Title: Processing and storage of tree fruits, cereals and pulses at PPNA Sharara, southern Jordan

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ESM 2 Seed catalogue

Seed catalogue

The following seed catalogue presents detailed descriptions of all taxa and potentially identifiable plant remains identified during this study, including how minimum numbers of individuals (MNIs) were calculated in each case. Photographs and measurements were obtained using a PixeLINK camera attached to a Nikon SMZ25 stereomicroscope and coupled to a PC, assisted by PixeLINK Capture and NIS-Elements D software, or a Leica DFC495 camera attached to a Leica Z6 APO and coupled to a PC, assisted by LAS software. Measurements were recorded in millimeters (mm) to two decimal places. Scanning Electron Microscope (SEM) images were captured on a Jeol JSM-5510.

Identifications were made on the basis of morphological characteristics, size, surface texture and where visible internal structure. Relevant publications (e.g. van Zeist and Bakker-Heeres 1982, 1984a, b, 1985; van Zeist et al. 1984) and online resources, including George Willcox's Atlas of images of charred archaeobotanical finds (http://g.willcox.pagespersoorange.fr/index.htm) helped to guide identifications, along with the following reference texts: the Atlas of Seeds and Small Fruits of Northwest-European Plant Species with Morphological Descriptions (Berggren 1969, 1981; Anderberg 1994) the Digital seed Atlas of the Netherlands (Cappers et al. 2006, 2012) the Identification Guide for Near Eastern Grass Seeds (Nesbitt 2006), the Identification of Cereal Remains from Archaeological Sites (Jacomet 2006). To refine identifications, potential species lists were compiled using the Flora Palaestina (Zohary 1966, 1972; Feinbrun-Dothan 1978, 1986), as the most relevant flora for the study area. Identifications were confirmed through comparison with modern reference material housed at the School of Archaeology, University of Oxford. Archaeological specimens were compared to both modern uncharred and modern charred material wherever possible, to take account of the potential effects of charring on seed morphology (Boardman and Jones 1990; Braadbaart 2008). Fresh plant material was charred following protocols outlined by Fraser et al. (2013) for best replicating archaeologically charred material. This involved wrapping the material to be charred in aluminium foil and burying this in sand within a glass beaker to simulate reducing conditions. The beaker was then placed in a muffle furnace for 24hrs at 230°C. Charring was undertaken at the School of Archaeology, University of Oxford using a Gallenkamp muffle furnace.

Taxa are listed below in the order that they appear in Table 1 (Main Text) and the Supplementary Data Files (S1). Nomenclature follows the Flora Palaestina, except for family names which follow modern convention (e.g. Brassicaceae rather than Cruciferae). The term 'type' has been used to indicate specimens that are similar, in terms of their morphology and size to a particular taxon, while the term 'cf.' refers to specimens that compare favourably with that taxon and can most likely be identified as such.

1 CEREALS

Quantification: For all cereal grains whole, embryo, apical and mid-section fragments were recorded. MNIs were calculated by adding together the number of whole grains and the larger count from the embryo and apical ends. Mid-section fragments were only used to calculate the MNI in the absence of embryo or apical ends and in these cases MNIs were estimated by visual inspection. For barley rachis, MNIs were calculated using the upper scar as a unique feature with lower scars and internode fragments recorded for posterity. An MNI for detached lateral florets was arrived at by counting the number of fragments that preserved the base of the floret. For glume wheat chaff, MNIs were calculated at the level of glume bases with the upper scar being used as a unique feature. Thus, glume bases were given a score of '1' and spikelet forks a score of '2'.

1.1 Hordeum spontaneum/vulgare (barley)

1.1.1 Grain, Plate 1a

Identification: Barley grains were distinguished from other cereal caryopses by their shallow ventral groove. The majority were identified as hulled barley based on their 'boat-shaped' appearance, faceted shape in cross-section and the presence of palea and lemma impressions which were visible as linear grooves running parallel down the ventral face. Following White (White 2013, p. 96), grains have been categorised as 'domestic' if they had a breadth of 2.5 mm or more and a thickness of 1.5 mm or more, and 'wild' if they had a breadth of 2.25 mm or less and thickness of 1.5 mm or less. Grains falling between these two groups were classified as 'intermediate'. Breadth and thickness measurements were obtained for all grains and grain fragments (embryo, apical and mid-sections) identified as *H. spontaneum/vulgare* at Sharara. Breadth was measured in dorsal view and thickness in lateral view with measurements taken at widest part of the grain.

However, for grain fragments this may not represent the widest part of the whole grain and recorded values could be underestimates. For all whole grains, length in dorsal view was also measured for posterity. Barley grains that were not convincingly hulled (i.e., lacking palea and lemma impressions and a faceted appearance) were identified as *Hordeum* sp. indeterminate. These were typically poorly preserved.

1.1.2 Chaff, Plate 1b–h

Identification: Barley rachises were identified based on their overall straight Y-shape morphology and small abscission scar relative to the spikelet width. All barley rachis was identified as *H. spontaneum/vulgare*, with other *Hordeum* species excluded based on morphological and geographical criteria. Rachis remains were categorised into smooth and rough scar types based on the visual appearance of the abscission scar and following criteria described by Colledge (2001, p. 65) and Tanno and Willcox (2012). Abscission scars that could not be confidently identified to type (typically due to poor preservation) were categorised as non-diagnostic. Rachis remains that were missing their scars and typically part of their abaxial (front) surface were recorded as 'ripped' following White and Makarewicz (2012). These ripped scars were non-diagnostic, possessing incomplete scar surfaces that ruled out secure identification to either the smooth or rough type. Rachis remains were also categorised according to whether any palea and lemma material remained attached to the top of the rachis internode. When present this gave specimens a characteristic spikey appearance (see Plate 1b, e). A few unattached lemma bases were also identified at Sharara, along with the remains of the detached lateral florets of barley rachis.

1.2 Triticum dicoccoides/dicoccum (emmer) chaff, Plate 1i–k

Identification: Specimens of emmer wheat chaff were identified based on their narrow scar, glumes that inserted below the scar, the angle of the primary keel of the glume (which projected laterally) and the relatively straited appearance of the glumes. In addition to their taxonomic identification, emmer glume bases and spikelet forks were also categorised according to whether they had a flat scar consistent with wild emmer (*T. dicoccoides*), or a lifted scar consisted with domestic emmer (*T. dicoccum)* following Weide (2015). If the abscission scar could not be confidently identified to type (typically due to poor preservation) it was recorded as non-diagnostic. Glume bases/spikelet forks where the scar surface appeared to be missing, often along with part of the abaxial (front) surface where categorised as 'ripped' following the naming of similar morphological types in barley. *Triticum* sp. glume wheat

1.2.1 Grain, Plate 1l

Identification: Glume wheat grains were distinguished from other cereals by their deep ventral groove, presence of glume line impressions, ventral compression and strong dorsal ridge. At Sharara, only a handful of glume wheat grains were recovered, amongst them an apical fragment of a two-grained narrow type, identified by its flat ventral face and lateral compression. This could not be identified to species.

1.2.2 Chaff

Identification: Glume bases and spikelet forks that could not be identified to species were labelled as glume wheat indeterminate. This included two glume bases for which it was possible to rule out *T. timopheevii* (Zhuk.) Zhuk (new-type glume wheat) as an identification, based on the absence of a strong cable like primary keel inserting into the scar. These have been recorded as emmer/einkorn.

1.3 *Triticum* sp. (wheat) internode fragments

Identification: A single fragment of rachis internode broken beneath the scar has been identified as *Triticum* sp. indeterminate based on comparison with modern reference material. A further five internode fragments have been recorded as *Triticum/Aegilops* sp. where it was not possible to exclude and identification of *Aegilops* sp.

1.4 Cereal indeterminate

Identification: cereal grains that could not be identified to a genus, typically due to fragmentation and poor preservation were classified as cereal indeterminate. This category also included detached embryos that were quantified separately.

Plate 1. **a** *Hordeum spontaneum/vulgare* (barley) grain, from left to right in ventral, dorsal, lateral and cross-section views. **b** Barley rachis with smooth abcission scar, palea and lemma attached. **c** Barley rachis with rough abcission scar, no palea and lemma attached. **d** Barley rachis with non-diagnostic abcission scar, no palea and lemma attached. **e** Barley rachis with 'ripped' scar morphology, palea and lemma attached. **f** Barley rachis basal segment. **g** Barley rachis detached lateral florets. **h** Barley detached lemma base. **i** *Triticum dicoccoides/dicoccum* (emmer) spikelet fork, flat scar. **j** Emmer glume base, non-diagnostic scar. **k** Emmer spikelet fork with 'ripped' scar morphology. **l** Glume wheat two-seeded grain, from left to right in ventral, dorsal, lateral and cross-section views. All scale bars 1 mm.

2 PULSES

For all pulse seeds MNIs were calculated using the radicle as a unique feature. For pulse stalks all fragments were recorded and an MNI calculated based on visual inspection.

2.1 *Vicia ervilia* (bitter vetch), Plate 2a

Identification: A single seed of bitter vetch was identified based on its short hilum, flat to concave ventral face and triangular outline when viewed in all four faces.

2.2 *Lens* sp. (lentil), Plate 2b

Identification: Lentils were identified by their characteristic lenticular shape; formed by their two circular-flattened cotyledons. The relatively sharp edges of these cotyledons made them easy to differentiate from the other large-seeded legumes when viewed in cross-section.

2.3 *Lathyrus inconspicuus* (inconspicuus pea), Plate 2c-g

Identification: Seeds of this type varied in their shape from sub-spherical to sub-triangular and possessed a short, oval hilum. Where visible the lens lay close to the hilum. Eight species with small oval hila were initially considered as possible candidates for this type, following Melamed et al. (2008). These were: *Lathyrus aphaca, L. ciliolatus, L. inconspicuous, L. nissolia, L. sphaericus, Vicia parviflora, V. peregrina* and *V. tetrasperma*. Following comparison with modern reference material (charred and uncharred) and a review of the *Flora Palaestina*, six species were excluded as identifications, leaving only *L. inconspicuus* and *V. peregrina* (see Table 2.3.1 below) as possibilities.

Table 2.3.1. List of eight species with small oval hila considered as candidates for the archaeological pulse type, their presence in the *Flora Palaestina* (FP), morphological comparison to archaeological specimens and whether they were ultimately considered as a possible identification (ID).

Species	In FP	Morphological comparison to archaeological specimens	Possible ID
Lathryus aphaca	Yes	Seeds more ellipsoid in shape than archaeological specimens	Excluded
Lathyrus ciliolatus	No	No reference material	Excluded
Lathyrus inconspicuus	Yes	Good match	Possible ID
Lathyrus nissolia	Yes	Seeds possess a dense tuberculate surface pattern that is not observed on areas of testa preserved on archaeological specimens.	Excluded
Lathyrus sphaericus	No	Seeds more spherical than archaeological specimens	Excluded
Vicia parviflora	No	Seeds significantly smaller than archaeological specimens	Excluded
Vicia peregrina	Yes	Good match	Possible ID
Vicia tetrasperma	Yes	Hilum too long	Excluded

In terms of gross morphology, the archaeological specimens were a good visual match to both *L. inconspicuus* and *V. peregrina* seeds, with some more strongly resembling the former and some the latter. To distinguish between these two species, metrical analysis was undertaken and surviving portions of testa on archaeological specimens were also examined under SEM. Following Caracuta et al. (2017), measurements of seed circumference, absolute hilum length and absolute radicle length were obtained from 11 of the best-preserved whole specimens from hand-picked Sample BOT025. For consistency and to allow accurate comparisons, charred seeds of both *L. inconspicuus* and *V. peregrina,* taken from the modern reference collection housed in the School of Archaeology were also measured. Relative hilum and relative radicle length (as percentages of the seeds circumference) were additionally calculated.

Table 2.3.2. Measurements taken on 11 archaeological specimens of the pulse type from Sharara, with range of values and average values reported. * Measurements taken on charred seeds of *Vicia peregrina* (*n* = 3) and *Lathyrus inconspicuus* (*n* = 3) from modern reference collection. † Measurements reported in Caracuta et al. (2017), for *L. inconspicuus.*

Unique ID	Circumference (mm)	Absolute Hilum length (mm)	Relative hilum length (%)	Absolute radicle length (mm)	Relative radicle length (%)
A	8.42	0.62	7	1.26	15
B	8.78	0.73	8	0.93	11
C	8.54	0.60	7	0.83	10
D	8.90	0.55	6	1.39	16
E	9.14	0.54	6	1.23	13
F	8.49	0.54	6	1.15	14
G	7.70	0.62	8	1.21	16
H	8.19	0.60	7	1.20	15
I	7.42	0.59	8	1.16	16
J	9.87	0.80	8	1.57	16
K	8.76	0.63	7	1.25	14
Range	7.42–9.87	0.54–0.80	6–8	0.83–1.57	10–16
Average	8.40	0.60	7	1.15	14
L. inconspicuus *	8.74	0.86	10	1.15	13
V. peregrina *	12.3	1.08	9	1.60	14
L. inconspicuus †	9 ± 0.2	0.5 ± 0.1	5	0.7 ± 0.1	8

The measurements obtained on archaeological specimens were broadly consistent with those from modern charred *L. inconspicuus* seeds and values previously reported in Carcuata et al. (2017) for this species (see Table 2.3.2 above), although there was some overlap with values recorded from modern specimens of *V. peregrina*. Initial examination under SEM of surviving areas of testa on archaeological specimens from Sharara, also shows what appears to be a reticulate pattern (see Plate 2e). This is consistent with Butler's (1990 Plate 64) description of *L. inconspicuus* and the pattern observed on modern charred seeds of this type (see Plate 2f). In comparison, the testa of *V. peregrina* is characterised by a papillose pattern (Butler 1990 Plate 21). On this basis, the pulse type has been identified as *L. inconspicuus*. However, further analysis is needed to verify this identification for all the archaeological specimens, and we cannot exclude the possibility that both *L. inconspicuus* and *V. peregrina* are represented within the archaeological assemblage. Seeds that were less secure morphological matches to *L. inconspicuus* were recorded as 'cf.' identifications.

2.4 Vicia/Lathyrus sp.

Identification: These specimens were represented by only fragmentary material, which tended to be angular, robust and in at least one view a good match to either *Vicia* or *Lathyrus* specimens.

2.5 Pulse indeterminate

2.5.1 Seed

Identification: Fragments of pulses that were indeterminate to genus have been recorded as either 'pulse indeterminate non-*Lens* sp.' if lentil could be excluded as an identification based on a lack of a lenticular edge to the cotyledons, or simply 'pulse indeterminate' if lentil could not be excluded.

2.5.2 Stalk, Plate 2f

Identification: Fragments resembling legume stalks are heavily veined in circumference and are consistent in size and morphology with modern reference material.

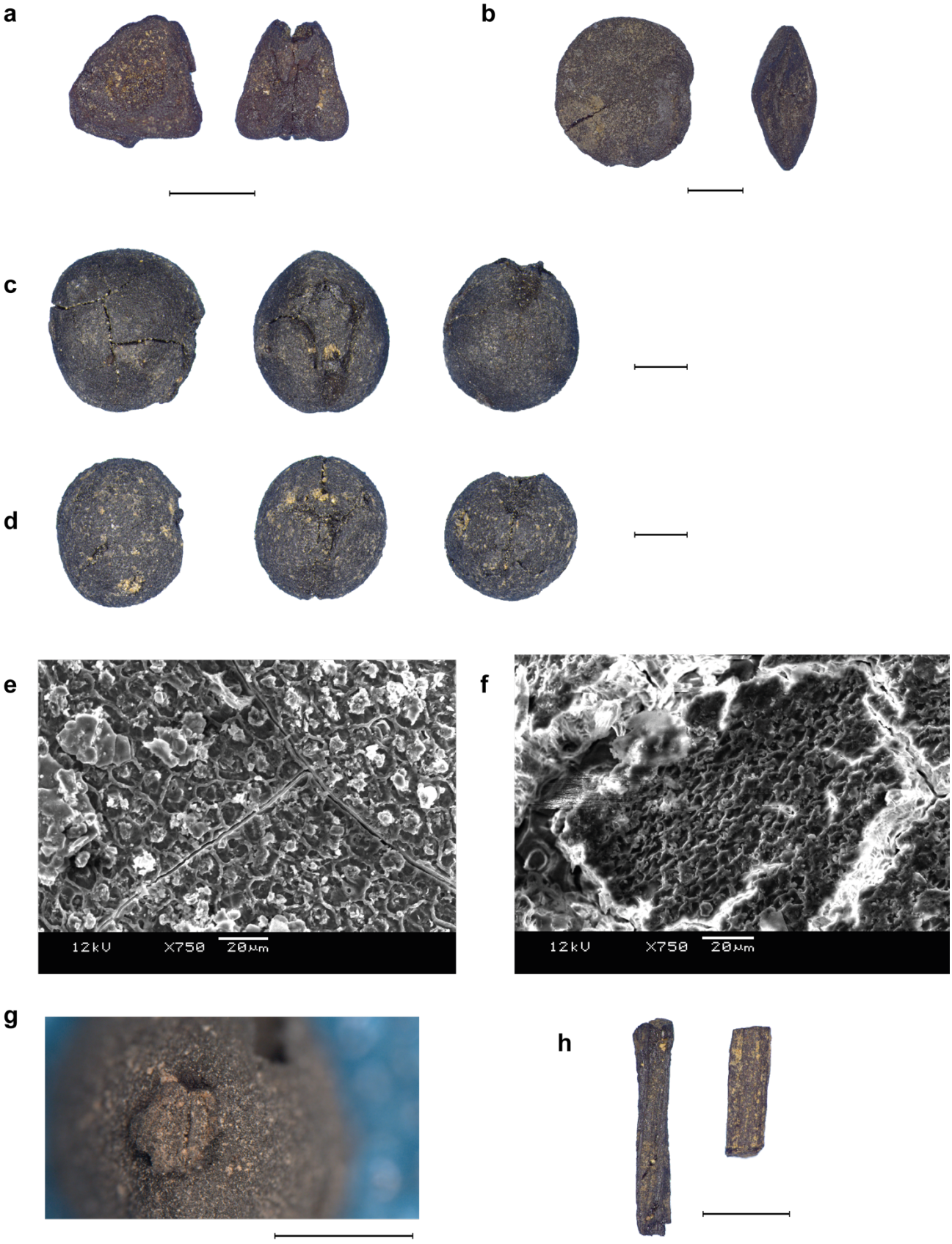

Plate 3. **a** *Vicia ervilia*. **b** *Lens* sp. **c, d** *Lathyrus inconspicuus* (inconspicuous pea). **e** SEM image of inconspicuous pea seed coat with characteristic reticulate pattern. **f** SEM image of modern charred inconspicuous pea seed coat with characteristic reticulate pattern. **g** Close up of hilum on archaeological inconspicuous pea. **h** Pulse indet. stalk. All scale bars 1 mm unless otherwise stated.

3 TREE FRUITS

Quantification: Figs were recovered both as whole and fragmented syconia (fruits) and as drupelets. These have been scored as separate categories, assuming they could be combined into a single category at a later stage if necessary. For fig fruits, MNIs were calculated by adding together the number of whole fruits to the number of whole fruits that were estimated by measuring the volume of fig fruit fragments and a conversion factor of 10 ml = 1 fig fruit. This conversion was arrived at by calculating the volume of 10 whole figs within the assemblage and averaging this. For drupelets, MNIs were calculated using the pointed apex of the drupelet as a unique feature. Due to time constraints, for samples that produced large quantities of drupelets MNIs were estimated based on the volume (ml) of drupelets present (1 ml = 600 drupelets). For detached fig stalks MNI's were calculated using the attachment point of the stalk as a unique feature.

For pistachio nutlets, MNI's were calculated using the attachment point as a unique feature. This meant estimating the number of whole nutlets by visual inspection of fragments that preserved part of attachment point. The total number of nutshell fragments and nutlet caps (attached and loose) were also recorded for posterity. For other species, represented only by nutshell, fragments were recorded and an MNI calculated based on visual inspection of these. In no case were there enough fragments in a single sample to suggest an MNI any higher than one.

3.1 Ficus carica (Fig)

3.1.1 Syconia, Plate 3a-d

Identification: Fig fruits were identified based on their size and morphological appearance, with attachment points and ostioles observed on better-preserved specimens. In some cases, stalks remained attached to the fruits. Fragmented fig fruits possessed an outer layer of fruit skin, with an inner structure composed of drupelets embedded in a fleshy matrix. Morphologically, the archaeological fig fruits from Sharara compared favourably with modern dried figs that had been experimentally charred, showing little distortion and lacking the large voids that were observed on fresh figs after charring (see Plate 3b). When fragments of fig skin were examined under SEM this revealed crystalline like features similar to those observed by Cartwright (Cartwright 2003, p. 346) on dried fruits and which are suggested to result from fruit sugars crystallising to the surface during sun drying.

Three species of fig are recorded in the *Flora Palaestina* (Vol. 1: 37): *F. carica, F. pseudo-sycomorus* and *F. sycomorus.* The latter is stated as being native to Ethiopia and tropical East Africa and has been excluded as an identification on this basis. Meanwhile, *F. pseudo-sycomorus* is described as being rare in the region and producing fruits that are 1–1.5 cm across. This is somewhat smaller than the whole fig fruits recovered from Sharara, most of which measure at least 2 cm in diameter. On this basis figs at Sharara have been identified as *F. carica*.

3.1.2 Drupelets, Plate 3e

Fig drupelets are laterally compressed, ovate in outline and pointed at the apex. In many specimens it was also possible to make out the small circular hilum below the apex. Some drupelets were found surrounded by or embedded in a fleshy matrix. These lumps of fruit flesh were distinguished from fig fruit fragments based on their smaller size (only being recovered from the 1 mm and 0.3 mm fractions) and lack of outer fruit skin.

3.1.3 Stalk, Plate 3f

Fig stalks were identified based on their visual appearance in comparison with modern reference material (charred and uncharred), as well as by comparison to archaeological specimens that retained their stalk attachments.

3.2 *Pistacia* sp. (pistachio), nutlets, Plate 3g

Identification: Fragments of pistachio nutshell were identified based on their size, shape and the thickness of the nutshell (0.34–0.45 mm thick). These fragments possessed a smooth surface with striations discernible on larger fragments. Identification to species has not been possible within the scope of this study, although the relatively bulbous appearance of larger fragments of nutshell rules out *P. lentiscus*.

3.3 Nutshell '*Quercus*-type', Plate 3h

Identification: This nutshell type is relatively thin (0.19–0.23 mm thick) and morphologically similar to the nutshell of *Quercus* (oak).

3.4 Nutshell '*Amygdalus/Prunus*-type', Plate 3i

Identification: This nutshell type is relatively thick in cross section (0.76–1.04 mm thick) and consistent in size with *Amygdalus/Prunus* (almond) nutshell. No fragments were identified with the characteristic pitted or striated outer surface pattern associated with almond and no suture that is distinctive of this type could be observed.

3.5 Fruit/Nut indeterminate

Identification: A single fragment of material resembling the remains of nut kernel was recovered from Sharara along with a single fragment of material resembling the remains of fleshy fruit or pod was recovered. In neither case could these be assigned to any taxa/type and their identification has been left as nut/fruit indeterminate.

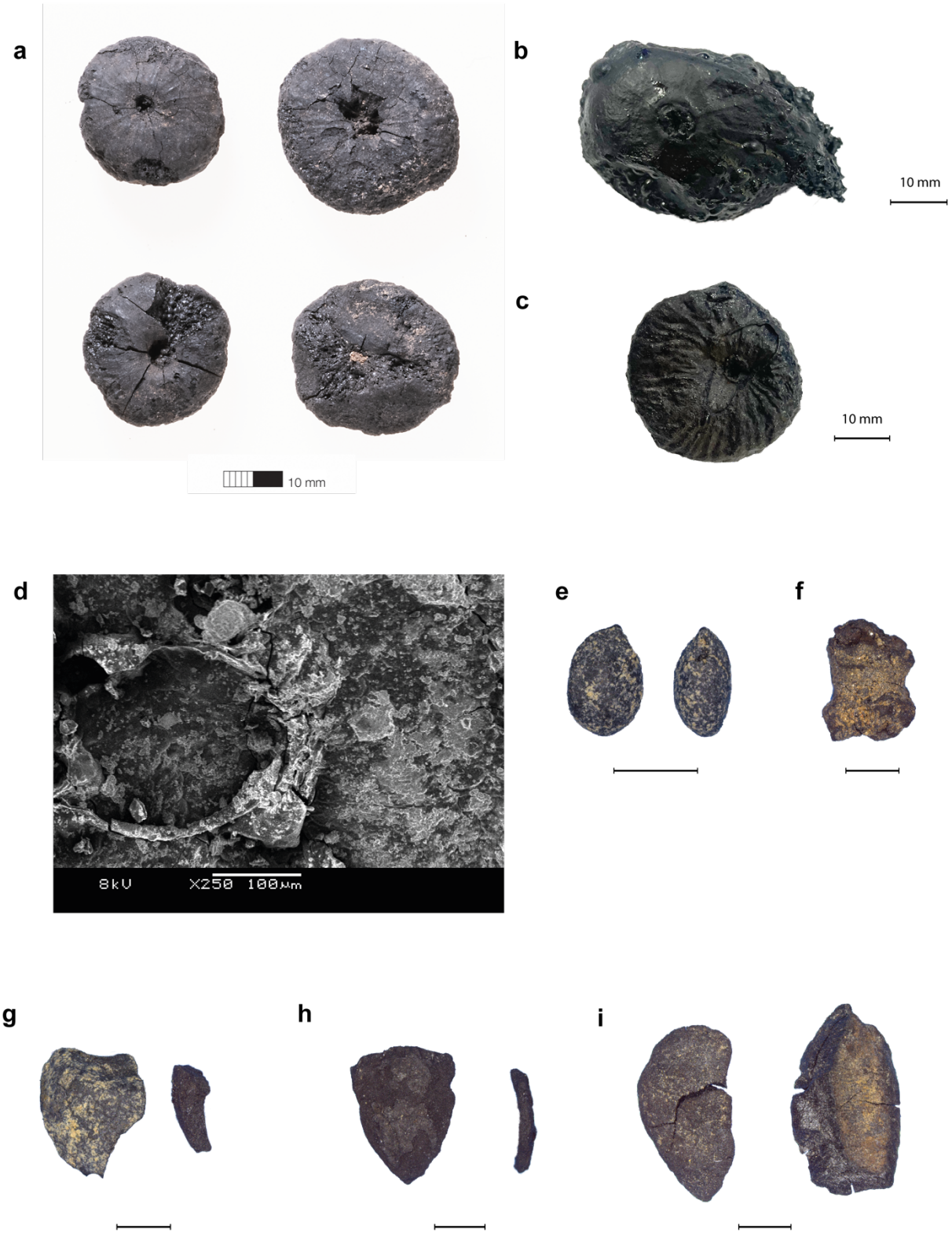

Plate 4. a *Ficus carica* (fig) synconia. **b** Modern fig (fresh) after charring. **c** Modern fig (dried) after charring. **d** SEM image of archaeological fig skin with crystalline features. **e** Fig drupelet. **f** Fig stalk. **g** *Pistacia* sp. nutshell. **h** Nutshell '*Quercus*-type'. **i** Nutshell '*Amygdalus/Prunus*-type'. All scale bars 1 mm unless otherwise stated.

4 WILD GRASSES

Quantification: For wild grasses, as with the cereals, whole, embryo, apical and mid-section fragments of caryopses were recorded. MNIs were calculated by adding together the number of whole grains and the larger count from embryo and apical ends. Mid-section fragments were only used to calculate the MNI in the absence of embryo or apical ends with MNIs estimated by visual inspection. For *Poa bulbosa* an MNI was calculated by taking the attachment point at bottom of the bulbil as a unique feature. Rachis/spikelet remains were given counts of one and for *Stipa* awn the number of fragments were counted and an MNI calculated based on visual inspection in comparison to whole individuals from the modern reference collection. In no case were there enough fragments in a single sample to suggest an MNI higher than one.

4.1 cf. *Eremopyrum* sp. (false wheatgrass), Plate 4a

Identification: A single grain was identified to this genus based on its grooved appearance in lateral and ventral views and its long linear hilum, which is deeply inset on the ventral face (Nesbitt 2006, p. 88). According to van Zeist's description (van Zeist and Bakker-Heeres 1982, p. 221) the greatest width is in the lower half of the grain and it slightly tapers towards the rounded apex. *Eremopyrum* caryopses also have a high-backed dorsal side with a prominent ridge, which is not visible on this specimen, although this could be due to the effects of charring. Given the uncertainties around this identification and the fact that both *Agropyron* and *Eremopyrum* have near identical caryopses (Nesbitt 2006: 80) the identification has been left at the level of 'cf.'.

Measurements: L = 2.91 mm; B = 0.99 mm; T = 0.91 mm

4.2 *Aegilops* cf. *speltoides* (goatgrass) spikelet base, Plate 4b

Identification: Three spikelet bases of this type were identified based on their circularity in cross-section and strong striations on the outer glume surface. A total of 11 *Aegilops* species are listed in the *Flora Palaestina* (Vol. 4: 168), of which nine were available as modern reference material to compare to archaeological specimens. Based on the presence of strong striations and the shape of the glumes, the spikelet bases at Sharara best match those of *A. speltoides.* However, as other species could not be definitively excluded this identification has been left as 'cf.'.

4.3 *Aegilops* sp. spikelet base

Identification: A single spikelet base was identified as *Aegilops* based on the circularity of the glume bases in cross-section. However, due to poor preservation identification to species was not attempted.

4.4 *Hordeum glaucum* (wall barley), Plate 4c

Identification: Caryopses of *Hordeum glaucum* were identified by their narrowly elliptic shape, blunt/rounded apex, dorsal compression, short embryo, the presence of a ventral groove (less visible on puffed-up specimens) and long linear hilum. Six species of wild barley are listed in the *Flora Palaestina* (Vol. 4: 179). Based on size criteria, *H. spontaneum* and *H. bulbosum* were excluded as possible identifications, while *H. secalinum* was excluded based on its narrow geographical distribution in the Near East (Nesbitt 2006, p. 86) and that fact that specimens of these species possess a slightly more pointed apical end than the archaeological specimens. The remaining three species listed in the *Flora Palaestina* are *H. glaucum* (syn. *H. murinum* subsp. *glaucum* (Steud.) Tzvelev), *H. marinum* and *H. hysterix.* The archaeological specimens corresponded well to modern reference material of *H. glaucum*, although it is recognised that distinguishing between these species is difficult (Nesbitt 2006, p. 87) and if there was any doubt specimens were left as cf. *H. glaucum.*

Measurements: L = 3.07 mm; B = 1.12 mm; T = 0.73 mm

4.5 *Taeniatherum crinitum* (medusa-head grass) spikelet base, Plate 4d

Identification: A single specimen of the characteristic spikelet base of this monotypic species (syn. *Taeniatherum caput-medusae* (L.) Nevski) was recovered from Sharara and identified by the distinctive appearance of its 'splayed-out' keels.

4.6 *Bromus* sp. (brome grass), Plate 4e

Identification: A single fragmented grain was identified as belonging to the genus *Bromus* based on its dorsal compression (T:B = *c.* 34), which gives it an almost papery appearance despite the grain having puffed up slightly during charring. The dorsal side is slightly rounded while the ventral side is concave in cross-section and has a distinctive hairy-like surface pattern with grooves running down both sides. Sixteen species are listed in the *Flora Palaestina* (Vol. 4: 184) and no attempt has been made at this stage to identify this specimen further.

Measurements: L = n/a; B = 0.92 mm; T = 0.32 mm

4.7 *Avena* sp. (oat), Plate 4f

Identification: A single grain has been identified to *Avena* sp. based on its overall shape (oblong to elliptic with rounded apical and basal ends), long linear hilum, ventral groove and V-shaped scutellum. The presence of fine hairs covering the grain is suggested by the surviving surface pattern. *Avena* caryopses closely resemble those of *Arrenatherum* but the former can be distinguished by the presence of the ventral furrow which is present on the archaeological specimen (Nesbitt 2006, p. 69). Six species of *Avena* are listed in the *Flora Palaestina* (Vol. 4: 196), including *A. sterilis* which can be excluded as an identification based on grain size. However, it has not been possible to exclude other species at this stage and the identification has been left at the genus level.

Measurements: L = 2.40 mm; B = 0.63 mm; T = 0.64

4.8 *Poa bulbosa* (bulbous meadow-grass), bulbils, Plate 4g

Identification: Specimens of *Poa bulbosa* were identified by their distinctive bulbils. This species is mainly viviparous and instead of florets containing caryopses, the glumes contain small bulbils surrounded by sheaths (Nesbitt 2006, p. 60).

4.9 *Poa* sp. (meadow-grass), Plate 4h

Identification: Two grains of this small-seeded grass were identified as *Poa* sp. based on their short embryo (19%), sub-basal hilum and lack of grain compression. They most closely resemble *Poa* caryopses when compared to modern reference material and match criteria for this genus as described by Nesbitt (2006, p. 60). Seven species of *Poa* are listed in the *Flora Palaestina* (Vol. 4: 244) and further identification has not been undertaken at this stage.

Measurements: L = 1.33 mm; B = 0.45 mm; T = 0.48 mm

4.10 Piptatherum holicforme/blancheanum (ricegrass), Plate 4j

Identification: Piptatherum caryopses are dorsally compressed with a long linear hilum and distinctive epidermal cell pattern (Nesbitt 2006, pp. 51–52). The apical ends range from pointed to blunt in outline, with more pointed specimens often indicating that the grains have been charred in their palea and lemma (Whitlam 2015, p. 314; Whitlam et al. 2018). The caryopses consistently taper towards the apex with their widest point approximately in the middle. Three species are listed in the *Flora Palaestina* (Vol. 4: 266): *P. miliaceum, P. blancheanum* and *P. holciforme. Piptatherum miliaceum* falls under the section Miliaceae (Nesbitt 2006, p. 52) and can be excluded as an identification with species in this group having much smaller caryopses that are nearly circular in cross-section.

Measurements: L = n/a; B = 1.18 mm; T = 1.08 mm

4.11 Stipa capensis (Mediterranean steppegrass), Plate 4k

Identification: Grains were identified to the genus *Stipa* based on their cylindrical shape and their embryo end, which in lateral view forms a distinctive 'chisel' shape (Colledge 2001, p. 226). The caryopses also possess a long hilum that is somewhat indistinct. In terms of size, they correspond well to the small *Stipa* grouping defined by Nesbitt (Nesbitt 2006, p. 52). Three caryopses have been further identified as *S. capensis* based on lateral compression towards the apex, which is a distinctive feature of this species (Nesbitt 2006, p. 52)

Measurements: L = 2.87 mm; B = 0.63 mm; T = 0.72 mm

4.12 *Stipa* sp. (feathergrass)

4.12.1 Grain

Identification: Specimens were identified to the genus *Stipa* based on the criteria described above, however identification to species was not attempted due to fragmentation. There are six species of *Stipa* listed in the *Flora Palaestina* (Vol. 4: 262) and we cannot exclude the possibility that these specimens may represent a species other than *S. capensis.*

4.12.2 Awn, Plate 4i

Identification: The highly distinctive awn of *Stipa* was also recovered at Sharara. This spiralled awn was distinguished from that of *Avena* based on the protruding edges of its spiral, which differed from *Avena* awns that twist to form a smooth, parallel-sided cylinder. Fragments of *Stipa* awn correspond well with *S. capensis* awn in the modern reference collection, but it has not been possible to rule out other identifications at this stage.

4.13 Medium-seeded Poaceae (grasses) indeterminate

Identification: Grass caryopses that were not able to be identified to genus were classified as medium-seeded grass indeterminate with the size of fragments excluding larger-seeded crop progenitors and smaller-seeded grasses such as *Poa, Crypsis, Sporobolus* etc. (see Weide et al. 2018; Whitlam et al. 2018). These specimens were typically highly fragmented.

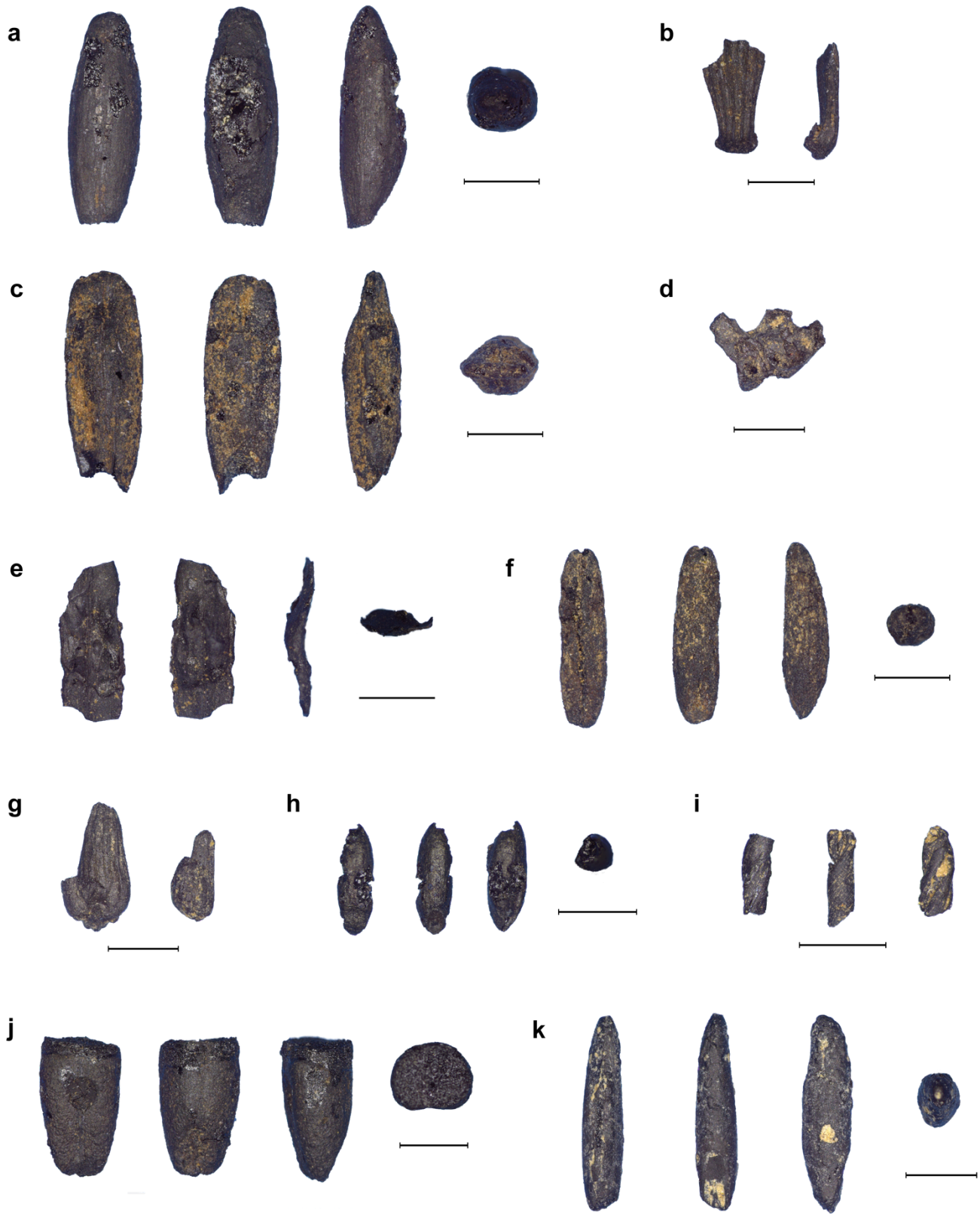

Plate 4. a cf. *Eremopyrum* sp. from left to right in ventral, dorsal, lateral and polar views. **b** *Aegilops* cf. *speltoides* spikelet base. **c** *Hordeum glaucum* from left to right in ventral, dorsal, lateral and polar views. **d** *Taeniatherum crinitum* spikelet base. **e** *Bromus* sp. from left to right in ventral, dorsal, lateral and polar views. **f** *Avena* sp. from left to right in ventral, dorsal, lateral and polar views. **g** *Poa bulbosa* bulbils. **h** *Poa* sp. from left to right in ventral, dorsal, lateral and polar views. **i** *Stipa* awn. **j** *Piptatherum holciforme/blancheanum* from left to right in ventral, dorsal, lateral and cross-section views. **k** *Stipa capensis* from left to right in ventral, dorsal, lateral and polar views. All scale bars 1 mm.

5 WILD/WEED

For wild (non-grass) taxa, plant remains were quantified using unique features, normally embryos or attachment points. For *Erodium* beak, all fragments were recorded and an MNI calculated based on visual inspection in comparison to whole individuals from the modern reference collection.

5.1 *Capparis* sp., Plate 5a

Identification: Capparis sp. seeds are obovate in outline and in side-view specimens taper slightly from the top to the base. The curved radicle is a prominent feature of this genus (van Zeist and Bakker-Heeres 1982, p. 213). Four species listed in the *Flora Palaestina* (Vol. 1: 241) but no further identification has been attempted at this stage.

Measurements: 2.17 mm x 2.12 mm x 1.35 mm

5.2 Brassica/sinapis sp., Plate 5b

Identification: Two seeds of *Brassica/Sinapis* were identified based on their spherical shape and the presence of a distinctive radicle travelling round their middle. These are reported as *Brassica/Sinapis* here in agreement with their nomenclature at other Neolithic sites in Southwest Asia e.g. Jerf el Ahmar (Willcox and Stordeur 2012).

Measurements: 1.11 mm x 1.00 mm x 1.09 mm

5.3 Brassicaceae sp., Plate 5c

Identification: Seeds of this type are oblong in outline and have a long radicle running down the length of one edge, which is approximately 1/3 the breadth of the seed in lateral view and the surface appears very faintly stippled. All but one of the seed of this type are laterally compressed and have been identified as Brassicaceae sp. ‘flat-type’.

Measurements: 0.98 mm x 0.83 mm x 0.63 mm

5.4 *Erodium* sp. (storksbill)

5.4.1 Seed, Plate 5d

Identification: Two seeds of this type were identified based on their obovate to elliptic shaped that narrows towards the base where there is a radicular lobe that runs approximately 3/4- 5/6 the length of the cotyledonary lobe. There are 18 species of *Erodium* listed in the *Flora Palaestina* (Vol. 2: 231) and while it may be possible to identify these specimens further to a species, or group of species, given the times constraints of this study and the number of specimens recovered this was not attempted.

Measurements: 2.01 mm x 0.62 mm x 0.72 mm

5.4.2 Beak, Plate 5e

Identification: Fragments of the spiral beak-like column that is attached to *Erodium* fruits were frequent in archaeological samples. These were identified based on their size, loose curve (in comparison to the tight spiralling of *Stipa* awn) and hair-like surface texture.

5.5 Small-seeded legumes, Plate 5f

Identification: The seeds in this group are variable in their size and shape, with the radicle visible as a small nose that runs approximately a 1/3 the length of the overall seed. The taxonomic identification of small-seeded legumes is problematic due to similarities in the morphology and size of seeds between genera. For this reason, small-seeded legumes have not been identified beyond this type and maybe represent several different genera (e.g. *Astragalus, Trifollium, Melilotus*).

5.6 *Malva* sp. Plate 5g

Identification: These reniform seeds have a deep hilar notch and surfaces that are slightly concave. Seeds are thinnest at the inner (ventral) side. The surface of the seed appears slightly textured and is consistent with specimens from the genus *Malva* sp. The *Flora Palaestina* lists six species of Malva (Vol 2: 315), one of which (*M. neglecta*) is rare and could be excluded as an identification.

Measurements: 1.16 mm x 1.23 mm x 1.11 mm

5.7 Malvaceae sp.

Identification: seeds of this type are consistent morphologically with those in the Malvaceae family, but seed fragmentation and poor preservation prevents further taxonomic identification.

5.8 *Ammi majus* L., Plate 5h

Identification: A single seed of this species was recovered at Sharara and identified as belonging to the Apiaceae family based on its ellipsoid shape and presence of ridges on its dorsal side. On the ventral face there is a deep ventral groove where the seed folds inwards. It has been identified as *Ammi majus* based on its size, shape, the depth of the ventral groove and by comparison to modern reference material.

Measurements: 1.44 mm x 0.61 mm x 0.47 mm

5.9 Solanaceae sp., Plate 5i

Identification: A single specimen of this type was identified by its overall shape, slight prominent radicle and characteristic reticular surface pattern. Due to its preservation and the fact there is only a single specimen, no further taxonomic identification was undertaken.

Measurements: 0.94 mm x 0.90 mm x 0.43 mm

5.10 *Plantago* sp. (plantain), Plate 5j

Identification: Seeds of this genus are elliptical and narrow in cross-section. On their ventral side they are concave and possess an oval hilum and inside-bended margin. Their dorsal side is domed. There are 19 species listed in the *Flora Palaestina* (Vol. 3: 220) and given the times constraints of this study and the poor preservation of many of the archaeological specimens further taxonomic identification was not attempted.

Measurements: 1.62 mm x 1.10 mm x 0.62 mm

5.11 *Centaurea* sp., Plate 5k

Identification: A single seed of this genus was recovered at Sharara. It was similar in appearance to *Centaurea* with a distinctive attachment point and hook-like projection at its base. Eighteen species are listed in the *Flora Palaestina* (Vol. 3: 391) and with only a single seed of this type no further taxonomic identification has been undertaken.

Measurements: 1.05 mm x 1.69 mm x 0.77 mm

5.12 Asteraceae sp. 1, Plate 5l

Identification: Two seeds of this type were identified to the Asteraceae family, based on their bottle-like shape that tapers towards the base and flat, apex. The seeds are very small in size with a distinctive longitudinal cell pattern.

Measurements: 0.78 mm x 0.31 mm x 0.29 mm

5.13 Asteraceae sp. 2, Plate 5m

Identification: A single seed of this type was identified to the Asteraceae family, based on its drop-like shape that tapers towards the base. At its apical end a clear attachment point is persevered along with some exocarp.

Measurements: 0.92 mm x 0.53 mm x 0.53 mm

Potentially identifiable types: Potentially identifiable (PI) types listed below refer to specimens that are morphologically consistent and almost certainly represent the same species, but where no taxonomic identification has been arrived at.

5.14 PI type 1, Plate 5n

Identification: PI type 1 is round and slightly laterally flattened with a groove running down the front and base, which does not appear to continue around the back (possibly as a result of preservation). It may represent a seed core.

Measurements: 0.89 x 0.87 x 0.50 mm

5.15 PI type 2, Plate 5o

Identification: PI type 2 is a rounded fruit with tapering base and attachment point on its apex. It looks to be valved with a central band visible running down the centre one side. It has a reticulate cell pattern.

Measurements: 1.03 mm x 0.84 mm x 0.88 mm

5.16 PI type 3, Plate 5p

Identification: A single specimen of this long trigonous seed which tapers at the base and has an attachment point was recovered from Sharara.

Measurements: 1.61 mm x 0.45 mm x 0.47 mm

5.17 PI type 4, Plate 5q

Identification: This species is bud-like in appearance, with multiple layers, a clear attachment point and a rounded, slightly tapering base. It had a very distinct fibrous texture between layers.

Measurements: 2.07 mm x 1.56 mm x 1.65 mm

5.18 PI type 5, Plate 5r

Identification: One specimen of PI type 5 was recorded at Sharara. It may represent part of a fruit or a pod and was slightly woody in appearance.

Measurements: 0.93 mm x 0.81 mm x 0.70 mm

5.19 PI type 6, Plate 5s

Identification: A single item of this type has been recovered. It bears some similarities to *Amaranthus/Chenopodium* based on its overall shape, size and cell pattern. However, it also appears to be formed from two distinct cotyledons and a taxonomic identification of Amaranthaceae was excluded on closer inspection and following comparison with modern reference material.

Measurements: 1.31 mm x 1.30 mm x 0.51 mm

5.20 PI type 7, Plate 5t

Identification: Two seeds of this type were recovered from Sharara. They are very small in size and have a distinct ridge running around their circumference and two ridges on their dorsal side. They are rounded at the base and seem to have been attached to something at their apical end. Originally identified as an Asteraceae, this taxonomic identification was excluded on closer inspection and after comparison with modern reference material.

Measurements: 0.33 mm x 0.64 mm x 0.28 mm

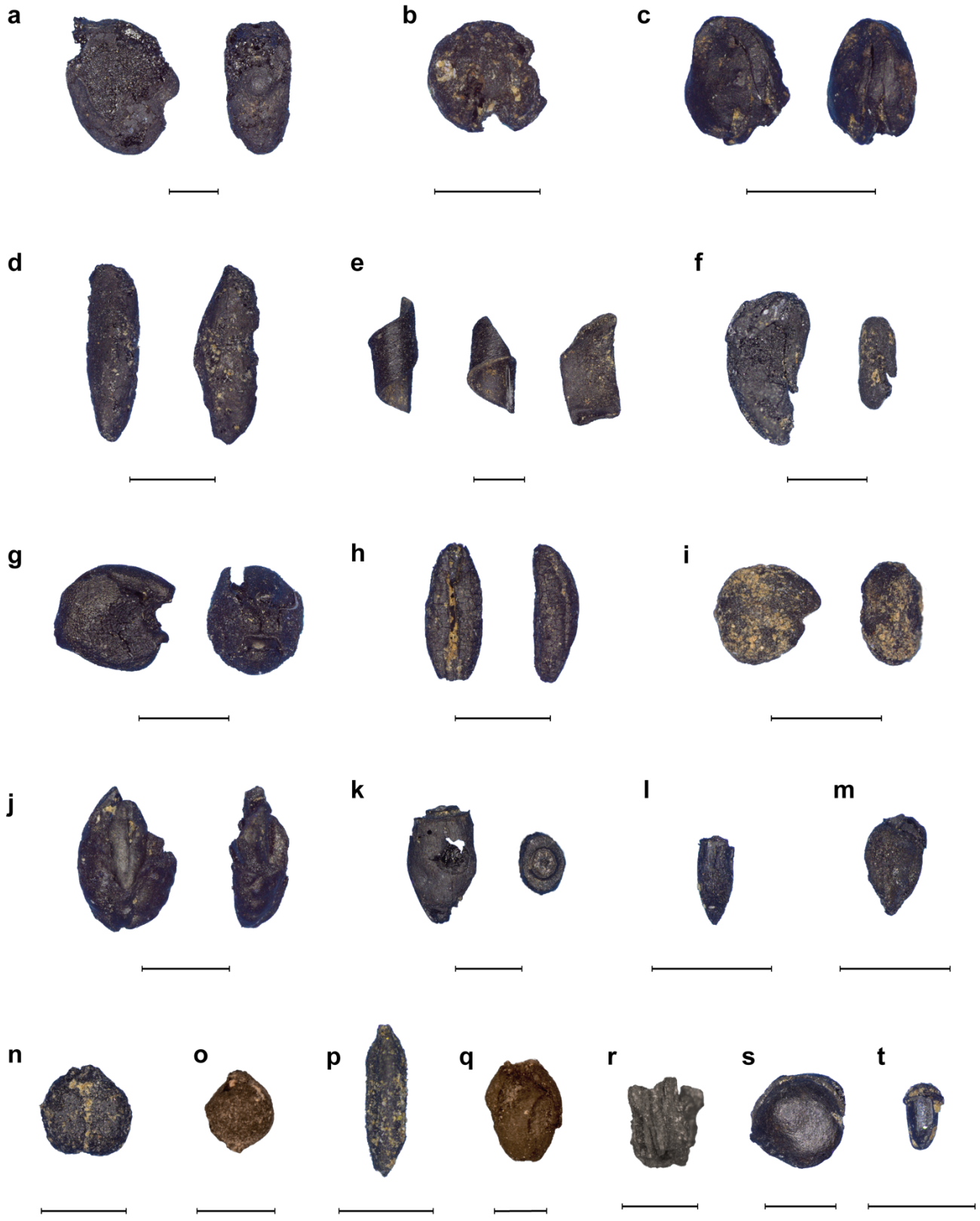

Plate 5. a *Capparis* sp. **b** *Brassica/Sinapis* sp. **c** Brassicaceae sp. (flat). **d** *Erodium* sp. seed. **e** *Erodium* sp. beak fragments. **f** Small-seeded legumes. **g** *Malva* sp. **h** *Ammi majus*. **i** Solanaceae sp. **j** *Plantago* sp. **k**. *Centaurea* sp. **l** Asteraceae sp. 1. **m** Asteraceae sp. 2. **n** PI type 1. **o** PI type 2. **p** PI type 3. **q** PI type 4. **r** PI type 5. **s** PI type 6. **t** PI type 7. All scale bars 1 mm.

6 OTHER

6.1 cf. Phragmites australis (common reed)

Quantification: For reed culm nodes, MNIs were calculated by visual inspection of node fragments. For nodal plates and rootlets\rhizomes all specimens were counted for the MNI. Fragments of reed culm internodes were only found in samples that produced nodes and due to extreme fragmentation were not systematically sorted and quantified.

6.1.1 Culm node, Plate 6a

Identification: Reed culm nodes were identified on the basis of the size for larger fragments (>3 mm), which excluded the possibility of these being Poaceae (meaning cereal or other grass) culm. For smaller fragments of reed culm that overlap with the size range of Poaceae culm (*c.* 1–2 mm) these were distinguished from the latter by (i) the thickness of the node, which is relatively narrow compared to the more robust nodes found in Poaceae, (ii) the lack of tapering towards the node which can be observed in Poaceae culm, (iii) the appearance of the epidermal cells which are relatively small and indistinct in reed culm compared to Poaceae, and (iv) the lack of columnar supportive cells that are found in Poaceae culm (E. Stroud, pers. comm). Both *P. australis* and *Arundo donax* (giant reed) grow in the region today and were considered as possible identifications, with the archaeological specimens being identified as the former based on criteria laid out by Schweingruber (1990, p. 157) for distinguishing between these species. However, it should be noted that distinctive phytoliths of both species have been recovered from the site (Elliott, personal communication) and the possibility that some of the archaeological specimens may derive from *A. donax* cannot be excluded. The identification has, therefore, been made as cf. *P. australis.*

6.1.2 Nodal plates, Plate 6b

Identification: A number of reed culm nodal plates were recovered. These are concave in shape and correspond well with those found in *P. australis*.

6.1.3 Rootlets/rhizomes, Plate 6c

Identification: Fragments of reed culm rootlets/rhizomes were identified by their overall morphology. On specimens where part of the culm base was preserved this was consistent with *P. australis.* Rootlets/rhizomes were only found in samples that produced other parts of reed culm (e.g. nodes and nodal plates), which supports their identification as cf. *P. australis*.

6.2 Culm indeterminate node

Identification: A single culm node was recovered that could not be distinguished as reed culm or Poaceae culm. It has therefore been left as culm node indeterminate.

6.3 Rodent pellets, Plate 6d

Identification: Rodent pellets were identified based on their shape, size (which varied somewhat) and the amorphous appearance of their internal matrix.

Measurements: 1.74 x 1.13 x 1.12 mm

6.4 Boraginaceae sp. 1, Plate 6e

Identification: Nutlets of this type are ovate with a truncated base and pointed at the apex. They possess a relatively small triangular base and distinct ventral keel. Their surface is grooved and densely covered with verrucae. They occur as both uncharred and charred nutlets, the latter distinguished by its grey colour. Due to their silica skeleton the fruits of Boraginaceae can survive uncharred in archaeological deposits. As a result, without systematic radiocarbon dating it is not possible to reliably determine whether these are contemporary with the archaeological deposits in which they're found. For this reason, all specimens of this type have been treated as potentially modern and excluded from archaeobotanical analyses.

Measurements: 1.86 x 1.35 x 1.15 mm

6.5 Boraginaceae sp. 2, Plate 6f

Identification: Nutlets of this type are trigonal to ovate in outline with a truncated base and obtuse apex. They possess a ventral keel and the surface is densely covered in verrucae. They were found only as uncharred nutlets and as with Boraginaceae sp. 1 and have been treated as potentially modern.

Measurements: 2.08 x 1.77 x 1.50 mm

6.6 Aizoon sp., Plate 6g

Identification: These slightly curled seeds have a prominent nose and possess a characteristic surface pattern with concentric ridges on the side faces and rows of papillae on the dorsal surface (van Zeist and Bakker-Heeres 1982, p. 210). Many specimens recovered from Sharara did not appear to be charred, based on their shiny appearance and colour which ranges from black to reddish-brown. This was confirmed by breaking these seeds open. All seeds of this taxon, including charred specimens have therefore been treated as potentially modern and excluded from archaeobotanical analyses. For samples recovered in the 2019 excavation season, *Aizoon* seeds were not systematically removed during sorting.

Measurements: 0.76 x 0.71 x 0.51 mm

6.7 PI type 8, Plate 6h

Identification: Specimens of this type are slightly faceted, with one pointed end and one rounded-flat end. They were often found amalgamated in a matrix and when broken open appear to be relatively homogenous inside. These may not be botanical.

Measurements: 1.86 x 1.35 x 1.15 mm

6.8 Phoenix dactylifera (date stone)

Identification: A single date stone was recovered from Sharara. This was identified based on its similarity to modern reference material and was noted as being only partially charred. This suggests it is modern.

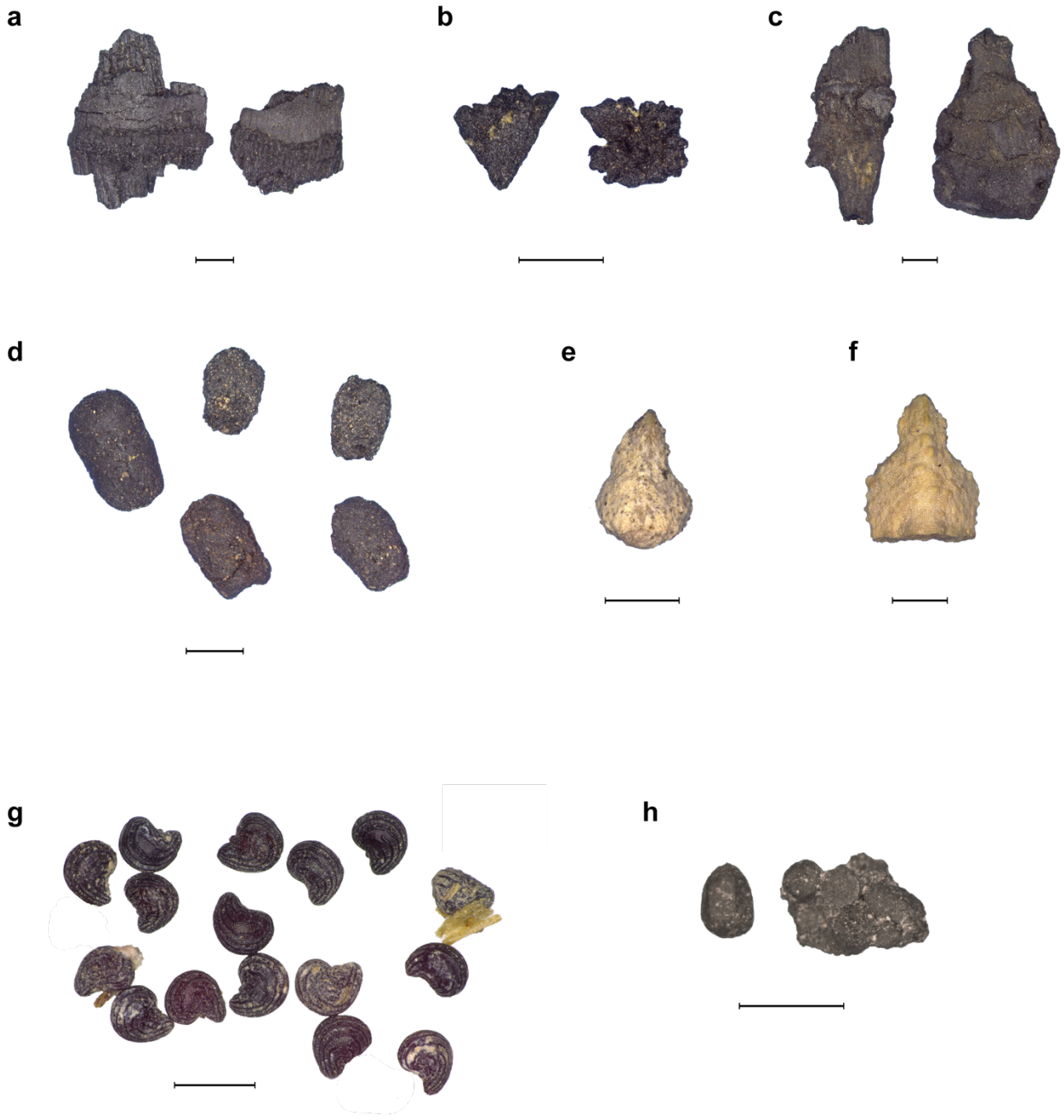

Plate 6. a *Phragmites australis/Arundo donax* (reed) culm nodes. **b** Reed culm nodal plate. **c** Reed culm rootlets/rhizomes. **e** Rodent pellets. **e** Boraginaceae sp. 1. **f** Boraginaceae sp. 2. **g** *Aizoon* sp. **h** PI type 8, from left to right single specimen and specimens in matrix. All scale bars 1 mm.

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