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Shanidar et ses fleurs? Reflections on the palynology of the Neanderthal 'Flower Burial' hypothesis

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ABSTRACT

Pollen clumps associated with the skeleton of the Shanidar 4 Neanderthal were interpreted by the excavator as evidence for a purposeful burial with flowers. This was one of several findings from Shanidar Cave that helped to shape modern perceptions of Neanderthals as sharing empathic characteristics with Middle Palaeolithic *Homo sapiens* (modern humans). Here the available evidence is reviewed critically from a palynological viewpoint. It seems likely that at least some of the pollen clumps were emplaced by nesting solitary bees, though other mechanisms may also have been involved. Shanidar 4 remains of notable importance, however, in being part of a tight cluster of remarkably complete and deliberately emplaced Neanderthal skeletal remains.

1. Introduction

The Shanidar Cave 'Flower Burial' hypothesis proposed by Arlette Leroi-Gourhan (1975) and developed by Ralph Solecki (1971, 1975, 1977), along with other findings from his 1951–1960 excavations of Shanidar Cave, in Iraqi Kurdistan (Fig. 1), had a transformative impact on ensuing debates about the abilities and humanness of Neanderthals (Pomeroy et al., 2020b: 12). Previously characterised in many texts as considerably less than human, Neanderthals were reappraised by Solecki (1977: 114) and many later commentators as having qualities of empathy and care.

The 'Flower Burial' hypothesis arose from palynological research. Six 'soil' samples were taken by Solecki in the sediment layers immediately below and adjacent to the Shanidar 4 Neanderthal and sent to Arlette Leroi-Gourhan, the leading cave palynologist of the day. Three of these samples, which from his account (Solecki, 1971: 247) and unpublished notes (Leroi-Gourhan, 1975: 563) were taken from the dark, loamy layer below the skeleton, contained clumps of pollen. Assisted by the leading Dutch pollen analyst Willem van Zeist, Leroi-Gourhan identified in the clumps pollen of six taxa: *Centaurea, Senecio* type, *Achillea* type, *Muscari, Ephedra* and *Althea*, plus two unidentified types (Leroi-Gourhan, 1975, 1998). In her verbal account to COH (1992, pers.comm.) Leroi-Gourhan suggested that some of the unidentified clumps of pollen seemed to consist of immature pollen grains. The pollen from the samples around Shanidar 4, illustrated by Leroi-Gourhan (1998) were all flattened and corroded. Conclusive identifications of all grains would not have been easy. Along with the clumps of pollen were fragments of woody tissue, identified by Jean-Louis Vernet (1981) as *Pinus*, perhaps *Juniperus* and *Abies,* and indeterminate deciduous species.

Some of the clumps of pollen were interpreted by Leroi-Gourhan (1975, 1998, 2000), and following her, by Solecki (1971, 1975) as having the shape of the anthers of flowers. Solecki (1971: 249–250; 1975, 1977) suggested that the body of the Neanderthal was placed on a bed of these flowers, possibly for medical reasons, and/or as a mark of affection and/or respect.

The hypothesis, although accepted quite widely and very influential, has been debated over many years. Chase and Dibble (1987: 275) suggested possible emplacement of the pollen by burrowing rodents, a point made in more detail by Sommer (1999) who suggested emplacement of the pollen by jirds (*Meriones persicus*) – small rodents known to bring flowers into their burrows – whose skeletal remains are known from the Shanidar Cave sediments in small numbers (Tilby et al., 2022). Gargett

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(1989: 176) suggested that flowers could have been blown by strong winds into the cave or that rodents might have brought plants into their nests amongst the bones. He also pointed out that the association between the samples containing the pollen clumps and the Neanderthal remains could not be established as strong because of the imprecision of the accounts of the original excavation. Although Solecki's published accounts (Solecki, 1971, 1975, 1977) are loosely worded, his unpublished notebooks, cited by Leroi-Gourhan (1975, 1998) seem quite precise. More recently, Fiacconi and Hunt (2015: 91), reported finding clumps of pollen in the modern surface sediments in Shanidar Cave, which they regarded as most probably emplaced by bees and/or through anthropogenic pathways such as people visiting the cave with pollen on their shoes.

While the 'Flower Burial' has been discussed from several perspectives, there has been no attempt to revisit the palynology, other than by Arlette Leroi-Gourhan herself (Leroi-Gourhan, 1998, 2000). Here, in the context of – and informed by – our current work in the cave (Hunt et al., 2017; Pomeroy et al., 2017, 2020a, 2020b, Reynolds et al., 2015, 2018, 2022; Tilby et al., 2022), we reflect on the palynology of the 'Flower Burial' identified and documented by Leroi-Gourhan (1975, 1998) and its significance for our understanding of Neanderthal behaviour and the natural processes operating in Shanidar Cave.

2. Solecki's excavation of the 'Flower burial'

Solecki conducted four major campaigns of excavation in Shanidar Cave, in 1951, 1953, 1956-57 and 1960. The final maximum dimensions of his stepped trench were 34 × 16 m, with a maximum depth of 14 m reached in 1956–57 (Solecki, 1961). The trench was excavated very quickly by local labourers under the supervision of a small number of American archaeologists and anthropologists, mostly in the great heat of Iraqi summers.

The 'Flower Burial' (Shanidar 4) was found in 1960. During this season, Solecki dug a 7.4 m deep cut on the western side of the main trench in order to recover the postcranial skeleton of Shanidar 2, and deepened a second cut below the find-spot of Shanidar 1 on the eastern side of the trench. On the 31st July, excavation at the find-spot of Shanidar 3 on the east side of the trench found further parts of this skeleton.

Fig. 1. Wild flowers at Shanidar Cave, photographed May 5, 2023. Photograph by C.O. Hunt.

On August 3rd, Shanidar 4 was located at 7.49 m below datum during straightening of the eastern side of the trench below the find-spots of Shanidar 1 and Shanidar 3 (Solecki, 1961: 695). On August 8th, a further skeleton, Shanidar 5, was located and partly lifted from the area to the southeast and about a metre above Shanidar 3, and on August 9th Shanidar 6 was found very slightly below, and in close proximity to, Shanidar 4 (Solecki, 1961: 696). On the advice of T. Dale Stewart, the project's osteologist, the closely-spaced remains of Shanidar 4 and 6 were cut out of the surrounding sediment, encased in plaster and wood, and lifted out as a single block. On examination of the block in Baghdad, he found two further individuals (Shanidar 8 and Shanidar 9) below the two skeletons (Shanidar 4 and Shanidar 6) seen during the excavation (Solecki, 1975: 880). Later in the same season Solecki located and lifted a 'proto-Neolithic' cemetery of 26 burials in a 2 × 8 m extension of the trench to the north. By any standards, Solecki and his co-workers proceeded extremely rapidly with the excavation.

Solecki's observations about the nature of the location of Shanidar 4 vary somewhat between his different accounts. In his initial account, he writes of the skeleton lying in "a loose occupation deposit of sandy soil" next to a very large rock, and with a layer of small stones above the skeleton that he interpreted as having caused the death of the individual through rock-fall (Solecki, 1961: 695). Some rodent holes were observed around the skeleton, but these are not apparent in his published drawing and photograph (Leroi-Gourhan, 1975: Fig. 1; Solecki, 1977: Figs 1. and 2). He made the suggestion that "the skeleton could have been redeposited in its present position" (Solecki, 1961: 695) but he did not explain why he reached this conclusion. In his later accounts Solecki wrote that the skeletons "appeared to lie in a niche, bounded on the south and east by large stone blocks" (Solecki, 1971: 237) and his interpretation changed to the bodies having been placed in "a small rocky crypt" and not killed by rock fall (Solecki, 1977: 114).

Solecki collected six soil samples from the layers just below and adjacent to Shanidar 4. Three (271, 315 and 326) seem to have come from the "loose brown sandy loam" lying over and between the bones (Leroi-Gourhan, 1975: 563, reproducing entries in Solecki's notebook). These yielded few pollen grains and no clumps of pollen grains. The samples that yielded the clumps of pollen appear to have come from a darker, denser, more organic, loamy layer on which the bones were lying. Sample 313 was "below and to west of Shanidar IV", sample 314 was "20 cm. N.E. of Shanidar IV; dark brown loamy soil overlying what looks like a dark organic discolored layer" and sample 304 was close to and "north of? the pelvis area" of the skeleton (Leroi-Gourhan, 1975: 563, reproducing entries in Solecki's notebook). Samples 304 and 313 were in immediate proximity to the skeleton; 314 was more distant and closer to nearby boulders. There is no mention in any of Solecki's published accounts of any burial cut or other stratigraphic indicator of deliberate burial associated with Shanidar 4, although according to his unpublished notes in the Smithsonian Archives, he seems to have looked for these (Ralph S. and Rose L. Solecki papers, 1904–2017 (bulk 1950–1999), Series 1: Shanidar Cave and Zawi Chemi Shanidar, Iraq, Box 6, Folder "Season IV Field Notes", National Anthropological Archives, Smithsonian Institution).

3. Taxonomy

As noted in the Introduction, the plants identified by Leroi-Gourhan (1975: Table 1, 1998: 85, Fig. 5: 13, 14) from the pollen clumps were *Centaurea*, *Senecio* type, *Achillea* type, *Muscari, Ephedra altissima* plus two unidentified taxa. The *Centaurea* was identified as *Centaurea solstitialis* (Solecki, 1971: 248, Leroi-Gourhan, 1998: Fig. 5: 1–3). *Althea* was found dispersed in very large numbers in the same samples, but otherwise found only in mixed clumps (Leroi-Gourhan, 1975: 563). The pollen-taxonomic attributions of the identified taxa are extremely secure given that they were made by two of the leading experts of their generation and later supported by illustrations (Leroi-Gourhan, 1998: Fig. 5).

The pollen morphologies of the taxa identified, however, may in some cases be attributable to several genera and species which have rather similar pollen. This is especially the case with the genus *Senecio* – the small to medium-sized subspherical conate-echinate tricolporate grains without visible columellae under the structured tectum of this huge genus are extremely similar to those reported in the genera *Bidens, Inula, Pulicaria, Eupatorium, Erigeron, Bellis, Gnapthalium, Solidago, Filago* and *Antennaria* (Moore and Webb, 1978: 71).

This is also the case with *Achillea,* since the small to medium subspherical echinate colporate grains with coarse columellae visible under the structured tectum in this genus are also found in, amongst others, *Anthemis, Chrysanthemum, Matricaria* and *Triplospermum* species (Moore and Webb, 1978: 71). Pollen-morphological studies of *Achillea,* including 18 species occurring in Turkey (Akyalçin et al., 2011, 2014; Koyuncu, 2020) and 12 occurring in Iran (Azani et al., 2009) showed that there was some variation between but also within species and that none were completely distinctive, so there are many candidates for these grains.

It was clearly intended that the images in Leroi-Gourhan (1998: Fig. 5) would substantiate these attributions, although it appears that the grains attributed to *Achillea* by Leroi-Gourhan (1998: Fig. 5: 5, 6) are in fact of *Senecio* type, while the grains attributed to *Senecio* (Fig. 5: 9, 10) are in fact of *Achillea* type.

In her original work, Leroi-Gourhan (1975: 564) identified *Ephedra* from samples 313, 314 and 304 as *E. altissima*. In Leroi-Gourhan (1998: Fig. 5: 13, 14) grains identified as *Ephedra altissima* are figured. Two grains in her Fig. 5:14 are clumped but these look more like *E. distachya* than *E. altissima*, while the grain in her Fig. 5:13 looks more like *E. fragilis*. *E. altissima* is a North African species, so the original attribution is unlikely.

Muscari is a large genus with 49 species in Turkey (Citak et al., 2022: 2692). We have recorded two *Muscari* spp. in the countryside around Shanidar Cave: probably *Muscari walii* and *M. erdalii* (unpublished data). Citak et al. (2022: Fig. 7: L14 and Fig. 6: L9 respectively) have described the pollen morphology of these species. Leroi-Gourhan's illustration (1998: Fig. 5: 4) is consistent with *M. erdalii* or a species with similar morphology. Only *Centaurea solstitialis* (Leroi-Gourhan, 1998: Fig. 5: 1–3) and *Althea rosea* (Leroi-Gourhan, 1968, 1975, 1998: Fig. 5: 11) thus seem to be secure attributions to single species.

The taxonomic composition of the three samples was different. Sample 304 was dominated by wood fragments and had comparatively few pollen. Sample 314 was rich in pollen, but most clumps were *Achillea* type. Sample 313 had many clumps of *Centaurea* (Leroi-Gourhan, 1998: 85). Unfortunately, full species lists and counts for these samples were not given.

Although she did not mention their presence in her 1975 paper, Leroi-Gourhan (1998: Fig. 5: 8, 12, 16) illustrated clumps of unidentified species. In her verbal account to COH (pers. comm. 1992), she suggested that some of the unidentified clumps may have been immature pollen.

4. Seasonality of pollen production

The scenario put forward by Solecki (1971, 1975, 1977) of Neanderthals gathering flowers around Shanidar Cave relies implicitly upon all the identified species being available to be picked at the same time, identified by him and Arlette Leroi-Gourhan as between the end of May and the beginning of July (Solecki, 1971: 250). Survey of the plants in the Shanidar landscape by the current Shanidar Project in successive spring seasons suggests that under modern conditions this might be problematical, although there is an approximately one to three-week delay in first-flowering dates between the valley below the cave and the local hilltops (Table 1). Although *Muscari walii* is still just flowering on local hilltops at the time *Centaurea solstitialis* started to flower at lower altitudes in the Zab Valley, the locally-rarer *M. erdalii* has finished flowering in mid April. Our preliminary findings (Tilby et al., 2022) suggest that climate at the time of the deposition of Shanidar 4 was

Table 1
Start and (where known) end of flowering of Shanidar flowers near Shanidar Cave in the spring during the period 2014–2023.

Species	On local valley floor (ca. 540 m above sea level)		Adjacent to Shanidar Cave (735 m above sea level)		On local hills (ca. 950 m above sea level)	
	Start	End	Start	End	Start	End
Centaurea solstitialis	Late May	After end May	After end May	After end May	After end May	After end May
Senecio type (if *Senecio*)	Early May	After end May	Mid May	After end May	Latest May	After end May
Achillea type (if *Achillea*)	After end May	After end May	After end May	After end May	After end May	After end May
Muscari erdalii	Not seen		Early April	Mid April	Not seen	
Althea rosea	Early May	After end May	Early May	After end May	Mid May	After end May
Ephedra altissima	Not seen		Not seen		Not seen	

broadly similar to that of today. We do not know the impact that many millennia of environmental change may have had on flowering times, but it is clear that under current conditions it would be impossible to gather all of these species locally around the cave at the same time.

5. The possibility of intrusive modern pollen

Solecki was working with a large group of local labourers and a very small professional staff. The local labourers seem to have learned the methods employed by Solecki but cannot be expected to have had a rigorous archaeological training. Reading Solecki's (1971) account of the excavation, he appears to have been a careful excavator, but standards and expectations of excavation hygiene have changed since the 1950s. Recent forensic palynology has identified that pollen is easily carried, for instance on hands (Hunt and Morawska, 2020), footwear (Bull et al., 2006), and clothing (Mildenhall, 2006) so intrusion of modern pollen has to be considered. The pollen and pollen clumps illustrated by Leroi-Gourhan (1998: Fig. 5) from samples 304, 313 and 314 were flattened and corroded, however. This is consistent with these being ancient, rather than a modern intrusion associated with Solecki's excavation.

The season of excavation also militates against intrusive pollen from the Solecki team. Solecki excavated at Shanidar whenever he was able and had an extended season in 1956–57, overwintering at Shanidar. But he excavated Shanidar 4 in August. At that time of year, noonday heat is over 40° C, the flowering season is completely over and all herbaceous plants are dried and brown. Bees are virtually inactive and pollen on the surface of the soil is likely to have oxidised considerably. This makes contamination from grains introduced by Solecki's group considerably unlikely, perhaps making more likely the point about the antiquity of the pollen made above.

6. The possibility of contemporary or modern animal vectors

An important taphonomic indicator was mentioned by Leroi-Gourhan: "Some of these clusters contained two or three different species of agglutinated pollens" (Leroi-Gourhan, 1975: 562–563, Table 1). The proportion is not inconsiderable: ~23% of the pollen clumps were taxonomically mixed (Leroi-Gourhan, 1975, Table 1). This was an important observation, since if whole flowers were emplaced the grains in each individual anther would be monospecific. It is corroborated by Fig. 5: 12 in Leroi-Gourhan (1998), where the uppermost grain in the image is clearly tricolporate, while several of the other grains in the image are colpate - probably monocolpate.

To produce mixed clumps of pollen, another mechanism than straightforward deposition of flowers (whether by Neanderthals or by burrowing jirds) must have been operating. The most likely is that the pollen was accumulated by nesting solitary bees. The pollen loads of

Fig. 2. Solitary bee excavating a burrow on the section wall of our trench in Shanidar Cave photographed September 4, 2022. The bee has broken through a whitish efflorescent crust into slightly-consolidated sediment behind. The insect is head-down in the burrow, spraying loose sediment out of the hole with her legs. Her abdomen is arrowed. Photograph by E. Pomeroy.

Fig. 3. Ancient silty clay-lined insect burrow excavated from sediments about 1.5 m below the position of Shanidar Z, photographed in May 2023. The fill in this specimen was virtually unconsolidated and fell out on the short walk and drive from the cave to the dig house. Scale in cm. Photograph by C.O. Hunt.

individual bees can contain more than one species if they are foraging different species at once (e.g. Free, 1970; Ramalho et al., 1994).

The burrows of solitary bees are present in less-trampled areas on the contemporary cave floor. They are particularly common in the rear of the cave close to the cave wall. Most burrows are sub-vertical to vertical and shallow (<5 cm), but some are more than 0.5 m deep and 6–8 mm in diameter (Figs. 2–4). Some of the shallower burrows are lined with silty-clay (Fig. 3). The bullet-shaped linings are extremely durable and ancient linings are visible in our excavations (Fig. 4). Burrowing bees also colonise standing sections after they have been exposed for a few years (Fig. 2). In this case, the burrows are sub-horizontal and may penetrate more than 0.5 m into the sediment (Fig. 4). Some species line their long sub-horizontal burrows with silty-clay. The recent burrows are typically very well-defined and do not have a fill (Fig. 4). Older burrows tend to have a sandy, often ashy fill and are more difficult to see, although careful observation reveals textural differences from the host sediment and that they cut through stratification (Figs. 4 and 5).

It is worth noting that the area in which Shanidar 4 and associated skeletal remains were found had been left open for more than a year before excavation started there. There is therefore a possibility that the pollen clumps were introduced by bees contemporarily with Solecki's excavation. There is also a possibility that bees were nesting in the sediments around the positions of the Shanidar 4 cluster, contemporary with or immediately after the individuals were deposited. The state of the pollen clumps in Leroi-Gourhan's photos (1998, Fig. 5) and in her verbal account to COH (pers. comm. 1992) is strongly suggestive of the pollen being ancient and thus broadly contemporary with the Shanidar 4 cluster.

In our current excavations at the site, some probably-ancient mud-lined sub-horizontal and sub-vertical bee burrows have been found close to the location of Shanidar 4, Shanidar Z (discovered 2016, see Pomeroy et al., 2020a) and some fragmentary Neanderthal skeletal remains below Shanidar Z. Modern bee burrows also appeared between our excavation seasons (Fig. 4). It is also worth noting that our recent excavations at this

Fig. 4. Modern (red arrow to left) and ancient clay-lined (red arrow to right) insect burrows in deposits about 1 m west of the position of Shanidar 4, photographed in September 2022. Vertical photo; East to top of image, larger scale measures 30 cm, small scale in cm. Photograph by C.O. Hunt. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Fig. 5. Ancient insect burrows (arrowed) in the trench wall, in deposits ~15 cm below the location of Shanidar Z and very close to the level of new, unpublished, fragmentary Neanderthal remains, photographed in May 2022. The sandy fill of the middle burrow is particularly apparent. Looking North, scale measures 15 cm. Photograph by C.O. Hunt.

level have been illuminated by artificial light, whereas it would seem from his accounts of the excavations (e.g. Solecki, 1961, 1971) that Solecki did not use artificial light while he was excavating. It is thus quite likely that he was unable to see bee burrows in his excavations at depth, as in the Shanidar 4 zone. Bee burrows could, however, be felt by the current excavation team while trowelling, so Stewart, who excavated around Shanidar 4, might have noticed them even if he could not see them.

Although his publication did not mention Shanidar Cave, Bottema (1975: 22) pointed out that bees emplaced clumps of Compositae pollen in their nests in cave sediments. Further, Fiacconi and Hunt (2015: 91) noted clumps of pollen in the modern surface sediments at Shanidar Cave and attributed them to the action of bees or their recent import on the feet of people and/or animals.

Although the clumps of mixed pollen could be consistent with bee nesting, other aspects may be inconsistent with this theory. In particular, if Arlette Leroi-Gourhan was correct in identifying clumps of immature pollen, some other mechanism was almost certainly involved, since bees are only able to gather mature pollen once flowers open.

We have encountered small mammal burrows in the Shanidar cave fill, for instance around Shanidar 5 (Pomeroy et al., 2017). These are quite distinctive, circular in section and 3–5 cm in diameter (Figs. 6 and 7). None are visible in the extremely well-stratified deposits around the location of Shanidar 4, Shanidar Z and the new remains just below them. Two analyses of burrow fills round Shanidar 5 by Marta Fiacconi (pers. comm. 2016) contained no pollen. It is difficult to completely rule small mammal activity out as a factor in the 'Flower Burial' pollen but at present we have no positive evidence for it.

7. Protecting the dead?

The original suggestion of the 'Flower Burial' relied on the idea that Neanderthals were mourning or may have been laying medically-active plants under the body (Solecki, 1971, 1975). The flowering heads of *Centaurea solstitialis* bear sharp hard spines over 2 cm long (Figs. 8 and 9). If flowers of this species were involved, while it is plausible that these could have been gathered for medicinal reasons (Solecki, 1975; Lietava 1992), their choice for placing a dead body on is difficult to understand in terms of modern notions of empathy.

Alternative explanations might also be entertained. Leroi-Gourhan (1975: 563) remarked on wood fragments in the samples containing clumps of pollen and these were identified by Vernet (1981: 142) as *Pinus halepensis*, probably *Juniperus* and another gymnosperm, maybe *Abies*, and indeterminate deciduous species. Wood fragments and pollen were also found within the body cavity of the nearby Shanidar Z (Pomeroy et al., 2020a, Fig. 9). It seems likely that these had filtered into the rib-cage from above. While microscopic wood fragments can be fairly common in sediments of caves frequented by early people, the coincidence of wood fragments and pollen of immature plants might point to branches and other vegetation being placed over the bodies. In a scenario of this sort, the very spiky heads of *Centaurea solstitialis*, with branches and other vegetation, might be thought to help to defend the bodies from scavengers.

8. A reappraisal of the 'Flower burial'

The evidence from the skeletal remains found by Ralph Solecki at Shanidar Cave was a major step towards the reassessment of the capacities and 'humanity' of the Neanderthals during the late 20th Century (Pomeroy et al., 2020a: 12). The 'Flower Burial' hypothesis was an important part of this evidence. Several aspects of the hypothesis have been questioned on various grounds (Chase and Dibble, 1987; Gargett, 1989; Sommer, 1999; Fiacconi and Hunt, 2015).

This current reappraisal suggests that Solecki's hypothesis — that all of the pollen clumps associated with Shanidar 4 were the result of flowers being placed under a deceased Neanderthal – is very unlikely. There are strong reasons to do with the seasonality of flowering of the species concerned to doubt Solecki's scenario of a single flower-gathering event (Table 1). The mixed clumps of pollen are more consistent with an alternative view, that ground-nesting bees were responsible for the emplacement of the clumps of pollen over one or more spring flowering seasons, while their corroded and flattened state

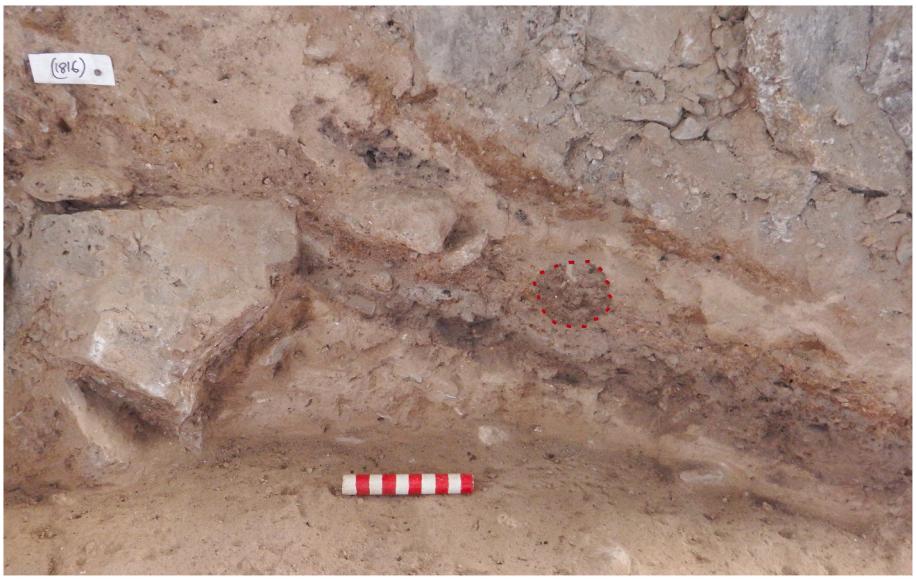

Fig. 6. Ancient rodent burrow in the trench wall, less than 1 m stratigraphically below and approximately 4 m to the East of the location of Shanidar 5, photographed in September 2018. Scale measures 10 cm, looking South. Burrow outlined by a dashed red line. Photograph by C.O. Hunt. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

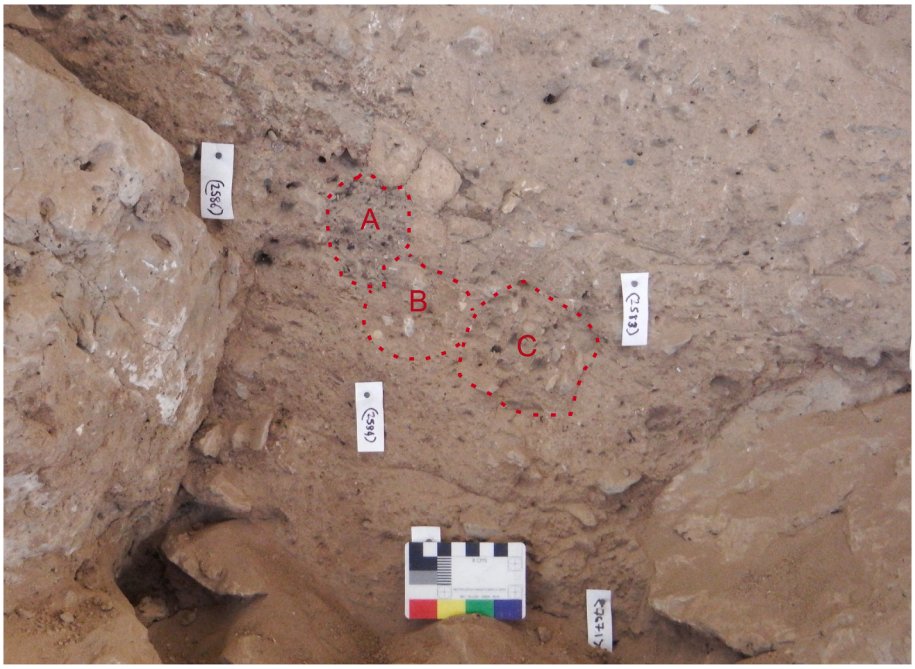

Fig. 7. Ancient rodent burrows in the trench wall, in layers stratigraphically just below and approximately 2 m to the East of the location of Shanidar 5, photographed in May 2023. There may be more than one generation of burrows in this photograph, since the fill of A is very soft and ashy, whereas the fills of B is dense, silty and characterised by some stones with long-axes vertical and C is fairly dense, silty, fairly rich in charcoal and with stones with long-axes vertical. Scale in cm, looking South, burrows annotated with a red, dashed line. Photograph by C.O. Hunt. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

might suggest that the pollen is ancient and thus that this happened more-or-less contemporarily with the Neanderthal activity.

The situation may, however, have been more complex than this. If Leroi-Gourhan was correct in identifying some of the pollen clumps as immature grains, there is a possibility that immature flowers were introduced by some mechanism. Many possibilities might account for this: the actions of small mammals, on the feet of Neanderthals or animals, in the gut contents of animals taken by the Neanderthals, or because the Neanderthals were gathering plants for food, or that they placed plants below or over the body of Shanidar 4. The finding of wood fragments in association with Shanidar 4 and wood fragments and pollen in the body cavity of Shanidar Z (Pomeroy et al., 2020a) might be consistent with vegetation being placed around these bodies but is not conclusive. The suggestion by Gargett (1989) of flowers being blown into the cave seems unlikely, since in our observations over 12 excavation campaigns since 2015, some in spring and some at the end of the summer, only dead leaves from nearby oak trees have been blown into the cave. At this point, we can only conclude that the 'Flower Burial' hypothesis seems unlikely, that nesting bees were probably responsible for some of the pollen clumps – certainly the mixed ones – and that there is a possibility that if immature pollen were involved it could have come from plants placed over or under the body.

Although the 'Flower Burial' hypothesis seems increasingly unlikely, the cluster of Neanderthal bodies associated with Shanidar 4 is certainly associated with mortuary behaviour – the placement of bodies. Shanidar 4 and Shanidar Z were certainly carefully placed, and it is possible that

Fig. 8. *Centaurea solstitialis* photographed May 27, 2022 in the valley below Shanidar Cave, showing the spiky flower-heads. Photograph by C.O. Hunt.

the fragmentary skeletal material found below them was from another placed individual. This is consistent with members of their group(s) feeling empathy (Pomeroy et al., 2020a, 2020b). It has become clear from the work of the Shanidar Cave Project that several bodies in the Shanidar 4 cluster were placed episodically, close to what would have been a major landmark on the cave floor - a very large boulder over 2 m high when the bodies were deposited. The episodic, repeated deposition of Neanderthal bodies within a very confined space, as evidenced by the Shanidar 4 group, seems to be worthy of further consideration and debate.

It seems very likely that the re-use of the same distinctive location can be associated with the Neanderthals using Shanidar Cave having topographic memory. Conceivably, this is evidence that the Shanidar Neanderthals inhabited 'storied landscapes' (*sensu* Langley, 2013), as do modern humans (Barker and Hunt, 2023). This insight was not available to Ralph Solecki, because Stewart was unable to investigate in detail the stratigraphic relationships between the individuals in the Shanidar 4 block after the displacement of the skeletal material within it during the journey to Baghdad (Solecki, 1971: 237).

9. Conclusions

Much still remains to be discovered about the behaviour of the Neanderthals. Modern understanding owes a huge debt to the pioneering work of Ralph Solecki and his co-workers at Shanidar Cave. However, whilst gripping the imagination of generations of archaeologists and anthropologists, the 'Flower Burial' hypothesis has not been substantiated by this review.

The pollen around the Shanidar 4 Neanderthal shows flattening and corrosion in the illustrations provided by Leroi-Gourhan (1998: Fig. 5). This is consistent with it being ancient. We can therefore discount the possibility that the pollen was introduced by Solecki and his colleagues walking through pollen-rich pasture to the cave and instead conclude that the pollen is likely to be approximately contemporary with the Neanderthal with which it is associated.

Although some of the pollen clumps may have been anther-shaped, the presence of taxonomically-mixed clumps is not consistent with these clumps of pollen being from the deposition of anthers and therefore whole flowers. Instead, it is far more likely that the taxonomically-mixed pollen was collected and deposited in clumps by bees. This makes it perhaps less likely that the monospecific clumps of pollen in the same samples resulted from activity by agents other than bees. The fact that, under modern conditions at least, the flowers represented in the Shanidar 4 pollen cannot be collected at the same time is another argument against the hypothesis of flowers being gathered at the time of death to be laid with the body. On the other hand, Leroi-Gourhan's suggestion

Fig. 9. *Centaurea solstitialis* seed heads photographed in September 2022. Photograph by G. Barker.

that some clumps contained immature pollen might suggest more complex scenarios.

Some things are still to be resolved, however. In particular, we need to establish why clumps of pollen were only recovered from three samples associated with Neanderthal remains, out of the 21 samples containing pollen analysed from the cave by Leroi-Gourhan. The presence of wood fragments may also be worthy of further consideration, particularly because wood fragments are present within the fill of the body cavity of Shanidar Z (Pomeroy et al., 2020a).

Our final reflection is that the debates about the 'Flower Burial' have in many respects obscured its most significant aspect: that it was part of a tight cluster of what our evidence suggests were emplaced bodies that is practically unique in the Neanderthal realm. The potential implications of this behaviour for Neanderthals' sense of space and place are probably the most intriguing aspect of the Shanidar Cave Neanderthals, rather than whether an individual was buried with flowers.

Credit author statement

C.O. Hunt Conceptualisation, Methodology, Investigation, Writing – original draft, Writing – Review and Editing, Funding acquisition, E. Pomeroy Investigation, Writing – Review and Editing, Funding acquisition, T. Reynolds Investigation, Writing - Review and Editing, Funding acquisition, E. Tilby Investigation, Writing - Review and Editing, G. Barker Investigation, Writing – Review and Editing, Project administration, Funding acquisition, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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COH remembers that reading Leroi-Gourhan (1975) when he was a student was a seminal moment in shaping his decision to become a palynologist. In 1992 he met Arlette Leroi-Gorhan and was hugely impressed by her detailed and thoughtful discussion of the 'Flower Burial'. This paper is dedicated to her memory.

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