenches were excavated parallel to the house. The south trench completely covered feature 1. The other trench was 50 cm to the north and excavated as a stratigraphic control. Trenches were excavated artificial 10-cm levels and all dirt was screened, especially to check for small bone fragments and teeth, since cremation was a possibility. Sediment samples were taken from each stratigraphic level. The entire process of survey, excavation, and exhumation was documented with written records, sketches, and photographs. Geographic coordinates were obtained from an eTrex 10 GPS.

Laboratory analysis

The human bones, materials associated with the grave and the individual (remains of textiles, plastic bags, clothing and personal objects) and entomological material were processed at the CMFyC anthropology laboratory.

The human bone remains were analyzed in stages. First, a 5-cm bone sample was taken from the diaphysis of the right femur and sent to the Forensic Genetics Laboratory (CMFyC in its Spanish acronym) for processing and DNA analysis. Then, the bones were cleaned with dry fine bristle brushes to remove adhered dry sediment (no tissues were attached) and an inventory of the elements were made for anatomical identification. In the case of the skull, which was highly fragmented (see below), assembly was carried out using a silicone glue gun because it cools rapidly and does not have chemical components that affect bone tissue. Finally, we proceeded with the analysis of the osteobiographic profile: sex, age, ancestry, stature, and body mass, individual dental chart,

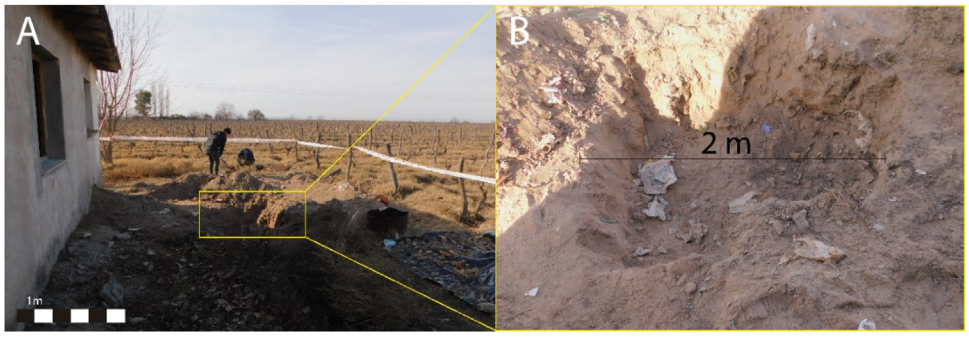

Fig. 1. Location of the crime scene (behind the rural house). A: location of the pit made by the scientific police. B: detail of the unsystematic pit (note the absence of clear profiles).

Fig. 3. Excavation of north (left) and south (right) trenches. The yellow box indicates the material located immediately below feature 1.

antemortem fractures, indicators of functional mechanical stress, and perimortem injuries to determine the circumstances of death.

To assess the individual's osteobiographic profile, sex was determined based on dimorphic characteristics of the pelvis [19,20] and measurements on the vertical diameter of the humeral head and the maximum diameter of the femoral head [21]. The skull was not used to assess sex because it was damaged. Age was estimated from macroscopic observation of the pubic symphysis [22,23] the auricular surface [24], the metamorphosis of the sternal end of the ribs [25], and the apical transparency of the roots of the uniradicular teeth [26]. Since the cranium was damaged, ancestry was evaluated based on the subtrochanteric shape of the femur following Gilbert and Gil's [27] method. Height was estimated from the length of the femur and the regression formulas in Trotter and Glesser [28]. Body mass was calculated from regression equations based on the vertical diameter of the femoral head and the bi-iliac width by rearticulating the coxal and sacrum and taking the estimated height into account [29]. To evaluate the individual osteobiographic profile, a dental record was made based on teeth that were present or absent antemortem, perimortem, and postmortem, based on the state of the alveoli. The presence of carious lesions, restorations, prosthesis, periapical diseases, and periodontitis was assessed [30]. Normal variations of the skeleton and bone pathologies associated with functional mechanical stress or nonspecific infectious processes were analyzed [31,32] as well as antemortem and perimortem trauma associated with the circumstances of death [33,34]. Taphonomic indicators such as thermal alteration, rodent and carnivore marks, and roots, among others, were analyzed [35].

To check for pathology and trauma, bone and dental remains were first examined macroscopically and then with a 3x magnifying glass; bones with potential indicators were analyzed with computed tomography (CT). Since the skull was badly damaged, fragments were manually assembled and then a clear image of the fracture lines was obtained from a CT scan.

Objects associated with burials are of special importance in identifying the individual and characterizing the conditions that influence postmortem processes [12,36]. Each object was described according to the type of material, coloring, and inferred function. Based on this, they could be classified into three groups: 1) body wrappings (bedsheets and a plastic bag), 2) clothing and 3) a metal ring. In order to observe the ring more clearly, impurities and corrosion were removed with a 5% acetic acid solution [37].

The entomological material recovered at the scene and in the laboratory was processed in the Entomology Laboratory of the Argentine Dryland Research Institute (*Instituto Argentino de Investigaciones de las Zonas Aridas*; IADIZA, CCT-CONICET), Mendoza. Cleaning and identification were carried following published criteria [16–18] using a Nikon SMZ745 20× loupe.

Results

Survey, excavation, and exhumation

In the pit dug by the scientific police and its back dirt, there was no human bone. It did include bone from commonly consumed animals, remains of food, plastic containers, and glass, suggesting this was a household garbage disposal area. Several combustion events could be observed, but their chronology could not be determined, since the stratigraphy had been disturbed and arbitrarily removed during the original excavation by police personnel. During the excavation of the two trenches, a 70 cm circular area was identified in the south trench with a very limited accumulation of materials, exactly 10 cm below the surface of feature 1 (Fig. 3).

The stratigraphic sequence of the materials was as follows, from top to bottom: black plastic sheet over fragments of oxidized sheet metal (n = 2), mixture with whole and fragmented bricks (n = 7), fragments of roofing membrane (n = 8), and glass bottle containers (n = 3) (Fig. 4A, B). All of these materials were between 20 and 50 cm in depth mixed with a sandy loam sediment that was less compact than the sediment of both trenches. Below this material there was a transparent plastic bag with human bones. The bag was opened its contents recorded: the upper half of a human skeleton (skull, torso and upper limbs) with clothes (sweater and T-shirt), hair, a ring, a cushion, and abundant carrion insects. Immediately below this, the rest of the skeleton was found wrapped in a bedsheet. This included the coxal bones, sacrum, and lower limbs with clothing (pants and underwear). The body was in a seated position with the feet resting on the bottom of the pit. The legs were hyperflexed against the torso; the arms were semi-flexed on both sides and the skull faced downwards [14,15].

The cone-shaped pit had a diameter of 70 cm at the top and 30 cm at the bottom and a depth of 110 cm (Fig. 4C). On the walls of the pit, marks were visible that were probably left by the round point shovel used to dig the pit (Fig. 4D). There was no evidence of thermal alteration in the pit's sediment or excavated material. All material was transferred to the CMFyC laboratory. Only the cushion was given to the scientific police to test for blood traces. The result was negative.

Laboratory analysis

The human skeletal remains are from a completely skeletonized adult (Fig. 5A). The skeleton was well- preserved. There were no soft tissues but there were hair and abundant carrion insects. No weathering or marks from roots or carnivores were observed, and there were no signs of heating or burning of the bones. The taphonomic pattern and the burial position indicate that after death, the burial conditions and body were stable, so this is a primary burial.

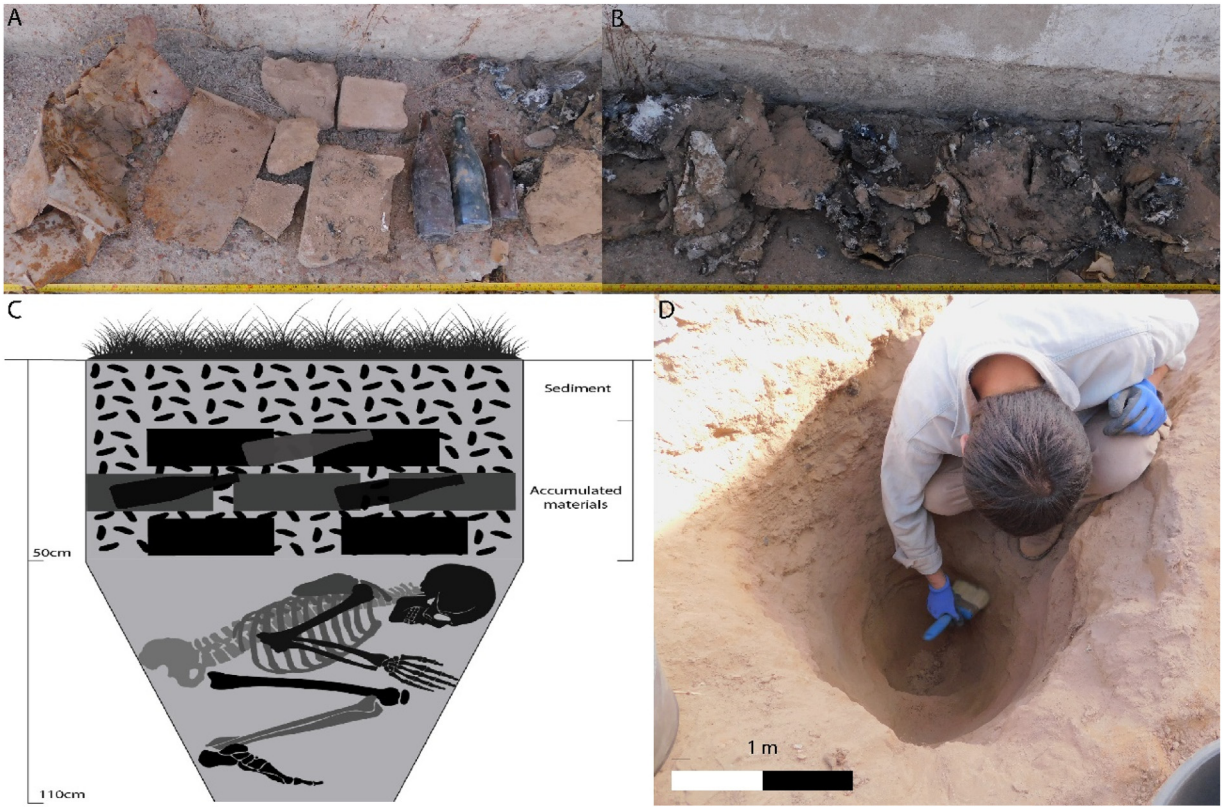

Fig. 4. Clandestine burial. A and B: materials found in the pit's fill. C: sketch of skeleton found in primary position. D: excavation showing original burial pit edges.

As for the general biological profile, it was determined that it is a male individual, with an age at death of approximately 50–65 years. The hair was dark chestnut brown, wavy, and fine with a few grey hairs. The estimated height was 170 ± 5 cm. The subtrochanteric index indicated an eumeric type (IP = 92.43) and the estimated average body mass was 68 kg.

With regard to dentition, there were six teeth: the upper right central incisor, lower left and right central and lateral incisors, and the first lower left premolar. The rest of the teeth were full resorption of alveolar ridge (absent before death). He had flat, grade 6 tooth wear. Untreated cavities were observed on the occlusal surface of the upper central incisor and the lower left lateral incisor. The palate had an anomaly inside the incisor channel (Fig. 5B) consistent with a small inclusion or fissural cyst of the palate [31,36].

In terms of antemortem pathologies and trauma, there was osteoarthrosis, mostly in the lumbar area of the spine (Fig. 5C). The 3rd, 4th, and 5th right ribs had antemortem fractures in the medial sector, which had completely healed and had partially remodeled bone calluses (Fig. 5D).

Transverse perimortem fractures were found in the sternal end of six left ribs and two in the sternum. The skull presented multiple comminuted fractures in the facial region that generated 38 small bone fragments of less than one centimeter each. In addition, part of the frontal and left temporo-parietal bone had evidence of perimortem fractures that resulted in 22 larger bone fragments. The rest of the skull was complete, with some postmortem fractures and deformation that resulted from the pressure of the material used to fill the burial pit. The jaw, on the other hand, had a complete linear perimortem fracture of the chin. The skull could not be completely reconstructed because of the postmortem plastic deformation and the small size of the fragments. Even so, the partial reconstruction, aided by a CT scan, clearly showed the fracture pattern (Fig. 6).

As for the elements associated with the individual, body wraps, clothing, and a metal ring were documented. The body wrappings consisted of a transparent plastic bag on the upper half of the body, measuring 60 × 120 cm, and a light blue bedsheet wrapped around the legs. The clothes included a wool sweater in good condition, a nearly-disintegrated cotton shirt, navy blue cotton sweatpants in good condition, and black cotton boxer shorts. All these garments were moist and greasy from being in contact with the body and the burial pit. No socks or shoes were found. Finally, a highly corroded and oxidized metal ring was found. There was a green stain on the phalanges of the first and fifth fingers of the right hand, which allows us to infer not only contact with the ring but that it may be made of copper, following the interpretation of some archaeological skeletons buried with copper ornaments [38,164]. After removing impurities from the surface of the ring, no inscriptions or engravings were observed.

Of the entomological fauna recovered in the skeletal remains and clothing, many empty puparia were recorded and identified as *Megacelia scalaris* (Diptera: Phoridae) (n>500) and adult *Euspilotus* (Hesperosaprinus) *modestus* (Erichson) (Coleoptera: Histeridae) (n<50). In the sediment samples, there were adult *E. modestus* (n<50), *Phelister rufinotus* (Coleoptera: Histeridae) (n = 2), *M. scalaris* puparia and adults (n>500), and puparium fragments from *Ophyra aenescens* (Wiedemann) (Diptera: Muscidae) (n = 5). Diptera species grew through immature stages in the human cadaver, consuming the soft tissues and reducing the body to bones. In corpses, the Histeridae species *E. modestus* and *P. rufinotus* prey on immature Diptera. In all the material, no living carrion insects were identified.

Discussion

This paper has demonstrated that the personnel from the scientific police did not use an optimal method for locating buried human bones.

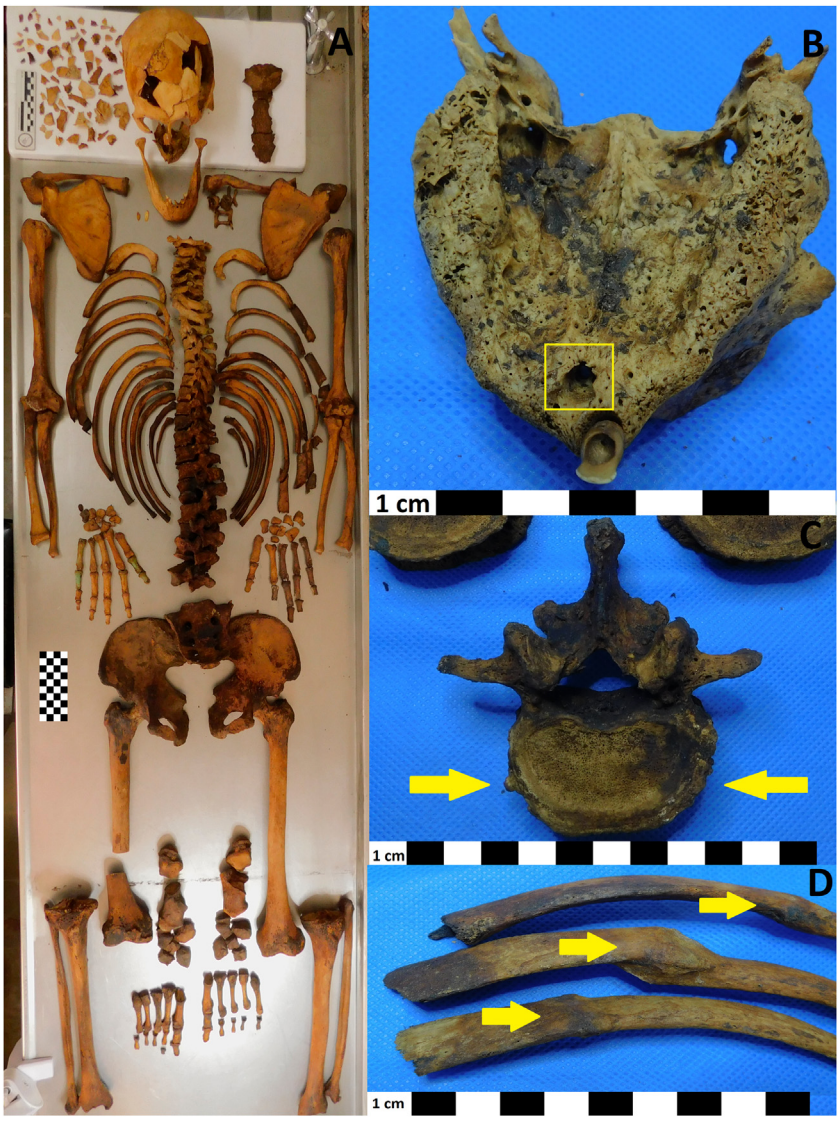

Fig. 5. Skeleton and antemortem indicators. A: complete skeleton. B: maxilla with a small cyst in the incisor channel (yellow box). C: lumbar vertebrae with marginal osteophytes. D: ribs with healed fractures.

The place chosen to dig was incorrect and the uncontrolled excavation irreversibly destroyed contextual evidence. This disturbed the stratigraphy and the association between objects, stratigraphic units, and features that documented human activities. In contrast, the approach based on forensic archaeology by experts yielded positive results for the search and location of the clandestine grave. A potential area was selected in an under an hour of work and the clandestine burial was located and excavated systematically. Systematic documentation recorded evidence using standardized scientific methods. Research was continued in the laboratory by the same anthropologists with support from other disciplines such as forensic dentistry, entomology, and imaging, achieving an integrated investigation from the crime scene to the final report.

The clandestine burial was found through a combination of archaeological techniques for the locating burials. Feature 1 was identified from a concentration of vegetation, a visual indicator that is characteristic of human burials [3,12]. The more extensive growth of *S. kali* was probably a result of the conditions created by the burial:

1) a less compact and sandy sediment favors root development in this annual species, 2) greater availability of rainwater, due to the inclination of the roof of the house toward feature 1, in addition to the effect of the plastic bags and sheets that kept the soil moist, 3) the availability of micronutrients such as ferrous ions from oxidized metal, 4) the availability of nitrogen from the carcass at a depth of about 50 cm. All of these factors probably had a beneficial effect on the increased growth of *S. kali* in and above the pit. This species has a fasciculated, superficial extended root system that can extend to one meter below the surface (Dalmasso, personal observation), so it may have reached nutrients released by the corpse such as nitrogen. This plant flowers in the spring and summer. In the spring and summer prior to the exhumation of the body, the 135 mm of rainfall were sufficient so for the plant to flower. This species is very common in ruderal and preferably sandy soils, which is consistent with the contents in the pit. This is the first study of a clandestine burial being located based on the growth of *S. Kali*.

Another visual indicator of burial, topographic depression [3,12], was not observed in this case study. This was likely due to the material that filled the grave (fragments of plates, roof membrane, bricks, and bottles), which acted as a barrier that prevented the sediment from settling after the body decomposed. This effect has been observed in other clandestine burials where the burial is filled with a mixture of soil and aggregates such as lime and cement [39], with the intention of sealing the pit and concealing evidence of the crime.

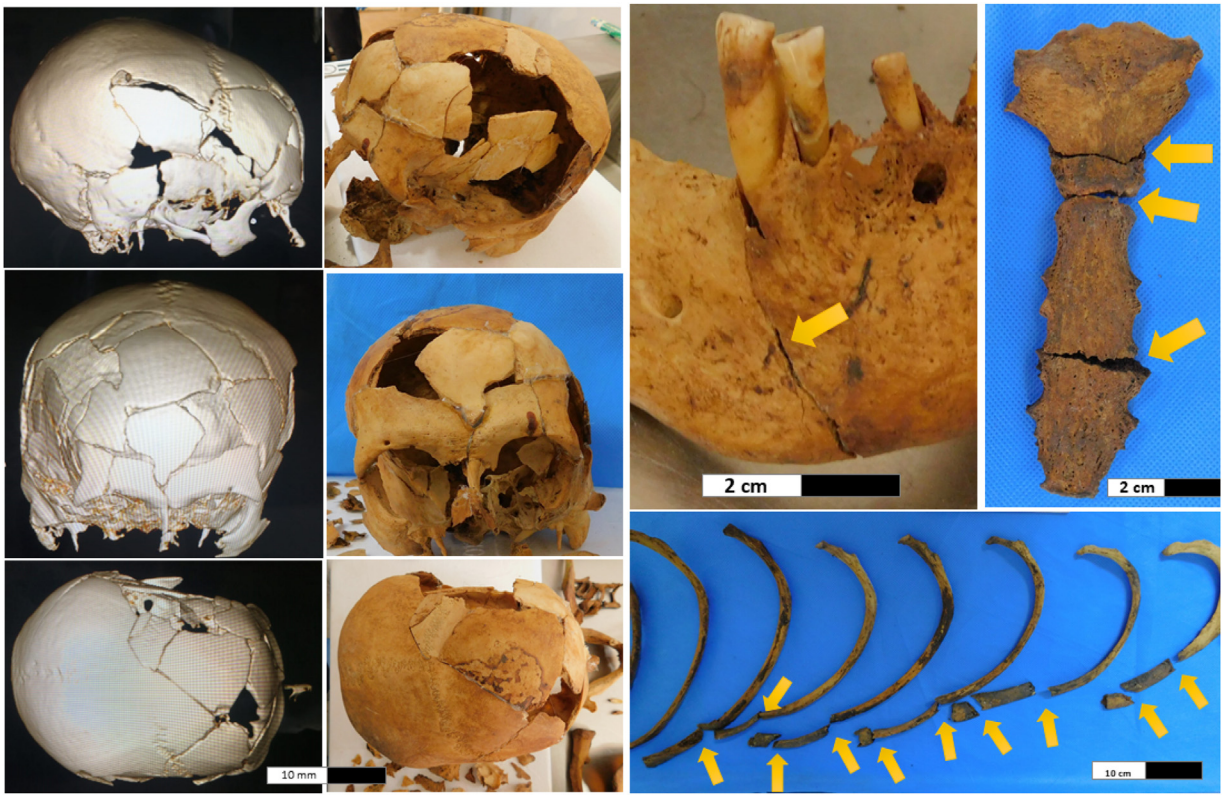

Fig. 6. Perimortem skull fractures (from top to bottom: lateral, frontal, superior; left column shows CT scans). In the three images on the right, yellow arrows indicate the perimortem fractures in the jaw, sternum, and ribs.

Additionally, excavating parallel trenches enabled us to conduct a systematic exploration of the subsoil, make a quick review of anomalies, and use one trench as reference for undisturbed stratigraphy. Excavating in levels allowed us to identify the original edge of the pit and the tool used to dig it; it also facilitated the preservation and registration of the pit's fill. Having anthropologists on-site made it possible to identify the burial position as well as the activities prior to burial (wrapping with a plastic bag and a bedsheet). It also made it possible to rule out the possibility that the body was cremated.

Once the human remains were found, the legal investigation accelerated and required two important facts from the forensic anthropologists: to confirm if the general and individual

biological profile of the body matched the missing person and to clarify the circumstances and probable cause of death. The laboratory result, presented in a preliminary report two days after the exhumation, provided a postmortem profile that could be compared to the District Attorney's information about the missing person. Although the information was scarce, since they only had sex (male) and age (65 years) at the time of disappearance, some data collected later coincided with the postmortem profile obtained, such as approximate height and weight, hair color, dental characteristics, and clothing. Additionally, antemortem fractures of the right ribs (an event that occurred at least a month and a half before his death) were accounted for by an accident or intentional injury (from the fall or impact of an object) on the right side of the thorax. Other elements, such as indicators of functional stress, allowed the individual to be characterized in more detail. Osteophytes detected in the vertebrae suggested that the individual carried out activities with high levels of physical demand in the lower back region, coherent with his reported occupation as rural worker.

The cause of death was identified from the fractures *perimortem* of the cranium, sternum, and ribs, which revealed there were multiple blows to the head and torso by a blunt object at low speed. Such head injuries are associated with low-velocity; high-impact blows when the head is immobilized or against a solid surface [43]. The absence of defensive fractures in the forearms (radius-ulna), in addition to the fracture pattern of the skull, jaw, sternum, and ribs, allows us to infer a possible scenario: the blow occurred when the victim's hands were tied, unsuspecting, asleep, or unconscious. He received all the blows (or most of them) to his head when it was against a surface that was probably soft. Afterwards, the body was wrapped with a plastic bag from the head to the waist and with a sheet around the legs. It was then placed in a shallow grave and covered with readily available materials (garbage and debris).

The shallow depth of the burial and the porosity of the materials (the clothing and the cloth wrapped around the lower limbs) not only allowed for the body's bacteria to decompose but also allowed for the presence of carrion insects. The upper plastic bag even served as a trap for carrion insects. Entomological evidence reinforced the interpretation that the body was~ never in contact with fire given the development of Diptera larva (Cyclorrhaphan), *M. scalaris* larvae and *Ophyra aenescens* larvae which feeds on soft and moist tissues [40,41]. There was no evidence of Calliphoridae, a family of primary colonizing species in arid environments [41], whose presence indicates immediate interment after death. This confirms this was a primary burial. Regarding the postmortem interval (PMI), Phoridae species have been recorded in human corpses buried at depths of 30 and 40 cm [44,45] and even up to 200 cm [46] with postmortem intervals ranging from 6 months [47] to 18 years [46], but more commonly, 3–5 years [48]. In Buenos Aires, Argentina, *Megaselia scalaris* larvae, pupae, and empty puparia were recorded in human corpses with postmortem intervals of 6 and 7 months [47,49]; empty puparia of the same species were recorded in corpses buried at 40 cm [45]. In our case study, there were empty *M. scalaris* puparia in the corpse at a depth of 50 cm, consistent with previous research. *Megaselia scalaris* larvae can pass through materials such as plastic bags and dig down more than 50 cm to reach a cadaver [40], which is how the corpse was

colonized. The large number of empty puparia (>1000) and the presence of some puparia within other puparia suggest that the flies reproduced in the corpse over several generations by consuming soft tissues.

Ophyra aenescens (Wiedemann) has been recorded in corpses in urban [41] and natural environments [50]; the current study documents the species in a rural setting. Generally, in Argentina, *O. aenescens* is the most forensically relevant species in buried and confined bodies [5,45,47]. It is the most dominant taxon and empty puparia are present in human corpses buried at 40 cm depth, as recorded in cases from the humid environment in the province of Buenos Aires [45]. This contrasts with the current case study and our results from an arid environment. Here, *M. scalaris* was more common than *O. aenescens*. This difference can be attributed to the environmental differences between Mendoza and Buenos Aires.

Histeridae insects associated with cadavers and prey on Diptera larvae [18]. *Euspilotus modestus* were recorded in Argentina on exposed pig carcasses in the provinces of San Juan, Mendoza, and Chubut [18,42,51] and on exposed human carcasses in a forensic entomological survey [18]. *Euspilotus modestus* adults were found at a depth of 20–30 cm under a cow carcass one month after death in the spring in Mendoza [50]. The currents study may be of use in other forensic studies, as this species was found in a corpse buried at 50 cm deep in an arid environment. The presence of only adults of this species may be explained by the following scenario: adults colonized the body or completed their life cycle in the corpse and when they left the body, they were trapped by the plastic bag covering the corpse. *Phelister rufinotus* was recorded on exposed pig carcasses in Mendoza [18] and in the municipality of Arroyo Seco, Mexico [52]. This study provides a new case of *P. rufinotus* in a buried human carcass.

In one study, *Ophyra aenescens* and *E. modestos* were associated with a corpse buried at a depth of 20–30 cm, one month after death, in the spring, in the arid environment of Mendoza [50]. In Buenos Aires, Oliva [49] estimated a postmortem interval of seven months in the winter, for a buried corpse that had *M. scalaris*, so the species must have colonized the cadaver in the summer. These species likely colonized the cadaver in the first months of exposure in spring and summer. In the current study, the lack of live carrion insects in multiple samples indicates that the corpse had no more food resources for insects and that they consumed the entire corpse in less than 11 years. This result differs Martin-Vega *et* al. [46], who reported insect activity 18 years after death.

Hence the combination of the osteobiographic profile, burial context, materials, and postmortem history provided a preliminary match between the corpse and the missing person as well as the circumstances of death. With this information, police and legal authorities were able to apprehend and charge the suspects of a homicide in less than 72 h. Subsequently, the results of DNA analysis corroborated the identity of the victim. During the trial, the circumstances of death were revealed and the perpetrator (one of the sons) confessed to having beaten the victim "with an iron", corroborating the rib fractures.

Conclusion

In this paper, we have shown that forensic archaeology and anthropology are essential disciplines for locating and excavating human remains and that having experts at the crime scene is crucial. We have highlighted the importance of approaching an investigation holistically and as a process, from the fieldwork to the laboratory, and the final report, integrating the contributions of different disciplines such as entomology, dentistry, genetics and image diagnosis

Forensic anthropology played a key role. Once the remains were found, this approach provided information for a preliminary identification of the victim (later corroborated with DNA) as well as the circumstances and cause of death. This enabled the prosecutor to indict two suspects in less than 72 h on an eleven-year-old homicide. The confession of the perpetrator during the shortened trial gave details that coincided with the forensic results.

Finally, we see four directions for future work. First, more work could be done to coordinate with the District Attorney to collect more antemortem information on suspected victims. Second, more bioanthropological research is needed on contemporary local populations (sex, age, height, body mass). Third, entomological studies would benefit from more research on corpses buried in arid environments that could help establish the specific time period of colonization, succession, and skeletonization based on specific insect species. This information could be used to better estimate the postmortem interval. Fourth, it should be more common for forensic anthropologists to participate in preliminary investigations and work at crime scenes in Mendoza.

Declaration of Competing Interest

The authors report no declarations of interest.

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References

[1] D.C. Dirkmaat, J.M. Adovasio, The role of archaeology in the recovery and interpretation of human remains from an outdoor forensic setting, in: W.D. Haglund, M.H. Sorg (Eds.), Forensic Taphonomy: The Postmortem Fate of Human Remains, CRC Press, Boca Raton, 1999, pp. 39–64, doi:http://dx.doi.org/10.1136/bmj.319.7207.458.

[2] M. Skinner, D. Alempijevic, M. Djuric-Srejic, Guidelines for international forensic bio-archaeology monitors of mass grave exhumations, Forensic Sci. Int. 134 (2003) 81–92, doi:http://dx.doi.org/10.1016/S0379-0738(03)00124-5.

[3] T.L. Dupras, J.J. Schultz, S.M. Wheeler, L.J. Williams, Forensic Recovery of Human Remains: Archaeological Approaches, second ed., CRC Press, Boca Ratón, 2011.

[4] L.L. Menez, The place of a forensic archaeologist at a crime scene involving a buried body, Forensic Sci. Int. 152 (2005) 311–315, doi:http://dx.doi.org/10.1016/j.forsciint.2005.03.018.

[5] R. Mariani, R. García-Mancuso, G.L. Varela, I. Kierbel, New records of forensic entomofauna in legally buried and exhumed human infants remains in Buenos Aires, Argentina, J. Forensic Leg. Med. 52 (2017) 215–220, doi:http://dx.doi.org/10.1016/j.jflm.2017.09.012.

[6] D.C. Dirkmaat, L.L. Cabo, Forensic archaeology and forensic taphonomy: basic considerations on how to properly process and interpret the outdoor forensic scene, Acad. Forensic Pathol 6 (3) (2016) 439–454, doi:http://dx.doi.org/10.23907/2016.045.

[7] A. Ruffell, C. Donnelly, N. Carver, E. Murphy, E. Murray, J. McCambridge, Suspect burial excavation procedure: a cautionary tale, Forensic Sci. Int. 183 (2009) 11–16, doi:http://dx.doi.org/10.1016/j.forsciint.2008.10.013.

[8] M.S. Mohd Noor, L.S. Khoo, W.Z. Zamaliana Alias, A.H. Hasmi, M.A. Ibrahim, M.S. Mahmood, The clandestine multiple graves in Malaysia: the first mass identification operation of human skeletal remains, Forensic Sci. Int. 278 (410) (2017) e1–e9, doi:http://dx.doi.org/10.1016/j.forsciint.2017.05.014.

[9] M. Salado, L. Fondebrider, El desarrollo de la antropología forense en la Argentina, Cuad. Med. Forense 14 (53-54) (2009) 213–221.

[10] D. Mansegosa, S. Giannotti, J. Marchiori, C. Fernandez Aisa, Antropología forense en Mendoza: puesta en marcha del acuerdo institucional entre la Facultad de Filosofía y Letras y el Ministerio Público Fiscal, in: A. Laguens, M. Bonnin, B. Marconetto (Eds.), Libro de Resúmenes del XX Congreso Nacional de Arqueología Argentina, Universidad Nacional de Córdoba, Córdoba, 2019, pp. 661–665.

[11] J. Morello, La Provincia Fitogeográfica Del Monte, Opera Lilloana, 2(1958) , pp. 11–155.

[12] A.M. Christensen, N.V. Passalacqua, E.J. Bartelink, Forensic Anthropology: Current Methods and Practice, Academic Press, 2014, doi:http://dx.doi.org/10.1016/C2013-0-09760-5.

[13] The Scientific Working Group for Forensic Anthropology (SWGANTH), Scene Detection and Processing Revision 0 2013; http://www.swganth.org (Accessed 1 September 2020).

[14] D.H. Ubelaker, Enterramientos Humanos, excavación, análisis e interpretación, Aranzandi, Munibe, (2007) .

[15] R. Sprague, A suggested terminology and classification for burial description, Am. Antiq. 33 (4) (1968) 479–485, doi:http://dx.doi.org/10.2307/278597.
[16] A. Oliva, Diptera (Insecta) de interés forense o causante de miasis, Claves artificiales para estadios preimaginales, in: O.D. Salomón (Ed.), Actualizaciones en artropodología sanitaria Argentina, Fundación Mundo Sano, Serie Enfermedades Transmisibles, Diptera de interés forense o causantes de Miasis, Buenos Aires, 2002, pp. 51–60.
[17] K.L. Sukontason, W. Boonsriwong, S. Siriwattanarungsee, S. Piangjai, K. Sukontason, Morphology of puparia of *Megaselia scalaris* (Diptera: Phoridae), a fly species of medical and forensic importance, Parasitol. Res. 98 (2006) 268–272, doi:http://dx.doi.org/10.1007/s00436-005-0052-4.
[18] F.H. Aballay, G. Arriagada, G.E. Flores, N.D. Centeno, An illustrated key to and diagnoses of the species of Histeridae (coleoptera) associated with decaying carcasses in Argentina, Zookeys 261 (2013) 61–84, doi:http://dx.doi.org/10.3897/zookeys.261.4226.
[19] T.W. Phenice, A newly developed visual method of sexing the os pubis, Am. J. Phys. Anthropol. 30 (1969) 297–302, doi:http://dx.doi.org/10.1002/ajpa.1330300214.
[20] P.L. Walker, Greater sciatic notch morphology: sex, age, and population differences, Am. J. Phys. Anthropol. 127 (2005) 385–391, doi:http://dx.doi.org/10.1002/ajpa.10422.
[21] T.D. Stewart, Essentials of Forensic Anthropology, Especially as Developed in the United States, Springfield, ll Charles C. Thomas, 1979.
[22] S. Brooks, J.M. Suchey, Skeletal age determination based on the os pubis: a comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods, Hum. Evol. 5 (1990) 227–238, doi:http://dx.doi.org/10.1007/BF02437238.
[23] D. Katz, J.M. Suchey, Age determination of the male Os pubis, Am. J. Phys. Anthropol. 69 (4) (1986) 427–435, doi:http://dx.doi.org/10.1002/ajpa.1330690402.
[24] C.O. Lovejoy, R.S. Meindl, T.R. Pryzbeck, R.P. Mensforth, Chronological metamorphosis of the auricular surface of the ilium: a new method for the determination of adult skeletal age at death, Am. J. Phys. Anthropol. 68 (1) (1985) 15–28, doi:http://dx.doi.org/10.1002/ajpa.1330680103.
[25] K.M. Hartnett, Analysis of age-at-death estimation using data from a new, modern autopsy sample - Part I: pubic bone, J. Forensic Sci. 55 (5) (2010) 1145–1151, doi:http://dx.doi.org/10.1111/j.1556-4029.2010.01399.x.
[26] H. Lamendin, E. Baccino, J.F. Humbert, J.C. Tavernier, R.M. Nossintchouk, A. Zerilli, A simple technique for age estimation in adult corpses: the two criteria dental method, J. Forensic Sci. 68 (1992) 15–28, doi:http://dx.doi.org/10.1520/jfs13327j.
[27] R. Gilbert, G.W. Gill, Metric technique for identifying American Indian femora, in: G. W. Gill, S. Rhine (Eds.), Skeletal Attribution of Race, Maxwell Museum of Anthropology, University of New Mexico, Albuquerque, 1990, pp. 97–99.
[28] M. Trotter, G.C. Gleser, Estimation of stature from long bones of American Whites and Negroes, Am. J. Phys. Anthropol. 10 (1952) 463–514, doi:http://dx.doi.org/10.1002/ajpa.1330100407.
[29] B.M. Auerbach, C.B. Ruff, Human body mass estimation: a comparison of "morphometric" and "mechanical" methods, Am. J. Phys. Anthropol. 125 (2004) 331–342, doi:http://dx.doi.org/10.1002/ajpa.20032.
[30] K.R. Burns, Forensic Anthropology Training Manual, Prentice-Hall, Boston, 2015, doi:http://dx.doi.org/10.4324/9781315664163.
[31] E. Barnes, Atlas of Developmental Field Anomalies of the Human Skeleton, Wiley-Blackwell, Hoboken, New Jersey, 2012, doi:http://dx.doi.org/10.1002/9781118430699.
[32] D.J. Ortner, Identification of Pathological Conditions in Human Skeletal Remains, second ed., Academic Press, San Diego, 2003, doi:http://dx.doi.org/10.1016/B978-0-12-528628-2.X5037-6.
[33] F. Serrulla Rech, Atlas de Antropología Forense, Correlaciones desde la Patología Forense, Aranzadi, (2020) .
[34] V.L. Wedel, A. Galloway (Eds.), Broken Bones: Anthropological Analysis of Blunt Force Trauma, second ed., Springfield, 2014, doi:http://dx.doi.org/10.1002/ajpa.22577.
[35] J. Pokines, S. Symes (Eds.), Manual of Forensic Taphonomy, CRC Press, Boca Raton, 2013, doi:http://dx.doi.org/10.1201/b15424.
[36] W.D. Haglund, M.H. Sorg (Eds.), Forensic Taphonomy, CRC Press, Boca Raton, 1996, doi:http://dx.doi.org/10.1201/9781439821923.
[37] P. Prado Herrero, Apuntes sobre la limpieza de minerales, Grupo Mineralogista de Madrid, Madrid, 2004.
[38] Y. Fernández-Jalvo, P. Andrews, Atlas of taphonomic identifications, Vertebrate Paleobiology and Paleoanthropology, first ed., Springer, 2016, doi:http://dx.doi.org/10.1007/978-94- 017-7432-1.
[39] D.R. Congram, A clandestine burial in Costa Rica: prospection and excavation, J. Forensic Sci. 53 (2008) 793–796, doi:http://dx.doi.org/10.1111/j.1556-4029.2008.00765.x.
[40] R.H.L. Disney, Natural history of the scuttle fly, *Megaselia scalaris*, Annu. Rev. Entomol. 53 (2008) 39–60, doi:http://dx.doi.org/10.1146/annurev.ento.53.103106.093415.
[41] J.H. Byrd, J.K. Tomberlin (Eds.), Forensic Entomology: The Utility of Arthropods in Legal Investigations, third ed., CRC Press, Taylor & Francis Group, Boca Raton, London, N.Y, 2020, pp. 103–139, doi:http://dx.doi.org/10.14411/eje.2020.014.
[42] F.H. Aballay, A.F. Murua, J.C. Acosta, N.D. Centeno, Succession of Carrion Fauna in the Arid Region of San Juan Province, Argentina and Its Forensic Relevance, Neotrop. Entomol. 41 (2012) 27–31, doi:http://dx.doi.org/10.1007/s13744-011-0005-9.
[43] E. Kranioti, Forensic investigation of cranial injuries due to blunt force trauma: current best practice, Res. Reports Forensic Med. Sci. 5 (2015) 25–37, doi:http://dx.doi.org/10.2147/rrfms.s70423.
[44] C.P. Campobasso, R.H.L. Disney, F. Introna, A case of Megaselia scalaris (Loew) (Dipt., Phoridae) breeding in a human corpse, Anil Aggrawal's Internet J. Forensic Med. Toxicol. 5 (1) (2004) 3–5.
[45] R. Mariani, R. García-Mancuso, G.L. Varela, A.M. Inda, Entomofauna of a buried body: study of the exhumation of a human cadaver in Buenos Aires, Argentina, Forensic Sci. Int. 237 (2014) 19–26, doi:http://dx.doi.org/10.1016/j.forsciint.2013.12.029.
[46] D. Martín-Vega, A. Gómez-Gómez, A. Baz, The "coffin fly" *Conicera tibialis* (Diptera: Phoridae) breeding on buried human remains after a postmortem interval of 18 years, J. Forensic Sci. 56 (6) (2011) 1654–1656, doi:http://dx.doi.org/10.1111/j.1556-4029.2011.01839.x.
[47] A. Oliva, Frecuencia y distribución temporal de moscas cadavéricas (Diptera) en la ciudad de Buenos Aires, Rev. Del Mus. Argentino Ciencias Nat. 9 (2007) 5–14.
[48] B. Bourel, G. Tournel, V. Hédouin, D. Gosset, Entomofauna of buried bodies in northern France, Int. J. Legal Med. 118 (2004) 215–220, doi:http://dx.doi.org/10.1007/s00414-004-0449-0.
[49] A. Oliva, Insects of forensic interest in Buenos Aires (Argentina). Addenda et corrigenda. I. Phoridae (Diptera: Brachycera), Physics 60 (138/139) (2004) 43–50.
[50] F.H. Aballay, F.N. Jofré, N.D. Centeno, Asociación y estratificación de la entomofauna cadavérica a deferentes profundidades en el suelo como indicadores complementarios en largos intervalos post mortem, Rev. Mus. Argent. Cienc. Nat. 19 (2) (2017) 225–234.
[51] A.P. Armani, S. Dahinten, N. Centeno, Artropodofauna cadavérica asociada a cerdo doméstico (Sus scrofa) en un ambiente ribereño en Chubut, Argentina, Rev. Colomb. Entomol. 43 (2) (2017) 262–267, doi:http://dx.doi.org/10.25100/socolen.v43i2.5955.
[52] S. Vergara-Pineda, I. Avilés Carrillo, J.A. Obregón Zúñiga, Escarabajos Histéridos (Coleoptera: Histeridae) asociados a cadáveres de cerdo (*Sus scrofa* domestica) durante verano en Concá, Arroyo Seco, Querétaro, Entomol. Mex. 7 (2020) 377–381.