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POLLEN ON THE SHROUD OF TURIN: THE PROBABLE TRACE LEFT BY ANOINTING AND EMBALMING*

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This study proposes an alternative interpretation of the pollen grains found on the Christian relic of the Shroud of Turin, the majority of which belong to entomogamous plants. The examination of the images in the literature and the observation of modern pollen under light microscopy and scanning electron microscopy reveal that the most abundant pollen on the relic may be attributed to the genus Helichrysum (Asteraceae family) instead of Gundelia tournefortii. The other most important pollen found belongs to the Cistaceae-Cistus spp.—the Apiaceae—probably Ferula spp.—and the Anacardianceae—the genus Pistacia. These pollen grains could have come from plants used to obtain expensive and valuable substances that would have been the basis for the oils of Helichrysum, ladanum and galbanum, as well as for mastic and terebinth products; this fact has not been considered by previous authors. Ancient historical records give us references that could link the pollen traces to a mixture of balms and ointments employed for preparing the body for funeral and burial. For this reason, the palynological study reveals coherency with these historical records about the rituals, as reported on by the important scientists Pliny the Elder and Dioscorides, dating back to the first century AD.

KEYWORDS: SHROUD OF TURIN, POLLEN, *HELICHRYSUM*, OINTMENTS, FUNERAL AND BURIAL RITES

INTRODUCTION

Death is the time to express the religious beliefs and the identity of the corpse, which is why burial rituals and funeral treatments are in accord with the cultural history of a given people. The care of the body, which follows rules dictated by the leaders and by the whole society, is necessary if the optimal level of purification demanded for the deceased to pass over the threshold between this life and the next is to be attained. It is performed using ointments and incenses, in a mixture of religion and magic. In the ancient native societies of the Mediterranean basin, funeral and burial rites differed from region to region, depending on the religious dogma and the social status of the deceased. However, the embalming of the body using ointments was also commonly applied to persons of higher social status from ancient times right up to the Early and Middle Ages and the Renaissance (Vermeeren and van Haaster 2002; Hadjouis *et al.* 2011; Charlier *et al.* 2015). The ointments had to be not directly visible, and they needed to maintain a certain stability, in the sense that there could be no odour or liquefaction during official presentations. The significance of the substances and the actual practices employed have a long history, which undergoes change with the passing of time. For example, in the 12th century AD, the embalming process was traditionally carried out by cooks (Le Breton 1993; Charlier 2006). In subsequent times, post-mortem preparation was executed by barbers, surgeons and apothecaries;

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in later centuries the process was supervised by chemists, who used plants to carry out the task (Gannal 1840).

The use of botanical products was very common, and the probable pollen content, with its strong and long-lasting coat, makes it possible for the preparation to remain attached to objects or burial remains; so it becomes helpful evidence in the quest to unravel events in history. The scientific support for pollen derives from the specific external morphological features possessed by each type, allowing us to identify the provenance of the particular botanical taxon involved. Palynological analysis has thus been useful in helping to discover techniques and substances utilized in ancient times in Egyptian and early modern mummies, as well as in the relics of Joan of Arc or of King Richard the Lionheart (Girard and Maley 1987; Mai and Girard 2003; Charlier *et al.* 2010, 2013; Giuffra *et al.* 2011).

From ancient times, the embalming traditions of the Egyptians (3500 BC to AD 700) became widespread throughout the Mediterranean; they carried out more or less durable embalming using different products, according to the dead person's particular caste (Girard and Maley 1987; Fuertes Rocañín *et al.* 2007). In nearby countries, other types of embalming were used not to preserve the body for all eternity but, rather, to help the person to pass on to the other life. An interesting practice of that period was carried out in the Phoenician population, which established the first cemeteries from the seventh century BC, and employed perfumes and balms to anoint and purify the corpse, as well as to give magical protection in the place of burial (Aubet 2004; Delgado and Ferrer 2007). From the First Punic War (264241 BC) onwards, the Phoenicians' customs for honouring the dead, as regards the use of scents, ointments and balms, spread from Asia Minor to Europe; the Romans spent fortunes in burning spices and anointing the body during funerals (Mengotti 1821 (Capitolo II. Aromi e unguenti); Blaizot 2009; Rottoli and Castiglioni 2011).

The specific Phoenician death rites from 593 BC were also the inspiration behind the Jewish funeral tradition. In Jerusalem, offerings and purification of deaths were celebrated with many kinds of incense (Blázquez 2001), in a fusion of profane and religious rituals. The body and burial cloths were spread with selected substances before passage to the afterlife; the ointments paying homage to the gods and honouring the dead. The first-century texts of Pliny the Elder (*Historia Naturalis*), especially book XIII (*Acervatim congesta honori cadaverum*), and of Dioscorides (*De materia medica*), register different botanical components, such as resins, barks and oils, that were used to produce ointments and perfumed balms. In these ancient documents, the botanical products of cinnamon (*Cinnamomum* spp.), cardamom (*Elettaria cardamomum*), calamus (*Calamus odoratus*), estoraque (*Styrax officinale*), frankincense (*Boswellia sacra*), ladanum (*Cistus* spp.), gum resins (*Pistacia terebinthus* and *Pistacia lentiscus*), myrobalan (*Prunus cerasifera*), myrrh (*Commiphora molmol*), nard (the Amaryllidaceae family) and many others were used in mixtures that are unknown today (Brun 2000). The Bible mentions the custom of applying oils and spices in funeral and burial rites; in the case of Jesus Christ, 'aloes' and myrrh are generally specified as those used by Joseph of Arimathea and Nicodemus during their practices (John 19:39). Nowadays, the only burial cloth attributed to have been used to wrap Jesus Christ is the relic of the Shroud of Turin. Remarkable scientific analyses have been carried out on this relic; palynological studies using pollen to point to Jerusalem as the geographical origin of the cloth (Frei 1976, 1979a, 1979b, 1982, 1983; Ghio 1986; Danin *et al.* 1999; Barberis 2009). The sindonic pollen found was linked with common plants from the desert of Israel, Turkey and the Western Mediterranean region; the most abundant species being attributed to *Gundelia tournefortii* L. (Wilson 1978; Danin *et al.* 1999). In general, the pollen of plants known to be spring-flowering in Israel was used to support the authenticity of the relic; today, the possibility of being able to pinpoint the geographical origin has been ruled out (Scannerini 1997; Scannerini and Caramiello 1989). Pollen could be contained in the substances used for treating the linen cloth as well as the body, being indeed a microscopic witness to what has happened over the passing of time (Boi 2012).

The goal of the present study is to discuss the Shroud pollen with regard to: (a) the erroneous identification of the majority pollen, discovered as the *Gundelia* type; and (b) the interesting data, not considered until now, of the significance of the most abundant pollen in relation to specific botanical substances typically used during the treatment of preparing the corpse and the burial cloth. The Shroud pollen found in the greatest abundance gives a snapshot of the cultural moment in which the funeral and burial rites were completed. Although the original ointments employed have deteriorated, the pollen attached to the fibres reveals new information, hitherto not taken into account.

MATERIALS AND METHODS

Pollen samples were collected from the Shroud in 1973 and 1978 by Frei, using common adhesive tape. Different images of the sindonic pollen under the optical and scanning electron microscope were published by Frei (1976, 1979a, 1979b, 1983, 1985, Ghio (1986) and Danin *et al.* (1999). The pollen found in the greatest amount were identified by Frei and subsequently confirmed by Danin *et al.* (1999), who analysed a part of the Frei samples. These pollen samples are inaccessible nowadays, and are kept in storage in the United States. Although Frei did not include the pollen count, Danin *et al.* (1999) count 313 pollen grains; from those, they identified some 204 that were distributed across 37 types of pollen. The images of the previous bibliographical texts were analysed and compared with diverse present-day pollen types, using optical and scanning electron microscopy. The comparative pollen samples were collected from the Herbarium of the Universitat de les Illes Balears (Balearic Islands, Spain), as well as from fresh pollen of common taxa of the Mediterranean region. Pollen were prepared for optical analysis using sticky tapes, following the Frei method (Frei 1976, 1979a, 1979b, 1983; Ghio 1986), and mounted on slides embedded in glycerine jelly using aerobiological methods (Galán *et al.* 2007). The pollen samples were analysed under an optical microscope (LM), at magnifications of ×400 and ×1000 (Olympus BX-41). For the analysis of structural external features, following the Erdtman method (1960, 1969), fresh and acetolyzed pollen were then dehydrated and mounted on stubs, and subsequently sputter-coated with a gold–palladium mixture. Finally, the pollen was examined under the SEM-Hitachi S-3400 N scanning electron microscope. In order to verify the identification of pollen grains, to species or genus level, its morphological characteristics and exine sculpturing and number of apertures (pores or furrows) (SEM), along with its size and shape (LM), were analysed. With reference to the pollen types identified in the previous studies, pollen of *Anemone coronaria* L., Cistaceae spp., *Ferula* spp., *Ridolfia segetum* (L.) Moris (Apiaceae), *Pistacia lentiscus* L. and *Helichrysum* species were examined at high magnification, and compared with the images from the previous palynological studies referred to above. For the pollen descriptions, various texts were consulted (Erdtman 1969; Valdés *et al.* 1987; Reille 1992, 1995, 1998; Boi and Llorens 2007; Hesse *et al.* 2009). The ethnobotanical uses of various species in the ancient classical texts of Theophrastus (*Historiae plantarum*, 300 BC), the Roman Pliny the Elder (*Historia Naturalis*, AD 23–79) and the Greek Dioscorides (*De materia medica*, AD 40–90) were also checked.

RESULTS

In Table 1, we report the four most important types of pollen found on the relic by the previous authors, their bibliographical references and the proposed new identification. Although Frei does

Table 1 *The sources of the majority taxa according to Frei and Danin et al., and the current identifications*

Botanical family	*Author Frei*		*Actual identification*	*Authors Danin et al.*			*Actual identification*
	Species	*Source*		*Species*	*%*	*Source*	
Anacardiaceae	*Pistacia lentiscus* L. *Pistacia vera* L.	Frei (1982)	*Pistacia* spp.	*Pistacia* sp.	0.6	Danin *et al.* (1999)	*Pistacia* spp.
Asteraceae	*Gundelia tournefortii* L.	Frei (1983)	*Helichrysum* spp.	*Gundelia tournefortii* L.	29.1	Danin *et al.* (1999)	*Helichrysum* spp.
Apiaceae	*Ridolfia segetum* (L.) Moris						
		Frei (1982)	*Ferula* spp.	Apiaceae	4.2	Danin *et al.* (1999)	*Ferula* spp.
Cistaceae	*Cistus creticus* L.	Frei (1982)	*Cistus* spp.	Cistaceae	7.3	Danin *et al.* (1999)	*Cistus* spp.
				Cistus incanus type	0.3		
				Cistus salvifolius type	0.6		
Ranunculaceae	*Anemone coronaria* L.	Frei (1983)	*Pistacia* spp.	Not confirmed	–	–	–

not indicate the percentage of pollen found, Danin *et al.* (1999) made a partial account, checking only part of the whole optical microscope slides. These previous authors concur with regard to the greatest amounts of pollen-*Gundelia tournefortii* (Asteraceae). The other pollen taxa, in order of abundance, are the Cistaceae type, *Cistus* spp., Apiaceae (not specified) and *Pistacia* spp. All of these taxa represent 64.21% of the total pollen recognized (Danin *et al.* 1999). Nevertheless, in the prior sindonic pollen studies, mistakes were made regarding the exact identification of the pollen grains discovered (Boi 2012). For example, in SEM images, *Pistacia lentiscus* was wrongly identified as *Anemone coronaria* (Figs 1 (a) and 1 (b)) and Asteraceae pollen (*Helichrysum* type) was identified as *Ridolfia segetum* (Apiaceae) (Figs 1 (g) and 1 (h)) (Frei 1983; Ghio 1986). Moreover, in an LM image (Danin *et al.* 1999), Asteraceae pollen was identified as *Gundelia tournefortii*. Although the authors distinguished *Gundelia tournefortii* as being the most represented, the illustrations, confirmed using the Frei SEM image, match with the *Helichrysum* type.

The pollen of Mediterranean *Helichrysum* shows a morphological similarity (Coutinho and Dinis 2009). *Helichrysum* pollen grains are tricolporate, spheroidal, prolate-spheroidal or oblate-spheroidal in shape, with a small or medium size (21–34 μm × 22–33 μm). The ectoapertures are short colpi and the endoapertures are elliptical pori. The ornamentation is echinate, with spines of 3–4 μm, not swollen at the base, and with a rugulate and microperforate tectum. The tectum is complete, with a exine thickness of about 2.0–3.5 μm (Fig. 2; in (a), the pollen is mounted on adhesive tape, as per the Frei method).

The pollen type of *Gundelia tournefortii* is described as a tricolporate pollen, with an average size of 48 μm in diameter, spheroidal or suboblate in equatorial view, circular in polar view, and isopolar. The sculpture is echinate, with conical spines of subglobose-shaped bases,

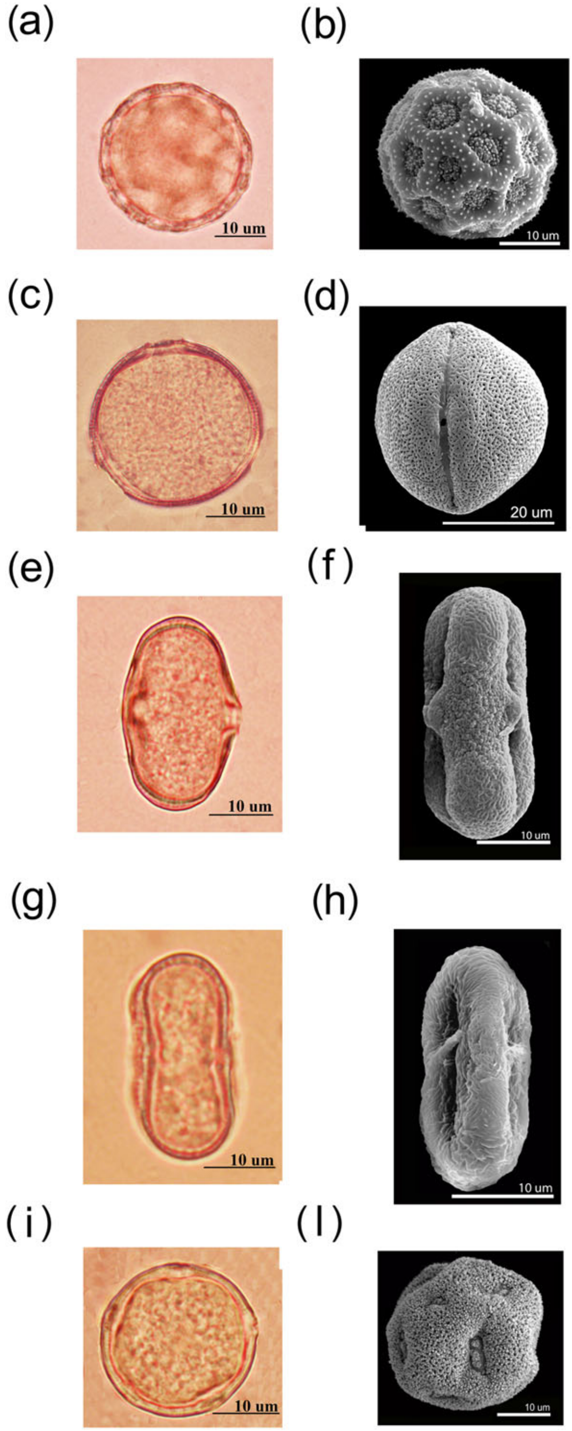

Figure 1 *Optical microscope (LM) and scanning electron microscope (SEM) images: (a, b) Anemone coronaria pollen; (c, d) Cistus albidus pollen; (e, f) Ferula communis pollen; (g, h) Ridolfia segetum pollen; (i, j) Pistacia lentiscus pollen.*

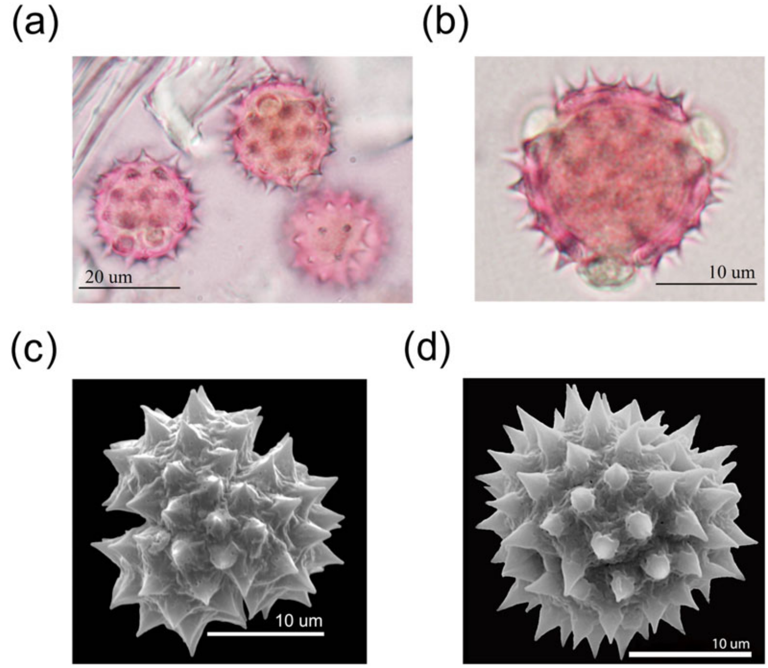

Figure 2 *(a) Helichrysum pollen on sticky tape (LM); (b) Helichrysum pollen type (LM) in polar view; (c, d) Helichrysum pollen ornamentation (SEM).*

4 μm long, with swollen bases, and the tectum is microperforate (Wortley *et al.* 2007; Katinas *et al.* 2008).

Because it is a stenopalynous type, Asteraceae pollen, requires examination of the micromorphological features for each taxon to be recognized. The previous images of the Asteraceae pollen on the Shroud, especially those made using SEM (Frei 1983), show a medium size, about 30 μm, with echinate spines, not subglobose at the base, with a microperforate tectum coinciding with the type *Helichrysum*. The *Helichrysum* characteristics coincide accord with the SEM image, as well as with the LM ones (Danin *et al.* 1999), which show an exine ultrastructure analogous to the *Helichrysum* genus.

The Cistaceae pollen is tricolporate, medium- or large-sized (32–67 μm × 27–53 μm) and circular or prolate to subprolate in shape. The ectoapertures are colpi and the endoapertures are elliptical or circular pori. The ornamentation shows striate, reticulate or rugulate patterns. The tectum is partial or complete, with an exine thickness of about 1.5–5.0 μm. In Figures 1 (c) and 1 (d), the reticulate pollen of *Cistus albidus* L. is displayed.

Apiaceae pollen is tricolporate and has a perprolate shape, being elliptic or subrectangular in equatorial view and triangular or circular in polar view, with an isopolar from a small to a medium size (15–49 μm × 5–28 μm). The ornamentation consists of smooth, scabrate, perforate, foveolate and rugulate types. *Ferula* spp. pollen is tricolporate and of medium size (28–37 μm × 12–17 μm). The pollen is perprolate, with large and narrow ectoapertures of colpi and with an endoaperture of elliptical pori. The tectum is complete, with an exine thickness of about 1.2–1.5 μm. In the polar area, the exine is rugulate and perforates; while in the equatorial part, the muri form narrow rugulae (Figs 1(e) and 1(f)). *Ridolfia segetum* shows a tricolporate pollen, of medium size (23–24 μm × 13–15 μm), perprolate in equatorial view and triangular in polar view. The pollen is perprolate, with large and narrow ectoapertures of colpi and with an endoaperture of elliptical pori. The tectum is complete, with an exine thickness of about 0.6 μm in the polar area and 2 μm in the mesocolpial area. The ornamentation is rugulate and perforate in the polar area, while in the equatorial part the muri form a narrow rugulae (Figs 1(g) and 1(h)).

Anemone coronaria of the Ranunculaceae family is pantoporate, with an average medium size of 30–36 μm. It is apolar, and circular or elliptic in shape. The pori, about 25 in number, are circular, and show aperture membranes of a microechinate operculum. The tectum is complete, with perforate and microechinate surfaces. The exine thickness is about 3–4 μm (Figs 1(a) and 1(b)).

Pistacia lentiscus (mastic) and *P. terebinthus* (terebinth) belong to the Anacardiaceae family. The pollen morphology of *P. lentiscus* and *P. terebinthus* are similar, both of them being of the pantoporate type, although *P. lentiscus* is smaller, with a diameter of 23–42 μm. They are apolar, with a circular or elliptical shape and 5–11 simple pores in *P. lentiscus* (Figs 1(i) and 1(j)); there are fewer in *P. terebinthus* (4–7 pores), the external rings of which are not easily distinguishable. The tectum is incomplete and microreticulate with perforation forming an irregular lumen; the muri are granulates. The exine thickness is about 1.5 μm.

With reference to the species identified and analysed (Table 1), the classical literature sources of Pliny the Elder and Dioscorides were consulted as regards ointments and odoriferous products.

Helichrysum

The name *Helichrysum* comes from the Greek ‘helios’ (sun) and ‘chrysos’ (gold), and is called such due to the alleged healing properties of the flowers. The plant’s inflorescences, consisting of floral buds, of an especially golden–yellow colour, conserve their fresh appearance for a long time, and so were given the name of ‘evergreen’ or ‘everlasting’. Theophrastus, whose original study was partially lost and whose works formed a large part of the sources for the compilations of Pliny the Elder, writes in *Historiae Plantarum* (book VI, 8, 1), in which mentions that Helichrysum was widely used in the ritual coronation of images. Pliny the Elder confirms that the plant comes from the metamorphosis of a nymph and is used for making crowns and garlands; it also possesses anti-inflammatory properties (*Historia Naturalis*, book XXI 96, 168, 169). In *Historia Naturalis* XXI (*Historiarum mundi*, book XXXVII), he writes ‘Eliocriso, some call it chrysanthemum: it has white stems, whitish leaves similar to the “abrotino” [*Santolina*—Asteraceae], when it reaches for the sun it shines like gold and it never fades. For this reason, the gods are crowned with it, and clothes are protected by its fragrance’.

Dioscorides, in book IV (58), defines: ‘The Elicriso, called by a few “Chrysanthemom” [*Chrysanthemum*] and by others “Amaranton” [*Amaranthus*], is a certain plant with which the idols are usually crowned. It is also called amaranth, because its flowers last indefinitely without corruption and without any loss of smell, combating the wounds of corruption’ (book I, 55). There are two species of ordinary amaranth: the yellow one, which the barbarians call ‘sticados citrina’ and another purple one, the so-called ‘flower amoris’, or ‘flower of love’. Dioscorides mentions *Helichrysum sanguineum* Boiss. as ‘bākkaris’, with the appearance of grass, used for crowns and with rough leaves. In book III (46), he comments that its smell provokes dreams. Amaranth does not wither, and as such is a symbol of immortality, consecrating the deceased. Pliny the Elder (*Historia Naturalis*, book XXI, 132) and Dioscorides (*De materia medica*, book III, 46) concur in identifying *Helichrysum*, and especially *H. sanguineum*, as being among the hypnotic, sedative, narcotic and psychotropic plants: ‘Helicriso, a flower that it does not wither, called immortal; it crowned their gods, as Ptolemy, king of Egypt says. It is a flower whose garlands and ointments give benevolence and glory, the oil is stored in golden glasses that are called apyron' (*Historia Naturalis*, book XXI, 6).

Cistus

The registers of the Cistaceae pollen include the genus *Cistus*, which produces resins all over the Mediterranean area that are collected during the flowering season (April and May). There are different gums of other species of the genus *Cistus* (rock roses), which were used to keep the corpse from smelling unpleasant (Pliny the Elder, book XIII, 1), and these were also used to treat wounds and as a pain reliever (Dioscorides, book II, 106, 108). 'Cisto' is quoted by Dioscorides as being used in poultices to heal wounds and burns (Dioscorides, book I, 106). The important resin of ladanum is collected from *Cistus ladanifer* (rose of Sharon); this resin, when mixed with myrrh and other oily scented ointments, was spread directly on to the body or burned during funerals (Dioscorides, book II, 108). The procedure to gather the resinous 'ladano' is ancient; the resin is collected from the fleeces of goats after they graze among the stems, because it remains stuck to the hair, or it is gathered with an ancient tool for flailing the plants (the ladanesterion) (Dioscorides, book I, 108).

Ferula

According to Dioscorides, perfumes and ointments were prepared with the resin of different 'Ferula' (book I, 59; book III, 85). This resin, called galbanum, was used to heal wounds, and it was also burned in temples during burial rituals (Pliny the Elder, book XII, 26). It is the base element of the ointment of 'Metopio', which heals wounds (Dioscorides, book I, 56). Galbanum is a strong-smelling oily gum–resin, similar to frankincense, which is extracted by making small cuts on the base of the stalk of the plant when it starts to bloom in April (Dioscorides, book III, 91).

Pistacia lentiscus and Pistacia terebinthus

According to Dioscorides (book I, 24, 36, 71, 72), these plants produce exudate resins, which when mixed with myrrh and other products, help wounds to heal. According to Pliny the Elder (book XIII, 6), the terebinth resin, commonly called incense, was also burned in burials to disguise unpleasant smells. From the species *P. terebinthus*, turpentine is obtained; on the island of Chios (Greece), the very valuable mastic is produced from *P. lentiscus*. The mastic plant produces a resin, and oil is obtained from the mature fruits (skinclaion) in a way similar to the use of the terebinth plant (Pliny the Elder, book XII, 36; book XIV, 25). The oil, made by the crushing of leaves and fruit or by boiling leaves, fruit and bark in water, was used as an ointment, or as a balsam to eliminate ulcers, sores and wounds (Pliny the Elder, book XII, 16). All the products of 'lentisco' show the same properties of wound and bone healing; 'terebinto' administrated in poultices is used to combat tiredness (Dioscorides, book I, 71, 72).

DISCUSSION

Frei (1976, 1979a, 1979b, 1983, 1985, Ghio (1986) and Danin *et al.* (1999) affirmed that the most numerous pollen types present on the relic came from entomogamous plants, their pollen needing the help of insects to complete pollination. The fact that this type does not travel by itself through the air made this discovery very interesting when considering the presence of the abundant pollen of *Helichrysum* (not of *Gundelia tournefortii*), as well as of the Cistaceae (*Cistus* spp.), the Apiaceae (*Ferula* spp.) and *Pistacia lentiscus*. Until recently, then, the most abundant pollen was considered to be the *Gundelia* type, but we would have to ask ourselves: how and why would that kind of pollen have come in contact with the relic anyway? *Gundelia tournefortii* (tumbleweed), called 'A'kub' or 'Ka'ub in Arabic, grows in the mountain deserts of Egypt, Turkey, Syria, Lebanon, Palestine, Jordan, Israel, Iraq, Iran, Azerbaijan, Turkmenistan, Armenia and Cyprus (Matthäus and Özcan 2011). In Israel and Palestine, it has a traditional culinary use, testified to in the Talmud of Babylonia (Mishnah—Beitzah 34a) (Danby 1933) as well as in the biblical text (Feliks 1968). The custom of collecting the entire plant for gastronomic use before flowering has led to a drastic reduction of this plant since ancient times (Lev-Yadun and Abbo 1999). The alleged high presence of this pollen has been used to link the Shroud of Turin to a past stay in Asia Minor (Frei 1979a), even though the morphological traits do not in fact correspond with this pollen type. The presence of supposedly *Gundelia* pollen was also claimed to have originated from the cloth coming into direct contact with the flowers after the death of the man wrapped in the Shroud, since blooming begins in March, the time of Easter (Danin *et al.* 1999). Furthermore, Danin *et al.* (1999) believed that this plant was used for the crown of the crucified person, because they found marks of the *Gundelia* plant seeming to show up as imprints. These appeared solely on a negative image of the Shroud, taken by the photographer Enrie in 1931, but would seem to be only a pareidolia phenomenon (Di Lazzaro *et al.* 2013). Other writers have noted that *Gundelia*, which does not have especially sharp thorns on the stem, is an unlikely contender for use in the 'crown of thorns' (Hind 2013). Moreover, if *Gundelia* flowers had really come into direct contact with the linen, latex residues would have been found on the fabric, along with the colloidal emulsion of stalk and leaves. *Gundelia* has now been ruled out as being the dominant species present on the relic (Bryant 2000; Danin and Guerra 2008).

The replacement of the *Gundelia tournefortii* by *Helichrysum* spp., taken alongside the whole set of sindonic entomogamous species, suggests the use of botanical products that were widely used in ancient funeral and burial rituals, whose purpose in embalming the body was to delay decomposition, as well as to make burials smell less unpleasant. These 2000-year-old techniques using ointments, oils and perfumed balsams were unusual in Europe, with some reported exceptions during the Roman Empire (Papageorgopoulou *et al.* 2009; Brenner 2014). Pliny the Elder and Dioscorides assembled the knowledge of many other earlier Roman, Greek and Asian writers, information that was read throughout a broad region of the world, remaining valid until the Middle Ages and the Renaissance. In the 14th century, the writings were given new life by physicists and naturalists, such as Matthiolus and Tabernaemontanus, who collected the works of Hippocrates and Galen, as well as of Dioscorides and Pliny the Elder, in expanding contemporary knowledge of nature. During the Middle Ages, there was a decline in the use of botanically based ointments; embalming consisted of innovative techniques, such as the injection of chemical substances or immersion of the body in alcohols. In the subsequent medieval period, the anointing of the body was substituted by the durable practice of embalming involving the evisceration of the body, which was then washed with cold water and aqua vitae, and its cavities filled aqua vitae–moistened cotton and powder. Finally, the corpse was then sewn up and wrapped in wax (Brenner 2014).

The investigations on the Shroud do not display evidence of the funeral practices of the Middle Ages or the medieval era. Rather, the pollen discovered in this relic could be from the compounds of early burial ointments, suggesting that its origins lie in the first century AD. It is not difficult for pollen to stay attached to fibres for a long time (Boi 2015), but the attachment can be even stronger when the pollen is combined with greasy botanical substances, such as those applied to the body after death, or those adhering to a burial cloth (Mariotti Lippi 1998). According to the Holy Bible and ancient history, the plants themselves never came into contact with a cadaver, especially in Jewish customs, whereas it was common to anoint the body for burial (Haklîlî 2005). The traces of the most abundant pollen on the relic point to plants used in ancient ethnocultural practices, rather than from secondary practices or contamination. The majority pollen type of *Helichrysum* Miller, known as 'Everlasting' or 'Immortelle', includes aromatic plants of the Mediterranean area from which, by pressing only the fresh flowers, a supreme-quality oil is produced. The use of *Helichrysum* oil in death practices has been documented in Arabia, Greece, across the whole of the Roman Empire and in Britain (Maffei *et al.* 1988, 1990; Seaton 1995; Antunes Viegas *et al.* 2014). In accordance with ancient practices, the burial cloth of the Shroud was treated with *Helichrysum* oil, probably in an effort to protect the textile fibres, as documented in the ancient texts (Pliny the Elder, book XXI, 25, 96, 168, 169; Dioscorides, book IV, 58). *Helichrysum* flowers were also used in head garlands for prominent people and for gods, denoting denoted fame and glory, according to Theophrastus (*Historiae Plantarum*, book VI, 8, 1). Oil extracted from flowers of different species of *Helichrysum* is currently highly valued for its important curative, pharmacological and antimicrobial properties combatting infections, fungi and viruses, and is an anti-inflammatory (Czinner *et al.* 2001; Sala *et al.* 2002, 2003; Sagdic *et al.* 2003; Tepe *et al.* 2005; Van Vurren *et al.* 2006; Sobhy and El Feky 2007; Albayrak *et al.* 2010; Zahin *et al.* 2010). The precise identification of *Helichrysum* pollen discovered in the previous images and formerly wrongly recognized as *Gundelia*, validates the theory that the corpse kept in the Shroud received a funeral and burial with all the honour and respect that was customary in the Hebrew tradition.

The lesser quantity of the other pollen present (Table 1) can be explained as having derived from resin, gum, fruit, bark and leaves, but not from flowers. Moreover, because the word 'ladanum' is similar to the Hebrew 'lebona', which means incense, it may have been wrongly translated in the Bible. All the incenses mentioned in the Bible might thus refer not to the pure incense, but to aromatic resins such as those of the genus *Cistus* or *Cistus ladanifer* (ladanum) and *Ferula* (galbanum) (Stewart 2003). The genus *Ferula* is an important source of aromatic resins in the Mediterranean region, North Africa and North India (Kanani *et al.* 2011). In ancient Mediterranean cultures, terebinth and mastic (*Pistacia* spp.) were used to mask the smell of the cadaver in the tomb (Conder 1830). *Helichrysum* flowers, as well as *Cistus* (ladanum) and *Ferula* (galbanum) products, are collected during the flowering period, a fact that could explain their high pollen representation; the resin and oil of *Pistacia* instead is gathered from July to October, during the fructification period.

Later observations demonstrate that the Shroud pollen samples have a covering of mineral substances and wax, which made specific botanical identification difficult (Riggi Di Numana, 1988). The pollen encrustation could be the residues left by products used in first-century Hebrew customs, offerings in purification and healing rituals carried out using valuable ointments and poultices of *Helichrysum* oil, ladanum, galbanum, mastic and terebinth products, which are still prized today, although the various formulas for these mixtures are not known today. Dioscorides and Pliny the Elder mention that luxurious botanical substances, more expensive than gold, were used in funeral and burial rituals over the whole Mediterranean region. In the first century, Judaism considered that the dead body should be respected and honoured as sacred, as well as buried in the same way regardless of whether it was that of an honest person or of a criminal (Lamm 2000). Furthermore, for the funeral rite to be concluded, it was necessary to dispose of the whole body, including the blood (Maimonides and Russell 1981).

The rituals of anointing the body and burning oils, incenses and spices on altars were carried out for purification, healing and disinfection of the air, as well as to keep the environment clear of scavenger insects; after the preparation and purification rites, the body was finally wrapped in a burial cloth (Rops 1961). The body was not washed with water during preparation for the funeral but, rather, cleaned and treated with scented oils and ointments, in elaborate practices designed to ensure the person's entry into the next life with honour. It was vital to carry out this process, because as soon as the body began to decompose, it became impure, as did everything that came in contact with it. The ritual therefore had to be completed within 24 hours of death (Deuteronomy 21:23); an unburied body or one that had been eaten by animals would invoke a curse (Maimonides and Russell 1981). In the case of the Shroud of Turin, the proof that the body was not washed is evidenced by the presence of blood and stains directly from precise body wounds (Wilson 1978, 1979, 1981). This in turn corroborates and supports the application of ointments (Meacham 1983; Fazio *et al.* 2015); after the anointing, the corpse was probably rinsed with water to clean away dirt (Krauss 1910–12). This leads us to assume that the body wrapped in the Shroud received a Hebrew funeral and burial rites according to the Torah, the Law of Moses (Deuteronomy 22:11).

Red traces of vermilion or cinnabar have also been found on the Shroud (McCrone 1990). Cinnabar has been employed for protective purposes since the Neolithic age as a pigment or cosmetic; it is also found at Neolithic burial sites and in Egyptian tombs (Saha 1972; Martin-Gil *et al.* 1995; Parsons and Percival 2005). It also has a symbolic meaning, as it gave a life-like colour to the corpse (Wreschner *et al.* 1980; López Padilla *et al.* 2012). Detection of the pigment could be explained if this mineral had been sprinkled on the body alongside the ointments at the time of burial, which was a normal practice in ancient times, in an attempt to preserve funeral artefacts (Edwards *et al.* 2004).

The presence of pollen on the Shroud acts as a guide in the quest to discover the kinds of ointments used in ancient times in burial rituals (Josephus, *Antiquities of the Jews*, 15, 61; Haklîlî 2005). For this reason, a new line of multidisciplinary research on the relic thus needs to be opened up, to allow the different new theories and palynological approaches to be further developed, especially in the light of the controversy surrounding the radiocarbon dating (Damon *et al.* 1989).

CONCLUSIONS

We have set forth new data about the Shroud of Turin. The pollen evidence shows that the relic could contain botanical substances used in anointing and embalming during funeral and burial rites in ancient times. The exact identification of the sindonic most abundant pollen of the Asteraceae (*Helichrysum*), along with the presence of the Cistaceae (*Cistus*), the Apiaceae (*Ferula*) and *Pistacia*, reveals the use of ointments. These plants were typically employed in expensive and valuable products cited in the scientific writings of Pliny the Elder and Dioscorides. Our conclusions show that the relic could be a real burial cloth, yielding pollen evidence of *Helichrysum* oil, as well as of ladanum (*Cistus* spp.), galbanum (*Ferula* spp.), mastic oil and gum (*Pistacia lentiscus*) and terebinth (*Pistacia terebinthus*), all of which are the bases of ancient ointments used in the first century AD. The precise identification of *Helichrysum* pollen, which had formerly been wrongly recognized as *Gundelia tournefortii*, confirms and authenticates the theory that the corpse kept in the Shroud received a funeral and burial with all the honour and respect that would have been customary in the Hebrew tradition. The largest amount of *Helichrysum* pollen originates from the form used to produce its oil, utilizing exclusively fresh flowers. The smaller quantities of the other pollen types can be explained by the use of products derived from other botanical components.

These botanical products have contributed to an exceptional preservation of the fabric right up to the present time; they have protected the linen by acting as powerful insect and fungal repellents. At the same time, they have caused the yellowish tinge of the Shroud, because these are substances that oxidize on coming into contact with the air.

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REFERENCES

Albayrak, S., Aksoy, A., Sagdic, O., and Hamzaoglu, E., 2010, Compositions, antioxidant and antimicrobial activities of *Helichrysum* (Asteraceae) species collected from Turkey, *Food Chemistry*, **119**, 114–22.

Antunes Viegas, D., Palmeira-de-Oliveira, A., Salgueiro, L., Martinez-de-Oliveira, J., and Palmeira-de-Oliveira, R., 2014, *Helichrysum italicum*: from traditional use to scientific data, *Journal of Ethnopharmacology*, **151**(1), 54–65.

Aubet, M. E., 2004, The Phoenician cemetery of Tyre-Al Bass: excavations 1997–1999, in *Bulletin d'Archéologie et d'Architecture Libanaises (BAAL)*, Hors-Série I edn, Ministère de la Culture, Beiruth.

Barberis, B., 2009, *Sindone: il messaggio universale*, Elledici, Torino.

Blaizot, F., 2009, Rites et pratiques funéraires à Lugdunum—du Ier au IV^{e} siècle, in *Ch. Goudineau, Rites funéraires à Lugdunum*, Catalogue exposition Musée Gallo-Romain de Lyon-Fourvière, Errance, Paris.

Blázquez, J. M., 2001, *Dioses mitos y ritos de los Semitas Occidentales de la antigüedad*, Ediciones Cristianidad, Madrid.

Boi, M., 2012, The ethnocultural significance for the use of plants in ancient funerary rituals and its possible implications with pollens found on the Shroud of Turin, www.shroud.comDOI: 10.13140/2.1.3690.3682.

Boi, M., 2015, Pollen attachment in common materials, *Aerobiologia*, **31**, 261–70.

Boi, M., and Llorens, L., 2007, *Atlas polínico de las plantas endémicas de las islas Baleares*, Conselleria de Medi Ambient del Govern de les Illes Balears, Palma de Mallorca.

Brenner, E., 2014, Human body preservation—old and new techniques, *Journal of Anatomy*, **224**(3), 316–44.

Brun, J. P., 2000, The production of perfumes in antiquity: the case of Delos and Paestum, *American Journal of Archaeology*, **104**, 277–308.

Bryant, V. M. Jr., 2000, Does pollen prove the Shroud authentic? *Biblical Archaeology Review*, **26**(6), 36–44.

Charlier, P., 2006, Evolution of embalming methodology in medieval and modern France (Agnés Sorel, the Duc de Berry, Louis the XIth, Charlotte de Savoie), *Medicina nei Secoli*, **18**, 777–97.

Charlier, P., Poupon, J., Eb, A., De Mazancourt, P., Gilbert, T., Huynh-Charlier, I., Loublier, Y., Verhille, A. M., Moulheirat, C., Patou-Mathis, M., Robbiola, L., Montagut, R., Masson, F., Etcheberry, A., Brun, L., Willerslev, E., Lorin de la Grandmaison, G., and Durigon, M., 2010, The 'relics of Joan of Arc': a forensic multidisciplinary analysis, *Forensic Science International*, **194**(1), e9–e15.

Charlier, P., Poupon, J., Jeannel, G. F., Favier, D., Popescu, S. M., Weil, R., Moulherat, C., Charlier, I. U., Dorion-Peyronnet, C., Lazar, A. M., Hervé, C., and Lorin de la Grandmaison, G., 2013, The embalmed heart of Richard the Lionheart (1199 AD): a biological and anthropological analysis, *Scientific Reports*, **3**, 1296. DOI: 10.1038/srep01296.

Charlier, P., Poupon, J., Jeannel, G. F., Favier, D., Popescu, S. M., Augias, A., Huynh-Charlier, I., Laquay, L., Boudouma, O., and Dorion-Peyronnet, C., 2015, The embalming of John of Lancaster, first Duke of Bedford (1435 AD): a forensic analysis, *Medicine, Science, and the Law*, **56**(2), 107–15. DOI: 10.1177/0025802415587318.

Conder, J., 1830, *A popular description of Turkey*, Duncan, Tegg and Sons, London.

Coutinho, A. P., and Dinis, A. M., 2009, A light, scanning electron, and transmission electron microscopic study of pollen wall architecture in the subtribe Gnaphaliinae (Gnaphalieae, Asteraceae), *Plant Systematics and Evolution*, **283**(1–2), 79–92.

Czinner, E., Hagymási, K., Blázovics, A., Kér, Á., Szoke, É., and Lemberkovics, É., 2001, The *in vitro* effect of *Helichrysum* floss on microsomal lipid peroxidation, *Journal of Ethnopharmacology*, **77**, 31–5.

Damon, P. E., Donahue, D. J., Gore, B. H., Hatheway, A. L., Jull, A. J. T., Linick, T. W., Sercel, P. J., Toolin, L. J., Bronk, C. R., Hall, E. T., Hedges, R. E. M., Housley, R., Law, I. A., Perry, C., Bonani, G., Trumbore, S., Woelfli, W., Ambers, J. C., Bowman, S. G. E., Leese, M. N., and Tite, M. S., 1989, Radiocarbon dating of the Shroud of Turin, *Nature*, **337**, 611–15.

Danby, H., 1933, *The Mishnah*, Oxford University Press, Oxford.

Danin, A., and Guerra, H., 2008, *L'uomo della Sindone: un botanico ebreo identifica immagini di piante della Terra Santa sulla Sacra Sindone*, Edizioni Art, Roma.

Danin, A., Whanger, A. D., Baruch, U., and Whanger, M., 1999, *Flora of the Shroud of Turin*, Missouri Botanical Garden Press, St. Louis, MO.

Delgado, A., and Ferrer, M., 2007, Interpreting household practices. Alimentos para los muertos: mujeres, rituales funerarios e identidades colonials, *Treballs d'Arqueologia*, **13**, 29–68.

Di Lazzaro, P., Murra, D., and Schwortz, B., 2013, Pattern recognition after image processing of low-contrast images, the case of the Shroud of Turin, *Pattern Recognition*, **46**(7), 1964–70.

Edwards, H. G., Jorge Villar, S. E., and Eremin, K. A., 2004, Raman spectroscopic analysis of pigments from dynastic Egyptian funerary artefacts, *Journal of Raman Spectroscopy*, **35**(89), 786–95.

Erdtman, G., 1960, The acetolysis method, *Svensk Botanisk Tidskrift*, **54**, 561–4.

Erdtman, G., 1969, *Handbook of palynology: morphology, taxonomy, ecology*, Munksgaard, Copenhagen.

Fazio, G., Anastasi, A., and Mandaglio, G., 2015, To suggest evidence for burial ointments in the Shroud of Turin, *Chemistry Today*, **33**(1), 18–20.

Feliks, J., 1968, *Plant world of the Bible*, Massada, Ramat Gan (in Hebrew).

Frei, M., 1976, Note a seguito dei primi studi sui prelievi di polvere aderente al lenzuolo della S, *Sindone, Sindon*, **23**, 5–9.

Frei, M., 1979a, Il passato della Sindone alla luce della palinologia, in *La Sindone e la scienza: bilanci e programmi. Atti del II Congresso Internazionale di Sindonologia, Torino 1978* (ed. P. Coero Borga), 191–200, Centro Internazionale di Sindonologia—Edizioni Paoline.

Frei, M., 1979b, Wissenschaftliche Probleme um das Grabtuch von Turin, *Naturwissenschaftliche Rundschau*, **32**(4), 133–5.

Frei, M., 1982, Nine years of palynological studies on the Shroud, *Shroud Spectrum International*, **1**(3), 2–7.

Frei, M., 1983, in *Identificazione e classificazione dei nuovi pollini della Sindone*, *La Sindone, Scienza e fede, Atti del II Convegno Nazionale di Sindonologia. Bologna, 27–29 novembre 1981* (eds. L. Coppini and F. Cavazzutti), 277–84, Editrice Clueb, Bologna.

Frei, M., 1985, Lettera del Pr. Max Frei in riferimento all'incarico avuto di un esame palinologico da effettuare sul 'Sudario' di Oviedo, in *Luomo della Sindone è Gesù* (ed. G. Ricci), 233–8.

Fuertes Rocañín, J. C., Cabrera Forneiro, J., and Fuertes Iglesias, C., 2007, *Manual de ciencias forenses*, Arán Ediciones, Madrid.

Galán, C., Cariñanos, P., Alcázar, P., and Domínguez, E., 2007, *Manual de calidad y gestión de la Red Española de Aerobiología*, Universidad de Córdoba, Córdoba.

Gannal, J. N., 1840, *History of embalming, and of preparations in anatomy, pathology, and natural history; including an account of a new process for embalming*, Philadelphia, PA.trans. R. Harlan Dobson

Ghio, A., 1986, *I pollini della Sindone dalle ricerche di Max Frei*, La Sindone, la Storia, la Scienza, 115–18, Edizione Centrostampa, Leinì (Torino).

Girard, M., and Maley, J., 1987, in *Étude palynologique, in Autopsie d'une momie égyptienne du Muséum de Lyon* (ed. D. L. Mourer), 103–10, Nouvelles Archives du Muséum d'Histoire naturelle, de Lyon 25, 198.

Giuffra, V., Fornaciari, A., Marvelli, S., Marchesini, M., Caramella, D., and Fornaciari, D., 2011, Embalming methods and plants in Renaissance Italy: two artificial mummies from Siena (central Italy), *Journal of Archaeological Science*, **38**(8), 1949–56.

Hadjouis, D., Corbineau, R., Ruas, M.-P., and Verdin, P., 2011, Techniques d'embaumement sur le corps d'un noble anglais mort de la peste (Saint-Maurice, Val-de-Marne), in *Actes du III^e colloque international de pathographie, Bourges, 2009* (ed. P. Charlier), 31–62, Editions De Boccard, Paris.

Haklîlî, R., 2005, *Jewish funerary customs, practices and rites in the Second Temple period*, 576, Brill, Leiden.

Hesse, M., Halbritter, H., Weber, M., Buchner, R., Frosch-Radivo, A., and Ulrich, S., 2009, *Pollen terminology: an illustrated handbook*, Springer Science & Business Media, Vienna.

Hind, N., 2013, *Gundelia tournefortii* Compositae, *Curtis's Botanical Magazine*, **30**(2), 114–38.

Kanani, M. R., Rahiminejad, M. R., Sonboli, A., Mozaffarian, V., Kazempour Osaloo, S., and Nejad Ebrahim, S., 2011, Chemotaxonomic significance of the essential oils of 18 *Ferula* species (Apiaceae) from Iran, *Chemistry and Biodiversity*, **8**(3), 503–17.

Katinas, L., Tellería, M. C., Susanna, A., and Ortiz, S., 2008, *Warionia* (Asteraceae): a relict genus of Cichorieae? *Anales del Jardin Botánico de Madrid*, **65**(2), 367–81.

Krauss, S., 1910, 12*Talmidische Arqueologie*, Vol. **3**, G. Fock, Leipzig.

Lamm, M., 2000, *The Jewish way in death and mourning*, Jonathan David Publishing, Middle Village, NY.

Le Breton, D., 1993, *La chair àvif: usages médicaux et mondains du corps humain*, Metailié, Paris.

Lev-Yadun, S., and Abbo, S., 1999, Traditional use of A'kub (*Gundelia tournefortii*, Asteraceae), in Israel and the Palestinian Authority Area, *Economic Botany*, **53**(2), 217–19.

López Padilla, J. A., de Miguel Ibáñez, M., Arnay de la Rosa, M., Galindo Martín, L., Roldán García, C., and Murcia Mascarós, S., 2012, Ocre y cinabrio en el registro funerario de El Argar, *Trabajos de Prehistoria*, **69**(2), 273–92.

Maffei, F. R., Carini, M., Mariani, M., and Cipriani, C., 1988, Anti-erythematous and photoprotective activities in guinea pigs and in man of topically applied flavonoids from *Helichrysum italicum* G. Don, *Acta Therapeutica*, **14**, 323–45.

Maffei, F. R., Carini, M., Franzoi, L., Pirola, O., and Bosisio, E., 1990, Phytochemical characterization and radical scavenger activities of flavonoids from *Helichrysum italicum* G. Don (Compositae), *Pharmacological Research*, **22**, 709–20.

Mai, B. T., and Girard, M., 2003, Pollens, ultimes indices de pratiques funéraires évanouies, *Revue archéologique de Picardie*, *Numéro special*, **21**(1), 127–37.

Maimonides, M., and Russell, H. M., 1981, *The book of knowledge: from the Mishneh Torah of Maimonides*, KTAV Publishing House, Brooklyn, NY.

Mariotti Lippi, M., 1998, Fabrics as pollen traps: some observations, in *ΑΧΕΙΡΟΠΟΙΕΤΟΣ—ACHEIROPOIETOS—Non fait de main d'homme*, *Actes du III^{me} Symposium Scientifique International du CIELT—Nice 1997*, 237–40, Paris.

Martin-Gil, J., Martin-Gil, F. J., Delibes-de-Castro, G., Zapatero-Magdaleno, P., and Sarabia-Herrero, F. J., 1995, The first known use of vermillion, *Experientia*, **51**(8), 759–61.

Matthäus, B., and Özcan, M. M., 2011, Chemical evaluation of flower bud and oil of Tumbleweed (*Gundelia tournefortii* L.) as a new potential nutrition sources, *Journal of Food Biochemistry*, **35**(4), 1257–66.

McCrone, W. C., 1990, The Shroud of Turin: blood or artist's pigment? *Accounts of Chemical Research*, **23**, 77–83.

Meacham, W., 1983, The authentication of the Turin Shroud: an issue in archaeological epistemology, *Current Anthropology*, **24**(3), 283–311.

Mengotti, F., 1821, *Del commercio' de Romani dalla primera guerra punica a Costantino, dissertazione coronata dall" Accademia delle iscrizioni e belle lettere di Parigi*, P. Cavalletti e Comp., Padova.

Papageorgopoulou, C., Xirotiris, N. I., Iten, P. X., Baumgartner, M. R., Schmid, M., and Rühli, F., 2009, Indications of embalming in Roman Greece by physical, chemical and histological analysis, *Journal of Archaeological Science*, **36**, 35–42.

Parsons, M. B., and Percival, J. B., 2005, A brief history of mercury and its environmental impact, in *Mercury: sources, measurements, cycles, and effects* (eds. M. B. Parsons and J. B. Percival), 1–20, Mineralogical Association of Canada, Ottawa.

Reille, M., 1992, *Pollen et spores d'Europe et d'Afrique du Nord*, Laboratoire de Botanique Historique et Palynologie, Marseille.

Reille, M., 1995, *Pollen et spores d'Europe et d'Afrique du Nord*, Laboratoire de Botanique Historique et Palynologie, Marseille.Additional issue 1

Reille, M., 1998, *Pollen et spores d'Europe et d'Afrique du Nord*, Laboratoire de Botanique Historique et Palynologie, Marseille.Additional issue 2

Riggi Di Numana, G., 1988, *Rapporto Sindone (1978/1987)*, 3 M Edizioni, Milano.

Rops, D., 1961, *La vie quotidienne en Palestine au temps de Jésus*, Hachette, Paris.

Rottoli, M., and Castiglioni, E., 2011, Plant offerings from Roman cremations in northern Italy: a review, *Vegetation History and Archaeobotany*, **20**(5), 495–506.

Sagdic, O., Karaha, A. G., Ozcan, M., and Ozkan, G., 2003, Effect of some spice extracts on bacterial inhibition, *Food Science and Technology International*, **9**, 353–6.

Saha, J. G., 1972, Significance of mercury in the environment, *Residue Reviews/Rückstands-Berichte*, **42**, 103–63.

Sala, A., Recio, M. D. C., Giner, R. M., Máñez, S., Tournier, H., Schinella, G., and Ríos, J. L., 2002, Anti-inflammatory and antioxidant properties of *Helichrysum italicum*, *Journal of Pharmacy and Pharmacology*, **54**(3), 365–71.

Sala, A., Recio, M. C., Schinella, G. R., Manez, S., Giner, R. M., and Rios, J. L., 2003, A new dual inhibitor of arachidonate metabolism isolated from *Helichrysum italicum*, *European Journal of Pharmacology*, **460**, 219–26.

Scannerini, S., 1997, *Mirra, aloe, pollini e altre trace: ricerca botanica sulla Sindone*, Editrice Elle Di Ci, Leumann, Torino.

Scannerini, S., and Caramiello, R., 1989, *Il problema dei pollini, Sindon*, 107–11, Nuova Serie, Vol. **1**.

Seaton, B., 1995, *The language of flowers—a history*, University Press of Virginia, Charlottesville, VA.

Sobhy, E. A., and El Feky, S. S., 2007, Chemical constituents and antimicrobial activity of *Helichrysum stoechas*, *Asian Journal of Plant Sciences*, **6**(4), 692–5.

Stewart, D., 2003, *Healing oils of the Bible*, Care, Marble Hill, MO.

Tepe, B., Sokmen, M., Akpula, H. A., and Sokmen, A., 2005, *In vitro* antioxidant activities of the methanol extracts of four *Helichrysum* species from Turkey, *Food Chemistry*, **90**, 685–9.

Valdés, B., Díez, M. J., and Fernández, I., 1987, *Atlas polínico de Andalucía occidental*, Instituto de Desarrollo Regional, Universidad de Sevilla, Excma, Diputacion de Cadiz.

Van Vurren, S. F., Viljoen, A. M., Van Zyl, R. L., Van Heerden, F. R., Husnu, K., and Baser, C., 2006, The antimicrobial, antimalarial and toxicity profiles of helihumulone, leaf essential oil and extracts of *Helichrysum cymosum* (L.) D. Don subsp. cymosum, *South African Journal of Botany*, **7**, 287–90.

Vermeeren, C., and van Haaster, H., 2002, The embalming of the ancestors of the Dutch royal family, *Vegetation History and Archaeobotany*, **11**(1), 121–6.

Wilson, I., 1978, *The Turin Shroud*, Penguin, Harmondsworth.

Wilson, I., 1979, *The Shroud of Turin*, Image Books, New York.

Wilson, I., 1981, *New findings on the Turin Shroud*, MS.

Wortley, A. H., Funk, V. A., Robinson, H., Skvarla, J. J., and Blackmore, S., 2007, A search for pollen morphological synapomorphies to classify rogue genera in Compositae (Asteraceae), *Review of Palaeobotany and Palynology*, **146**, 169–81.

Wreschner, E. E., Bolton, R., Butzer, K. W., Delporte, H., Häusler, A., Jacobson-Widding, A., Malinowski, T., Masset, C., Miller, S. F., Ronen, A., Solecki, R., Stephenson, P. H., Thomas, L. L., and Zollinger, H., 1980, Red ochre and human evolution: a case for discussion [and Comments and Reply], *Current Anthropology*, **21**, 631–44.

Zahin, M., Aqil, F., Khan, M. S. A., and Ahmad, I., 2010, Ethnomedicinal plants derived antibacterials and their prospects, *Ethnomedicine: A Source of Complementary Therapeutics*, 149–78.

APPENDIX

A. CLASSICAL SOURCES CONSULTED

Josephus, F., 1800, *Antiquities of the Jews*, the genuine works of Flavius Josephus, the Jewish historian.

Pedanius Dioscorides, 1563, *Acerca de la materia medica y los venenos mortíferos*, trans. M. Gast, Traducción de la lengua griega en la vulgar castellana, Salamanca.

Pedanius Dioscorides, 2006, *De materia medica* (eds. B. M. G. Rodilla and M. C. V. de Benito), Dioscórides. Estudios y traducción, vol. **25**, Ediciones Universidad de Salamanca, Salamanca.

Pedanius Dioscorides, 1906–14, *De materia medica libri quinque*, **3** vols, trans. M. Wellmann, Weidmann, Berlin (reprinted Olms, Hildesheim, 1958).

Pliny the Elder, 1603, *Historia naturale di Plinio Secondo, diuisa in trentasettelibri* (L. Domenichi), Pietro Ricciardi.

Theophrastus, 1926, *Enquiry into plants*, books I–V, trans. A. F. Hort, Loeb Classical Library Edition, Heinemann, London/G. P. Putnam's Sons, New York.

Theophrastus, 1926, *Enquiry into plants*, books VI–IX, *Treatise on odors, concerning weather signs*, trans. A. F. Hort, Loeb Classical Library Edition, Heinemann, London/G. P. Putnam's Sons, New York.