Journal of Medical Entomology, XX(X), 2019, 1–8
doi: 10.1093/jme/tjz102
Research

Insights on Funeral Practices and Insects Associated With the Tombs of King Ferrante II d'Aragona and Other Renaissance Nobles

Augusto Loni,[1] Antonio Fornaciari,[2] Angelo Canale,[1] Valentina Giuffra,[2] Stefano Vanin,[3] and Giovanni Benelli[1,4]

[1]Department of Agriculture, Food and Environment, University of Pisa, via del Borghetto 80, 56124 Pisa, Italy, [2]Division of Paleopathology, Department of Translational Research and of New Technologies in Medicine and Surgery, University of Pisa, Pisa, Italy, [3]School of Applied Sciences, University of Huddersfield, Queensgate, HD1 3DH Huddersfield, United Kingdom, and[4] Corresponding author, e-mail: giovanni.benelli@unipi.it

Subject Editor: Michael Rust

Received 11 April 2019; Editorial decision 23 May 2019

Abstract

The impressive Sacristy of the Basilica of St. Domenico Maggiore contains 38 wooden sarcophagi with the bodies of 10 Aragonese princes and other Neapolitan nobles, who died in the 15th and 16th centuries. To improve the knowledge about the entomofauna associated with bodies in archaeological contexts, herein we provide insights on the funerary practices and the insect community associated to Ferrante II King of Naples and other Italian Renaissance mummies of the Aragonese dynasty buried in the Basilica of St. Domenico Maggiore. We identified 842 insect specimens: 88% were Diptera (Muscidae, Fanniidae, and Phoridae), followed by 9% Lepidoptera (Tineidae) and 3% Coleoptera (Dermestidae and Ptinidae). Ninety-seven percent of the specimens were collected from the coffin of Francesco Ferdinando d'Avalos, which was the best preserved. A lack of fly species characterizing the first colonization waves of exposed bodies was noted. The most common fly was the later colonizing muscid *Hydrotaea capensis* (Wiedemann); only a few Fanniidae (*Fannia* spp.) were retrieved. The lack of blowflies, coupled with recording *H. capensis* as the dominant fly, supports our hypothesis that corpses have been kept indoors for a long time under confined environmental conditions. Other explanations include odorous oils/balms having been used in the embalming process, causing the delay or stopping the arrival of first colonizer flies. Hermetically sealing of the coffin with bitumen may also have played a role in preventing access to the corpses. This scenario describes a historical context characterized by a well-advanced knowledge of body preparation, with specific burial techniques adopted for nobles.

Key words: Phoridae, Muscidae, *Hydrotaea capensis*, Fanniidae, Italian Renaissance

Archaeoentomology deals with the collection and analysis of arthropods remain in archaeological contexts. It derives from the tradition of Quaternary entomology, covering the study of insects and insect fossils embracing the last 2.5 million yr. Insect remains can give important information regarding sites of archaeological interest, involved by human activities. They can cover physical environment, vegetation, human subsistence practices as well as hygiene (Moret 1998, Green et al. 2019). A more specific field within archaeoentomology is represented by funerary archaeoentomology, which mainly focuses on tombs or other burials of archaeological or historical interest (Huchet 2014, Giordani et al. 2018). Funerary archaeoentomology can be considered a discipline partially overlapped with classic archaeoentomology and forensic entomology, since both deal with the study of human cadavers. They share most of the methodology employed in collecting data, but they scopused to the obtaining of different goals (Vanin and Huchet 2017). In the case of funerary archaeoentomology the temporal distance between the collection of the insects and the time of their active presence on the cadaver or on the substrate, can encompass centuries or even millennia (Handschin 1944, Wylie et al. 1987, Germonpré and Leclercq 1994, Benelli et al. 2014). During this time, many hard-to-predict factors, including environmental ones, could strongly modify the preservation state of the insects. Furthermore, sampling methodologies could also affect the results of the collection. For this reason, data can be difficult to analyze focusing on their quantitative aspect. As a first consequence, all the collections of insect in archaeological contexts represent an incomplete sample of the original set, not giving a full picture of the original scenario. However, especially

in enclosed environments like a coffin, the remains of insects community can provide many important information about the environmental, ecological, taphonomical, and sometimes cultural events linked with specific past burial practices.

Information in funerary contexts is still poor, despite some efforts in the last decades, leading to the collection of data from excavation and exhumations performed in Europe, North Africa and South America (e.g., Panagiotakopulu 2001; Masetti et al. 2008; Vanin et al. 2009; Huchet and Greenberg 2010; Panagiotakopulu and Buckland 2012; Huchet et al. 2013a,b; Gaudio et al. 2015; Giordani et al. 2018).

In order to improve the knowledge about the entomofauna associated with cadavers from archaeological contexts, herein we analyzed the insects collected from Ferrante II King of Naples and three other Italian Renaissance mummies of the Aragonese dynasty (15th–16th centuries). Mummies had been buried in the Basilica of San Domenico Maggiore in Naples, Italy, and later exhumed and studied by Fornaciari (2006), applying in this archaeological context the methodology and techniques used in forensic entomology (Giordani et al. 2018). The entomofauna collected was analyzed to better understand the funerary practices, attempting to answer the following questions: 1) Did the body concealment in a coffin affect the composition of the cadaveric fauna? 2) Did the embalming and mummification process (well-documented for NASD6 and NASD20 (Table 2) influence the composition of the cadaveric fauna? 3) Did the secondary burial affect the general composition of the cadaveric fauna?

Historical and Archaeological Context

The Basilica of San Domenico Maggiore (14th century) is one of the largest and most important churches in Naples (Southern Italy). The impressive Sacristy of San Domenico Maggiore (Fig. 1A), located in a suspended gateway close to the vault, hosts 38 wooden sarcophagi containing the bodies of 10 Aragonese princes and princesses and other Neapolitan aristocrats, who died in the 15th–17th centuries (Fig. 1B–D).

Most of the individuals had been embalmed and this is certainly not surprising, considering the high social level to which the individuals buried in San Domenico belonged. From the physician Ulisse Aldrovandi, we know that during the Renaissance ‘the

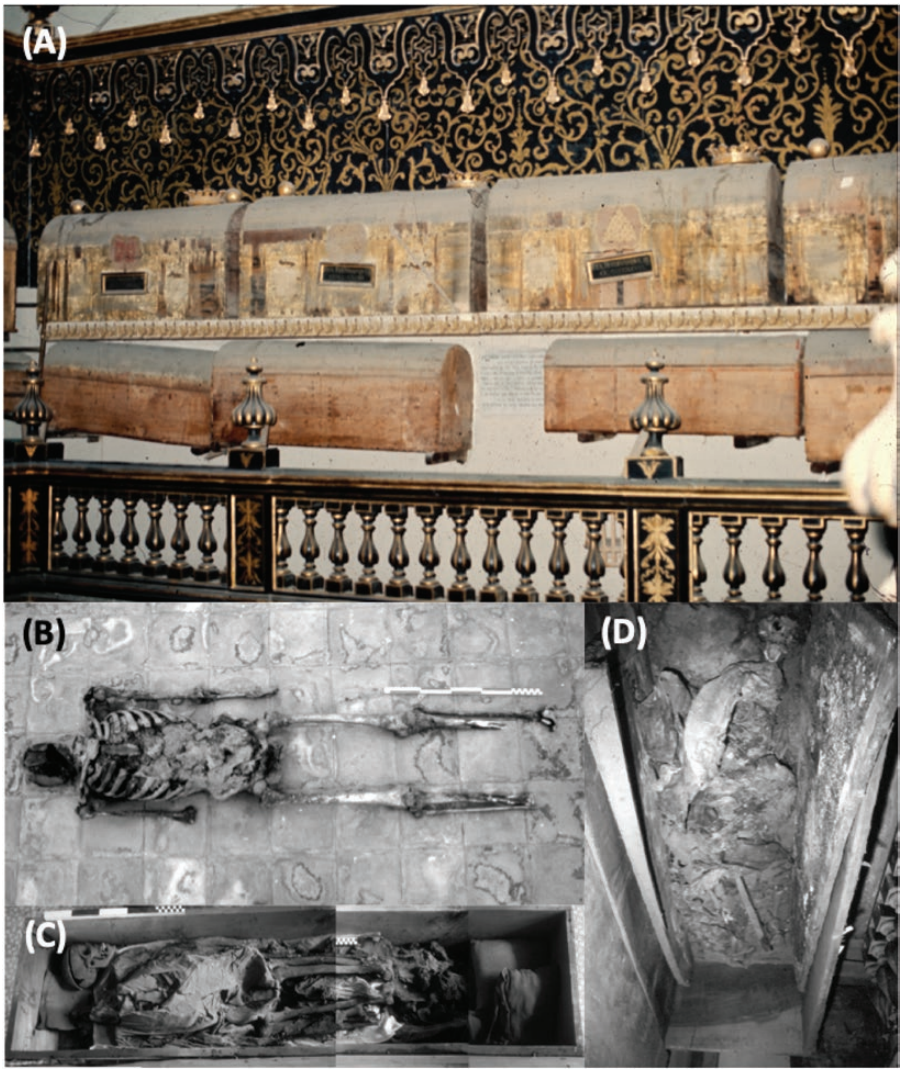

Fig. 1. (A) An overview of the sepulchres of members of the royal Aragonese family in St. Domenico Maggiore, Naples. (B) Badly preserved and partially burned artificial mummy of the King of Naples Ferrante II of Aragon (1469–1496, ID: NASD20). (C) Skeletonized artificial mummy most probably of Francis Ferdinand of Avalos, marquis of Vasto and Pescara (1530–1571, ID: NASD6). (D) Disconnected skeleton of the Queen of Naples Joan IV of Aragon (1479–1518, ID: NASD19).

European kings and great personages used to entrust embalming of their bodies to their doctors and surgeons' (cited in Gannal 1841). The very complex evisceration and embalming method indicates a long-practiced and a diffused embalming tradition.

The embalming process by evisceration in the Renaissance had a dual purpose: to preserve the body during the long funerary rituals (which also included prolonged exposure of the body) and to guarantee maintenance over time of the body of nobles and sovereigns (Giuffra et al. 2016). In Naples, in addition to evisceration and treatment with preservative vegetable substances, body preservation was favored by the permanence of the corpses in a dry room, in a tank probably filled with volcanic Vesuvian sand. Similar rooms still exist in the basements of the church of San Domenico Maggiore in Naples. However, some well-preserved individuals show no apparent signs of embalming. In this case, the natural mummification of the bodies can probably be attributed to the very dry microclimatic conditions of the Basilica (Fornaciari 1998).

The Sacristy of San Domenico Maggiore collection includes 32 individuals (Fornaciari 2006) but, for a first entomological study, four individuals were sampled (Table 1). One of the examined mummies, badly preserved and partially burned, is the King of Naples Ferrante II of Aragon (1469–1496) (NASD20) (Fig. 1B). Another mummy, almost completely skeletonized is Francis Ferdinand of Avalos, Marquis of Vasto and Pescara (1530–1571) (NASD6) (Fig. 1C). The third one, consisting of a disconnected skeleton, belongs to the Queen of Naples Joan IV of Aragon (1479–1518) (NASD19) (Fig. 1D), whereas the last one is a secondary burial of the trunk with well-preserved bones, belonging to Catherine of Moncada, Duchess of Montalto (deceased in 1659) (NASD31).

Material and Methods

Entomological samples were manually collected with sterile tweezers and paintbrushes from the remains within the coffins and stored in sterile glass vials at room temperature (15–20°C) to avoid any contamination that would damage or interfere with any further molecular investigations of the mummies and the entomological samples.

The entomological samples, observed with a stereoscopic microscope S9E (Leica, Germany) typically consisted of a combination of intact insects and insect parts or fragments. The puparium represents the nonmobile stage of the fly life cycle and because of its chemical and physical properties can be collected after centuries or millennia (Vanin and Huchet 2017). To estimate the minimum number of puparia that were highly fragmented, each complete puparium was considered as a single specimen; if fragmented, only the parts with the posterior spiracles, which often represent very reliable diagnostic structures, were counted as specimens (Skidmore 1985, Giordani et al. 2019).

Part of the material was mounted on entomological card and photographed to create a pictorial archive useful for the identification of the species (Skidmore 1985, Smith 1986, Peacock 1993, Giordani et al. 2018, Pradelli et al. 2019). Where the species identification was not possible because the remains were incomplete, badly preserved or because of the lack of an identification key for that developmental stage or fragment (e.g., Lepidoptera cocoon and Coleoptera exuviae), identification was done to the taxonomic level of genus or family.

Results

Eight hundred forty-two insect remains belonging to three orders, Diptera, Coleoptera, and Lepidoptera, were collected from the four Aragonese mummies examined in this study. Notably, 738 (87.6%) specimens were Diptera, followed by 77 (9.1%) Lepidoptera and 27 (3.2%) Coleoptera. Eight hundred fourteen (96.7%) of all the insect remains were collected from the coffin NASD6, 13 (1.5%) from NASD20, 10 (1.2%) from NASD19 and only 5 (0.6%) from NASD31 (Table 2).

Three families of Diptera were represented, Muscidae, Fanniidae, and Phoridae, along with two families of Coleoptera, Dermestidae and Ptinidae, and one family of Lepidoptera, Tineidae (Table 1).

Diptera

Among Diptera, Muscidae was the most collected taxon mainly represented by the species *Hydrotaea capensis* (Wiedemann) (Diptera: Muscidae). Puparia of this species (Fig. 2A and C) were present in all the examined human remains. Some puparia of *H. capensis* showed the typical exit holes produced by the emergence of Hymenoptera parasitoids (Fig. 2D and E). *Hydrotaea capensis* adult heads, wings, legs, and fragments of thorax were also present among the studied material (Fig. 3).

Twelve puparia belonging to a species in the genus *Fannia* Robineau-Desvoidy 1830 (Diptera: Fanniidae), were retrieved in sample NASD6. The immature stages of this genus are morphologically characteristic. Puparia are dorso-ventrally flattened and they show well-developed ramified processes on the lateral and dorsal sides (Fig. 4A and B).

One single puparium of Phoridae was present in the sample NASD6. Its shape fits well with the species *Conicera tibialis* Schmitz (Diptera: Phoridae) (Fig. 4C and D); however, the absence of adults prevents definitive identification to species.

Coleoptera

Several exuviae of Dermestidae larvae were identified among the studied samples, but they were not identified at the species level despite the presence of short setae that is characteristic/diagnostic of the species in the *Anthrenus* Geoffroy, or *Attagenus* Latreille genera (Coleoptera: Dermestidae) (Fig. 5A). A single elytron of a spider beetle (Ptinidae) was recovered in the sample NASD20. It is consistently matching with the genus *Ptinus* Linnaeus (Coleoptera: Ptinidae) (Fig. 5B).

Table 1. Identification of individuals and preservation of the bodies

Tomb ID	NASD20	NASD19	NASD31	NASD6
Identification	Ferrante II (1496)	Giovanna IV (1518)	Caterina di Moncada (1659)	Francesco Ferdinando d'Avalos (1571)
Body preservation	Artificial mummy	Disconnected skeleton	Disconnected skeleton	Artificial mummy
Postmortem damage	Fire, grave robbers damage	Grave robbers damage	Re-deposition in trunk	Partial grave robbers damage

Table 2. Abundance of insect remains retrieved from the mummies of Ferrante II d'Aragona, King of Naples (1496), Giovanna IV d'Aragona, Queen of Naples (1519), Caterina di Moncada, Duchess of Montalto (1659), and Ferdinando Francesco d'Avalos, Marquis of Vasto and Pescara (1571)

Order, family, and species	Abundance of insect remains (no.)				
	Ferrante II d'Aragona (1496) NASD20	Giovanna IV d'Aragona (1518) NASD19	Caterina di Moncada (1659) NASD31	Ferdinando Francesco d'Avalos (1571) NASD6	Total
Coleoptera	5			**22**	**27**
Dermestidae	4			22	24
Ptinidae, *Ptinus* sp.	1				1
Diptera	**2**	**4**	**4**	**724**	**738**
Fanniidae, *Fannia* sp.				12	12
Muscidae, *Hydrotaea capensis*	2	4	4	711	721
Phoridae, *Conicera tibialis*				1	1
Lepidoptera	**2**	**6**	**1**	**68**	**77**
Tineidae	2	6	1	68	77
Not identified					
Eggs	4				4
Total	13	10	5	814	842

Insect orders are outlined in bold. Within each order, the classification at family or species level was provided.

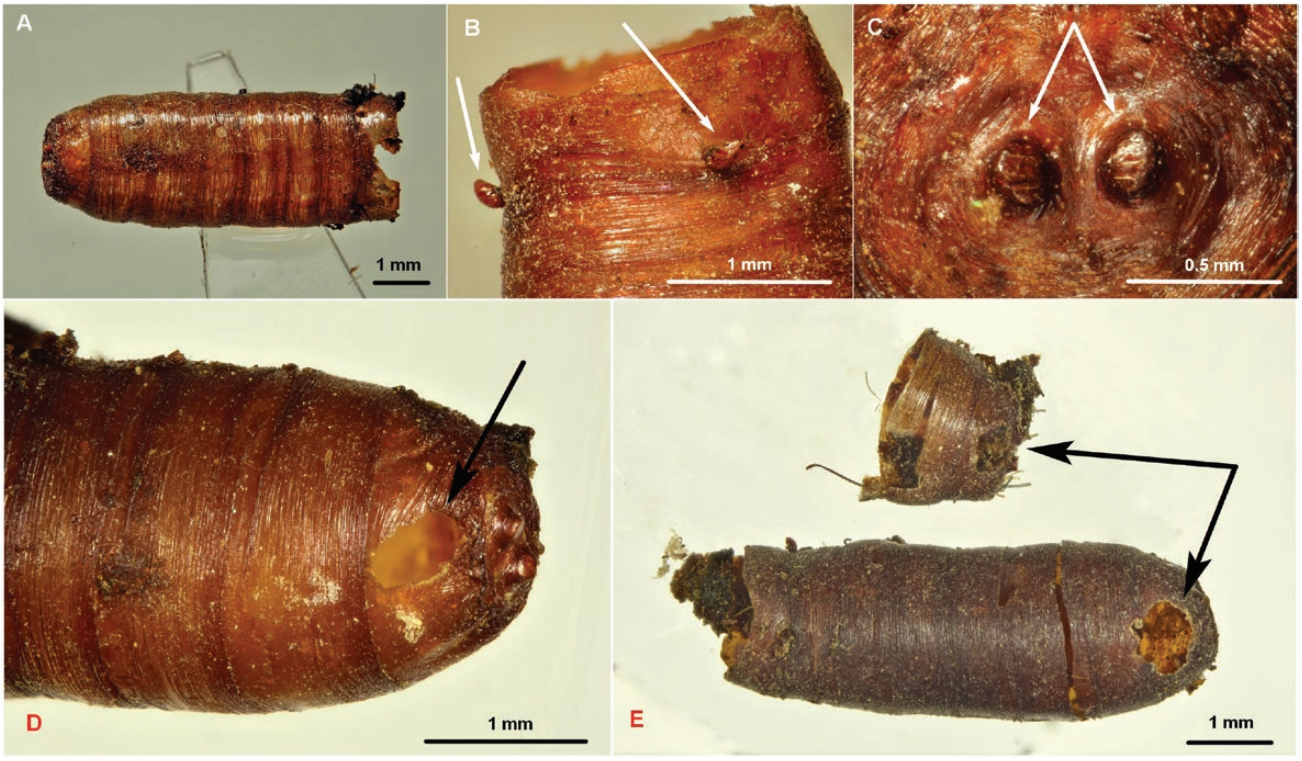

Fig. 2. *Hydrothaea capensis* (Diptera: Muscidae): (A) puparia global view, (B) arrows indicate the spiral anterior respiratory horns, (C) posterior spiracula, (D–E) arrows indicate the exit hole produced by the emergence of a parasitoid. Red scale bar: 1 mm; blue scale bar: 500 µm.

Lepidoptera

Cocoons (Fig. 6A and B) and cephalic capsules of Tineidae (Lepidoptera: Tineidae) larvae (Fig. 6D and E) were found in all the mummies. No remains of adults were detected, thus genus or species for this taxon remains undetermined. Furthermore, two cocoons showed the typical exit hole of a Hymenoptera parasitoid (Fig. 6C).

Unidentified Samples

Four insect eggs were recorded from sample NASD20 (Table 2).

Discussion

To the best of our knowledge, a strictly limited number of earlier studies examined the insect remains characterizing Aragonese tombs. Recently, Benelli et al. (2014) showed that the black soldier fly, *Hermetia illucens* (Linnaeus) (Diptera: Stratiomyidae), of supposed American origin and acknowledged in Europe only from 1926, was present in Italy several centuries earlier. Indeed, Benelli et al. (2014) found a larva of this species in the sarcophagus of the Renaissance princess Isabella d'Aragona (1470–1524). Earlier, Fornaciari et al. (2009) detected a double infestation of the head

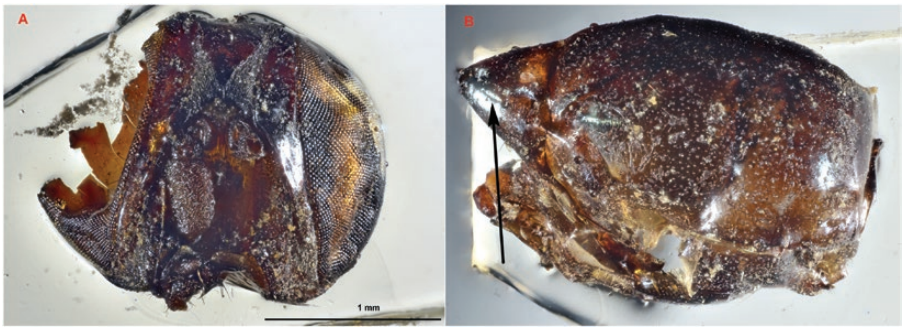

Fig. 3. Diptera Muscidae *Hydrothaea capensis*. (A) Head fragmented, frontal view, (B) thorax; arrow indicates the posterior side with scutellum. Red scale bar: 1 mm.

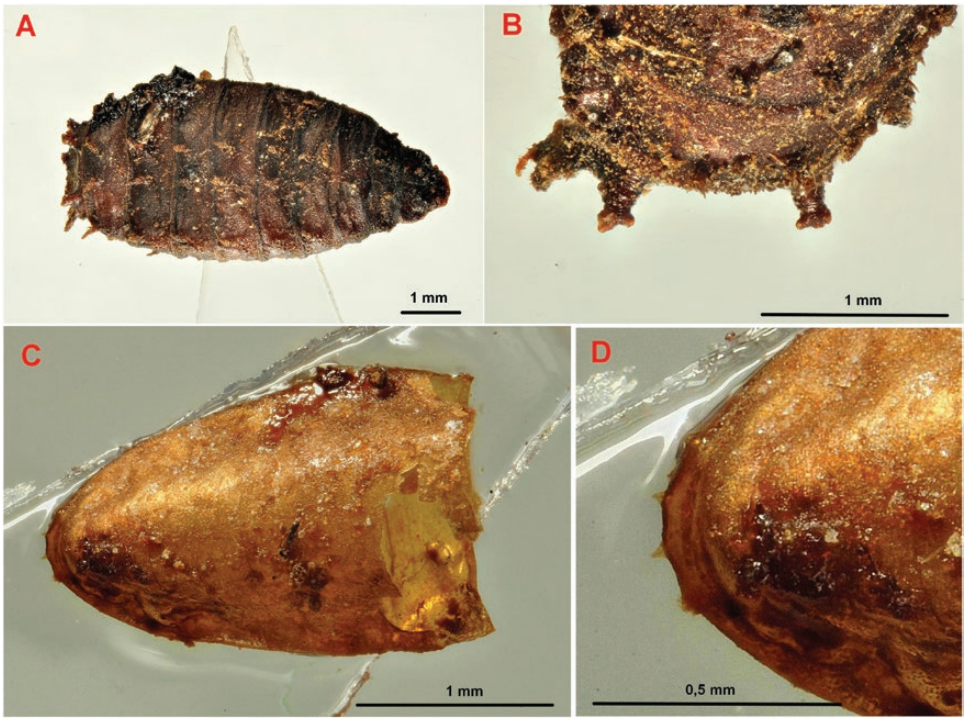

Fig. 4. (A) Diptera Fanniidae puparia global view, (B) detail, (C) *Conicera tibialis* (Diptera Phoridae) puparia global view, (D) detail. Red scale bar: 1 mm; blue scale bar: 500 µm.

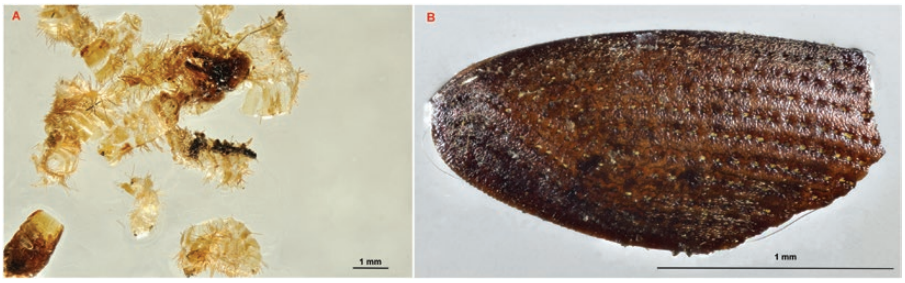

Fig. 5. (A) Larval exuviae of Coleoptera Dermestidae, (B) elytron of *Ptinus* sp. (Coleoptera Ptinidae). Red scale bar: 1 mm.

louse, *Pediculus humanus capitis* De Geer Anoplura: Pediculidae and the pubic louse, *Pthirus pubis* (Linnaeus) Anoplura: Pthiridae in the mummy of Ferrante II d'Aragona (1467–1496), King of Naples. This finding stressed that even members of the Renaissance upper classes were afflicted by louse infestations (Fornaciari et al. 2009). However, until now the other Aragonese mummies, buried in San Domenico Maggiore (Naples), remained unexplored.

In the present study, a remarkably higher number of insect fragments were found in the mummy NASD6 than in the other three Aragonese individuals. NASD6 was also subjected to inspection in

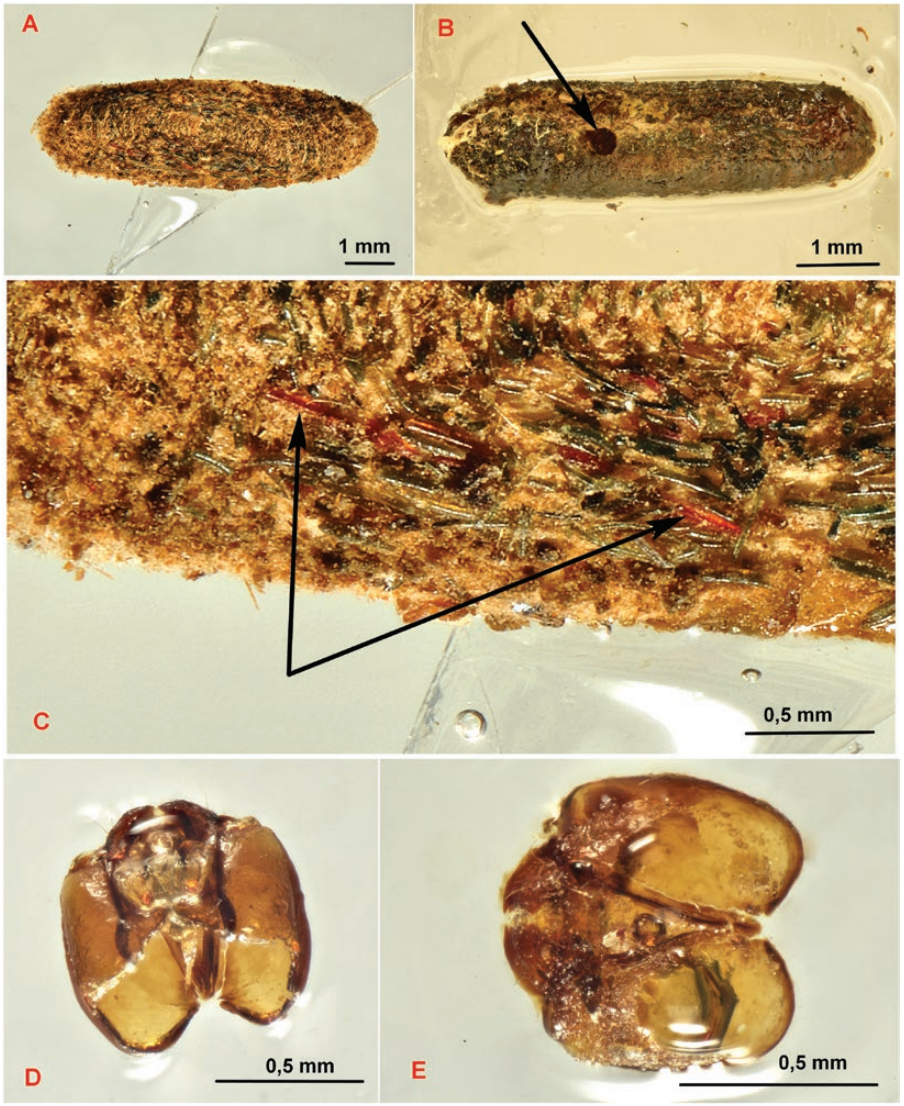

Fig. 6. Lepidoptera Tineidae. (A) cocoon, (B) parasitized cocoon, arrows indicated the parasitoid exit hole, (C) cocoon detail, arrows indicate red tissue fibers, (D) cephalic capsule ventral view, and (E) dorsal view. Red scale bar: 1 mm; blue scale bar: 500 μm.

1894 (Amante 1896) and it is the better-preserved deposition, with the skeleton still in partial anatomical connection. In contrast, the other three individuals consist of a mummy strongly damaged by the disastrous 1506 fire (Volpicella 1847) with disconnected limbs (NASD20) and in two disconnected skeletons (NASD19 and NASD31). The better preservation of mummy NASD6 compared to the other individuals can explain the abundance of the sampled insects.

All the insects found in our sampling belonged to species typical of a late cadaver colonization, with a lack of species characterizing the first colonization waves of exposed bodies (e.g., species belonging to the genera *Calliphora* Robineau-Desvoidy, *Lucilia* Robineau-Desvoidy (Calliphoridae), *Musca* Linnaeus, *Muscina* Robineau-Desvoidy (Muscidae), and *Sarcophaga* Meigen (Sarcophagidae)).

High numbers of *H. capensis* puparia, the most represented taxon, have been reported from human remains of historic and archaeological interest (for a review see Giordani et al. 2018). This species usually colonizes corpses in later succession waves during the ammonia fermentation. However, in concealed conditions, where no arrival of blowflies is possible, *H. capensis* is often the dominant Diptera species (see also Pradelli et al. 2019). This supports the hypothesis that corpses have been kept indoors for a long time under protected, confined environmental conditions, without exposure to open air (Couri et al. 2009). However, other explanations for NASD20 and NASD6 could be outlined, including an embalming process using odorous oils/balms that could have delayed or stopped the arrival of the first colonizer flies, followed by sealing the coffin with bitumen. On the other hand, the presence of specimens in the genera *Fannia* and *Hydrotaea* likely excludes the hypothesis of a preliminary dehydration of the body using volcanic sand, which quickly dries the treated bodies, strongly reducing the suitability of the environmental conditions for the colonization of these species. Overall, this scenario corresponds to a historical context with a well-advanced knowledge about body preparation where specific burial techniques existed and were adopted for the wealthy and aristocrats (Marinozzi and Fornaciari 2005).

The large abundance of Diptera puparia fragments is not surprising, because puparia represent the most resistant structural element of all the Diptera developmental stages. The puparia formation process is characterized by the sclerotization of the mature maggot cuticle rich in chitin, whose chemical structure can survive

for centuries to millennia (Vanin and Huchet 2017). Only a few, very damaged adult fragments of *H. capensis*, were found, which may be explained by their fragility (Panagiotakopulu 2004). The scarcity of adult fly fragments suggests that most of them could have had the possibility to fly away from the coffin or that their body could have been consumed by successive populations of the polyphagous insects, such as Dermestidae beetles. Such a situation is consistent with a possible later exhumation of the bodies that could have been exposed for a quite long period, e.g., after the visits of grave robbers.

Phoridae are small-size Diptera, well known in the forensic context for their ability to enter coffins or to reach deeply buried bodies (Manlove and Disney 2008). Their scarcity could suggest the coffins were well-sealed. However, in our case, the single partial puparium of *C. tibialis* was found in the sample NASD6, together with the high number of *H. capensis* remains, suggest that insects had easy access to this corpse. Furthermore, Fanniidae species usually are typical of a later colonization. In relatively advanced decomposed cadavers, the degeneration of the tissues to a liquid state, produces a wet environment on the bottom of the coffin, which is highly attractive for the species of this family, also known as 'latrine-flies' (Nuorteva et al. 1974, Smith 1986, Lee and Marzuki 1993). The finding of *Fannia* specimens in these contexts and, at the same time, the absence of bowflies remains, is consistent with the hypothesis of easier, later access by insects to the NASD6 corpse. For instance, if some slots appeared later in the coffin, due to structural adjustments, under the pressure of the gas produced by the decaying corpse.

Both Dermestidae and Ptinidae beetles are later colonizers of corpses, feeding on dried substrates and showing polyphagous habits, by consuming skin, hairs as well as clothes fibers and even other chitinized body parts. The discovery of a limited number of larval exuviae of Dermestidae and no adult remains, which represent the most resistant body parts, indicates that adult specimens had the possibility to leave the corpses quite easily through a well accessible opening.

Like Dermestidae beetles, Tineidae moths are associated with the last phases of the body decomposition. They feed on dry tissues, hairs, and textiles fibers, which are visible in the texture of the cocoons structure (Fig. 6B). We detected only cephalic head capsules of larvae and cocoons, without any traces of adult remains, supporting the hypotheses, already formulated for Dermestidae, that adults had the possibility to move out from the coffin after their emergence. Besides, the remarkable presence of moth remains could be associated with the abundance of textiles from the clothes used for the funerary ceremony of these people of high social status (D'Arbitrio 2001).

The finding of *H. capensis* puparia and Tineidae cocoons parasitized by Hymenopteran wasps highlights the ability of these parasitoids to reach concealed hosts and could also substantiate the hypothesis that the coffin NASD6, sometime after burial, was partially or entirely exposed to the open environment for a period, allowing a late insect colonization, including parasitoids that attack larvae and pupae of their hosts.

Conclusions

The examination of more than 800 insect specimens from four mummies belonging to these members of the Aragonese family confirm the historical information about the burial of people belonging to the Renaissance noblesse. In addition, the findings reported in this article underline how the concealment of the body plays a fundamental role in the selection of the entomofauna associated with body colonization. Our records, in agreement with previous work, highlight out the role of *H. capensis* in the colonization and organic material recycling in body located in confined conditions, in contrast to what happens with exposed bodies, where blowflies are the most important taxon in body colonization.

To attempt a reply to the three questions formulated in the introduction, it can be concluded that: 1) body concealment in coffins significantly affected the composition of the cadaveric fauna; 2) Furthermore, our results demonstrate that embalming and the mummification process can influence the composition of the cadaveric fauna as previously shown in other studies (Gilbert and Bass 1967, Huchet 2010, Huchet and Greenberg 2010, Nystrom et al. 2005). The embalming process appears to have stopped colonization from first colonizer flies, but it did not affect cadaver-breeding insects that colonize corpses during later stages of decomposition. 3) Lastly, the secondary burial affected the general composition of the cadaveric fauna. Indeed, the new exposition of the body allows the arrival of insects previously blocked on reaching the body.

Acknowledgments

We are grateful to the three anonymous reviewers, who kindly improved an earlier version of our manuscript. We declare no competing interests.

References Cited

Amante, B. 1896. La tomba di Vittoria Colonna e i testamenti finora inediti della poetessa. Zanichelli, Bologna, Italy.

Benelli, G., A. Canale, A. Raspi, and G. Fornaciari. 2014. The death scenario of an Italian Renaissance princess can shed light on a zoological dilemma: did the black soldier fly reach Europe with Columbus? J. Archaeol. Sci. 49: 203–205.

Couri, M. S., A. M. Cunha, S. Mendonca de Souza, and M. Laeta. 2009. *Ophira capensis* (Wiedemann) (Diptera Muscidae) found inside the esophagus of a mummy in Lisbon (Portugal), Pap. Avul. Zool. Museu Zool. Universid. São Paulo 49: 87–91.

D'Arbitrio, N. 2001. San Domenico Maggiore "La Nova Sacristia". Le arche, gli apparati e gli abiti dei re aragonesi. Savarese Ed., Napoli, Italy.

Fornaciari, G. 1998. Italian mummies, pp. 266–281. *In* A. Cockburn and E. Cockburn (eds.), Mummies, disease & ancient cultures. Cambridge University Press, Cambridge, United Kingdom.

Fornaciari, G. 2006. Le mummie aragonesi in San Domenico maggiore di Napoli. Med. Sec. 18: 843–864.

Fornaciari, G., V. Giuffra, S. Marinozzi, M. S. Picchi, and M. Masetti. 2009. 'Royal' pediculosis in Renaissance Italy: lice in the mummy of the King of Naples Ferdinand II of Aragon (1467-1496). Mem. Inst. Oswaldo Cruz. 104: 671–672.

Gaudio, D., A. Betto, S. Vanin, A. De Guio, A. Galassi, and C. Cattaneo. 2015. Excavation and study of skeletal remains from a World War I mass grave. Int. J. Osteoarchaeol. 25: 585–592.

Gannal, J. N. 1841. Histoire des embaumements. Desloges, Paris, France.

Germonpré, M., and M. Leclercq. 1994. Les pupes de *Protophormia terraenovae* associées à des mammifères pléistocènes de la Vallée flamande (Belgique). Bull. Inst. R. Sci. Nat. Belg. Sci. Terre 64: 265–268.

Gilbert, B. M., and W. M. Bass. 1967. Seasonal dating of burials from the presence of fly pupae. Am. Antiq. 32: 534–535.

Giordani, G., F. Tuccia, I. Floris, and S. Vanin. 2018. First record of *Phormia regina* (Meigen, 1826) (Diptera: Calliphoridae) from mummies at the Sant'Antonio Abate Cathedral of Castelsardo, Sardinia, Italy. PeerJ 6: e4176 doi:10.7717/peerj.4176

Giordani, G., A. Grzywacz, and S. Vanin. 2019. Characterization and identification of puparia of *Hydrotaea* Robineau-Desvoidy, 1830 (Diptera: Muscidae) from forensic and archaeological contexts. J. Med. Entomol. 56: 45–54.

Giuffra, V., A. Fornaciari, S. Minozzi, A. Vitiello, and G. Fornaciari. 2016. Autoptic practices in 16th-18th century Florence: Skeletal evidences from the Medici family. Int. J. Paleopathol. 15: 21–30.

Green, W., R. C. Schirmer, and W. T. Billeck. (2019). Plant remains and associated insects from the Millipede site (13ML361), a burned earthlodge in southwest Iowa. Plains Anthropologist. doi:10.1080/00320447.2019.1585409

Handschin, E. 1944. Insekten aus den Phosphoriten des Quercy Abh. Schweiz. Paläontol. Ges. 64: 1–23.

Huchet, J. B. 2010. Archaeoentomological study of the insects remains found within the mummy of Namenkhet Amon, San Lazzaro Armenian Monastery, (Venice/Italy). Adv. Egyptol. 1: 59–80.

Huchet, J. B. 2014. L'archéoentomologie funéraire, pp. 201–224. *In* D. Charabidze and M. Gosselin (eds.), Insectes, cadavres et scènes de crime, Principes et applications de l'entomologie médico-légale. De Boeck, Paris, France.

Huchet, J. B., and B. Greenberg. 2010. Flies, Mochicas and burial practices: a case study from Huaca de la Luna, Peru. J. Archaeol. Sci. 37: 2846–2856.

Huchet, J. B., C. Callou, R. Lichtenberg, and F. Dunand. 2013a. The dog mummy, the ticks and the louse fly: archaeological report of severe ectoparasitosis in Ancient Egypt. Int. J. Paleopathol. 3: 165–175.

Huchet, J. B., G. Pereira, Y. Gomy, T. K. Phillips, C. E. Alatorre-Bracamontes, M. Vásquez-Bolaños, and J. Mansilla. 2013b. Archaeoentomological study of a pre-Columbian funerary bundle (mortuary cave of Candelaria, Coahuila, Mexico). Ann. Soc. Entomol. France 49: 277–290.

Lee, H. L., and Marzuki, T. M. 1993. Preliminary observations of the occurrence of arthropods on carrion and its application to forensic entomology in Malaysia. Trop. Biomed. 10: 5–8.

Manlove, J. D., and R. H. Disney. 2008. The use of *Megaselia abdita* (Diptera: Phoridae) in forensic entomology. Forensic Sci. Int. 175: 83–84.

Marinozzi, S., and G. Fornaciari. 2005. Le mummie e l'arte medica nell'Evo modern. Casa Editrice Università La Sapienza, Roma, Italy.

Masetti, M., S. Gabrielli, M. Menconi, and G. Fornaciari. 2008. Insect remains associated with the mummy of Cardinal Giulio della Rovere, Archbishop of Ravenna (1533–1578), pp. 379–385. *In* P. Atoche Peña, C. Rodríguez Martín, and M. A. Ramírez Rodríguez (eds.), Mummies and science: world mummies research. Proceedings of the VI World Congress on Mummy Studies, Teguise, Lanzarote, Islas Canarias. Academia Canaria de la Historia, Santa Cruz de Tenerife, Spain.

Moret, P. (1998). L'archéo-entomologie, ou les insectes au service de l'histoire. Revue de Médecine Vétérinaire, 149: 995.

Nuorteva, P., Schumann, H., Isokoski, M., and Laiho, K. 1974. Studies on the possibilities of using blowflies (Diptera: Calliphoridae) as medicolegal indicators in Finland. Ann. Entomol. Fenn. 40: 70–74.

Nystrom, K. C., A. Goff, and M. L. Goff. 2005. Mortuary behaviour reconstruction through palaeoentomology: a case study from Chachapoya, Perú. Int. J. Osteoarchaeol. 15: 175–185.

Panagiotakopulu, E. 2001. New records for ancient pests: archaeoentomology in Egypt. J. Archaeol. Sci. 28: 1235–1246.

Panagiotakopulu, E. 2004. Dipterous remains and archaeological interpretation. J. Archaeol. Sci. 31: 1675–1684.

Panagiotakopulu, E., and P. C. Buckland. 2012. Forensic archaeoentomology–An insect fauna from a burial in York Minster. Forensic Sci. Int. 221: 125–130.

Peacock, E. R., 1993. Adults and larvae of hide, larder and carpet beetles and their relatives (Coleoptera Dermestidae) and of Derodontid beetles (Coleoptera Derodontidae), pp. 3–143. *In* R. R. Askew and W. R. Dolling (eds.), Handbooks for the identification of British insects, Vol. 5, Part 3. Royal Entomological Society of London, London, United Kingdom.

Pradelli, J., C. Rossetti, F. Tuccia, G. Giordani, M. Licata, J. M. Birkhoff, A. Verzeletti, and S. Vanin. 2019. Environmental necrophagous fauna selection in a funerary hypogeal context: the putridarium of the Franciscan monastery of Azzio (northern Italy). J. Archaeol. Sci. Rep. 24: 683–692.

Skidmore, P. 1985. The biology of the Muscidae of the world. Springer Netherlands, Dordrecht, the Netherlands.

Smith, K. G. V. 1986. A manual of forensic entomology. Comstock Publishing Associates, Cornell University Press, Ithaca, NY.

Vanin, S., and J. B. Huchet. 2017. Forensic entomology and funerary archaeoentomology, pp. 176–186. *In* E. M. J. Schotsmans, N. Marquez-Grant, and S. Forbes (eds.), Taphonomy of human remains: analysis of the death and the depositional environments. Chapter 13. John Wiley & Sons Ltd, Chichester, United Kingdom.

Vanin, S., M. Turchetto, A. Galassi, and C. Cattaneo. 2009. Forensic entomology and the archaeology of war. J. Conflict Archaeol. 5: 127–139.

Volpicella, G. 1847. Storia dei monumenti del Reame delle Due Sicilie. Vol. 2, Stamperia e Cartiere del Fibreno, Napoli, Italy.

Wylie, F. R., G. L. Walsh, and R. A. Yule. 1987. Insect damage to aboriginal relics at burial and rock-art sites near Carnarvon in central Queensland. Aust. J. Entomol. 26: 335–345.