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ORIGINAL ARTICLE

Getting to the root of the problem: new evidence for the use of plant root foods in Mesolithic hunter-gatherer subsistence in Europe

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Abstract

This paper presents new evidence for the harvesting of edible plant roots and tubers at Northton, a Mesolithic hunter-gatherer site on Harris, in the Western Isles of Scotland, in the north-west corner of Europe. The excavations uncovered abundant root tuber remains of *Ficaria verna* Huds. (lesser celandine), an excellent high energy and carbohydrate-rich food source, and produced the first evidence for the use of tubers of *Lathyrus linifolius* (Reichard) Bässler (bitter-vetch) at a hunter-gatherer site in Europe. Here we report on the analysis of the charred root and tuber remains and other charred plant macrofossils from the site and consider the significance of these results within the wider context of European hunter-gatherer subsistence. The wide range of root and tuber taxa recovered from European hunter-gatherer sites and the importance of appropriate sampling on hunter-gatherer sites are highlighted.

Keywords Archaeobotany · Hunter-gatherers · Mesolithic · Archaeological parenchyma · Roots · Tubers

Introduction

This paper presents new evidence for the harvesting of edible plant roots and tubers at Northton, the first Mesolithic site discovered in the Western Isles of Scotland. Traditionally, Mesolithic subsistence studies in Europe have focused on the remains of large mammals and hunting has tended to dominate interpretations (for example, Clark 1954; Jarman 1972). Many authors have challenged this, arguing that plant foods played an important role in hunter-gatherer subsistence in Europe (for example, Clarke 1976; Mason et al. 1994; Zvelebil 1994; Holst 2010; Bishop et al. 2014, 2015), and the potential significance of edible plant roots and tubers in Mesolithic diets has been increasingly recognised (Kubiak-Martens 1999, 2002; Mason et al. 2002; Kubiak-Martens et al. 2015; Klooss et al. 2016; Kubiak-Martens 2016).

Despite this, relatively few European Mesolithic sites have produced substantial quantities of edible plant roots and tubers, and their role in Mesolithic subsistence is difficult to assess. This partially reflects the relatively low rates of deposition of plant material on hunter-gatherer sites compared to farming settlements (Bishop et al. 2014). Plants are seasonal resources and hunter-gatherer sites were often occupied temporarily and so the range and quantity of plants collected, processed and deposited was more restricted than on permanent agricultural sites. However, the low frequency of plant remains, other than hazelnuts, on Mesolithic sites may also reflect low levels of sampling for plant macrofossils, as a consequence of assumptions about the central role of hunting for hunter-gatherers and the poor survivability of charred plant remains on Mesolithic sites (Hather and Mason 2002; Kubiak-Martens 2016).

A further problem is that charred roots and tubers (vegetative underground parenchymatous storage organs), remains of which are often referred to as archaeological parenchyma (undifferentiated tissue, composed of similar thin-walled cells: Hather 2000), are relatively difficult to identify. In the

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following text, the term ‘roots and tubers’ is used to refer to all types of vegetative underground parenchymatous root and stem storage organs, including roots, tubers, rhizomes, bulbs and corms. Under low magnification these remains can easily be confused with wood charcoal, particularly when poorly-preserved (Kubiak-Martens 2016). Roots and tubers also require a scanning electron microscope (SEM) for detailed study and identification, a technique which is relatively expensive and requires specialist skills, so the method has not been widely applied (Mason et al. 1994, pp 54–55; Hather and Mason 2002, p 2; Kubiak-Martens 2016, p 114). Key questions remain, therefore, with regards to the importance of roots and tubers in Mesolithic subsistence in Europe: were they occasional or staple foods? If they were potentially significant hunter-gatherer foods, how can we alter our strategies to increase the recovery of these types of remains from Mesolithic sites?

This paper examines these issues, using new evidence from the Mesolithic site at Northton, Harris, Western Isles of Scotland (Outer Hebrides), as a basis for discussion. The discovery of sealed layers of Mesolithic archaeology at Northton provided an excellent opportunity to further investigate this poorly understood element of European hunter-gatherer subsistence in more detail, through targeted excavation and extensive sampling for plant remains. Here we report on the analysis of the charred root and tuber remains and other charred plant macrofossils from the site, consider the significance of these results within the wider context of European hunter-gatherer subsistence, and suggest methods for increasing the recovery of these remains from Mesolithic sites.

The site at Northton

Site description

Northton (Taobh Tuath) is located on the southern end of the Toe Head peninsula on the island of Harris, Western Isles of Scotland (Outer Hebrides) (Fig. 1). Recent excavations there uncovered evidence for multiple occupation phases during the 8th-7th millennium cal BC, the earlier part of the Scottish Mesolithic (Ashmore 2004). The site is situated just above the present beach, below an area of eroding machair, a calcareous wind-blown shell sand (Fig. 2). Throughout most of the Mesolithic, the sea level in this area was approximately 1.5–4 m lower than today (Jordan et al. 2010), and the machair was a minor aspect of the topography (Ritchie 1979; Gilbertson et al. 1999). Although today the Western Isles are virtually denuded of trees, extensive pollen and wood macrofossil evidence shows that woodlands composed of *Betula* sp. (birch) and *Corylus avellana* L. (hazel) would have covered much of the islands in the Mesolithic, except in the most exposed locations (Bennett et al. 1997; Bishop et al. 2018). Although there are no published pollen diagrams from Harris, land snail samples from the layers immediately above the Mesolithic horizons at Northton were dominated by shade tolerant taxa. This may suggest that the area was wooded in the Mesolithic (Evans 1971, 1979), although there has been some debate over the interpretative value of land snails in Atlantic Scottish archaeological contexts (Church et al. 2006).

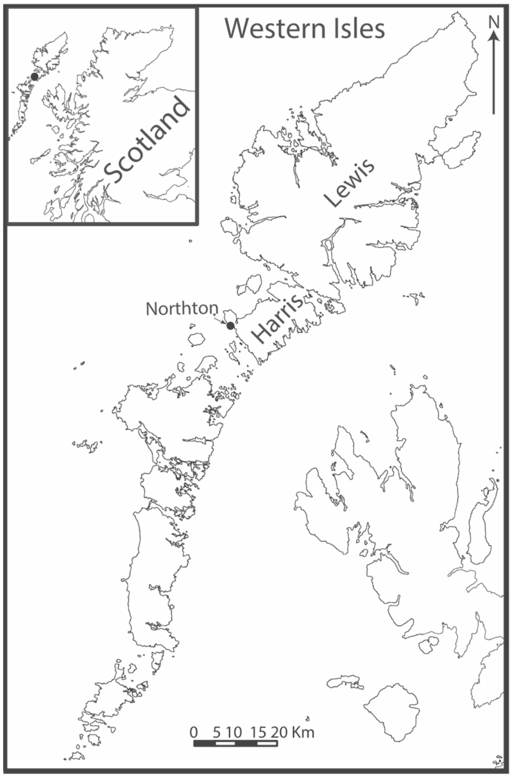

Fig. 1 Location of Northton (Taobh Tuath), Harris, Western Isles of Scotland (Outer Hebrides), United Kingdom (UK)

Fig. 2 The coastline at Northton, Harris and arrow showing the location of the Mesolithic excavation in 2010–2011

Excavations at Northton in the 1960s and 2001

A rescue excavation at Northton in the 1960s uncovered a series of later Neolithic and Bronze Age midden deposits associated with stone-built structures (Simpson 1976). The basal horizon was interpreted as an earlier Neolithic phase because a sherd of Neolithic pottery was recovered. However, subsequent small-scale sampling and radiocarbon dating in 2001 revealed that the basal deposits of the coastal erosion section of the site dated to the Mesolithic (Gregory et al. 2005; Simpson et al. 2006). This was the first archaeological evidence of Mesolithic date discovered in the Western Isles of Scotland and provides key evidence of hunter-gatherer settlement in the most north-western corner of Europe.

Excavations at Northton in 2010–2011

Over the following decade, the site was affected by severe coastal erosion and a decision was made to excavate and sample the eroding deposits more extensively, as part of a wider programme of Mesolithic research in the Western Isles led by researchers from Durham University. Three phases were identified: a lower, middle and upper Mesolithic horizon (Bishop et al. 2011, 2012). The radiocarbon dates and the equivalence of stratigraphic horizons between the different excavation seasons are described in ESM Table S1. The upper horizon, radiocarbon dated to ca. 6416 – 6090 cal BC (Ascough et al. 2017), consisted of two contexts (14 and 3) containing small quantities of redeposited Neolithic material as well as in situ Mesolithic remains. The middle horizon consisted of a single context (9), radiocarbon dated to ca. 6569 – 6088 cal BC (Gregory et al. 2005; Simpson et al. 2006). The lower horizon comprised two contexts (16 and 17), radiocarbon dated to ca. 7050 – 6652 cal BC. The horizons produced a large quantity of Mesolithic flint, quartz and chert lithics, carbonised plant remains, fish bones, marine shells and animal bones to characterise the activities at the site. Zooarchaeological analyses are in progress, but identified mammals include, *Lepus* (hare), *Lutra lutra* (otter) and *Pinguinus impennis* (great auk) (Hamilton-Dyer 2006; Peter Rowley-Conwy pers. comm.). The fish bone assemblage was dominated by Labridae (wrasse family) and Gadidae (cod family) (Blake 2011). No archaeological features were detected, and the site has been interpreted as a series of old ground surfaces incorporating discarded lithics and hearth deposits containing remnants of fuel and food (Bishop et al. 2011, 2012).

Materials and methods

Sampling methods

A 100% sampling strategy was adopted in 2010–2011 and so all the excavated archaeological deposits, except for the natural sand layers, were sampled in their entirety. The aim of this strategy was to maximise the recovery of plant material, as well as artefacts, animal bone and marine resources, as previous research had suggested that plant remains are present in low densities on Mesolithic sites (Bishop et al. 2014). The soil samples were processed using a Siraf-style flotation tank (Kenward et al. 1980), with a 1 mm residue mesh and 0.3 mm flot sieve. It has been noted that large-scale flotation methods can fragment fragile root and tuber remains (Hather 2000, p 74). It was not possible to process all the samples (ca. 890 L of soil) using small-scale manual methods in the field or to transport this volume of soil to the laboratory due to logistical reasons. Consequently, a 10–20 L subsample from each of the undisturbed Mesolithic contexts (9, 16, 17) was floated in a bucket using the wash-over technique (Kenward et al. 1980, p 9), with a 0.3 mm sieve for the flot and a 1 mm sieve for the residue to assess the impact of the machine flotation on archaeological parenchyma recovery.

Sorting and identification methods

The flots were sorted using a Leica M80 stereomicroscope with ×7.5–60 magnification. Only charred plant material was recovered from the samples because conditions on site did not permit the preservation of uncarbonised remains and hence all plant remains discussed here are charred. The residues were dry-sieved and fully sorted down to 2 mm. The dried 1 mm residues were refloated using the wash-over technique (Kenward et al. 1980, p 9) to ensure high recovery rates and to reduce residue sorting time for the very large samples (Wagner 1988, p 21). The 1 mm 'reflots' were sorted and analysed with the flots.

Corylus avellana L. (hazel) nutshell was only fully extracted and counted down to 2 mm because of the prevalence of small fragments in the 1 mm fractions. A riffle box (van der Veen and Fieller 1982) was used to subsample the 1 mm flot and residue from context 9 (12.5% of the flot and 6.25% of the residue) before sorting for nutshell and this was used to estimate the potential quantity of > 1 mm nutshell fragments in the samples. The mass and number of nutshell fragments from each sieve fraction (> 2 mm) was recorded. Due to the abundance of nutshell, the numbers of fragments in the 2 mm flot and residue of sample 21 (the main sample from context 9) were estimated by counting the number of fragments in a sub-sample. The total number of nuts represented was estimated by dividing the mass of the nutshell fragments by the average nutshell mass from one charred hazelnut (0.42 g; Carruthers 2000).

Parenchyma fragments were separated into different types according to the tissues present. The potentially identifiable specimens were then pressure-fractured in order to obtain a fresh (preferably transverse) surface and mounted on SEM stubs using conductive carbon cement (Hather 2000). The fragments were then either coated in mix of platinum and palladium in Leiden, or with gold in Bristol to improve the resolution of the SEM images. The platinum/palladium-coated fragments analysed in Leiden were examined using a Jeol JSM-6480LV SEM and the gold-coated fragments examined at University College Dublin with a Hitachi TM3030 Plus tabletop SEM.

All identifications were made using modern reference material and botanical literature (Beijerinck 1947; Berggren 1969, 1981; Hather 1993, 2000; Anderburg 1994; Cappers et al. 2006). Whole seeds, fragmented seeds, whole roots and tubers and fragmented root and tuber remains were all counted, but they were quantified separately. Nomenclature follows Stace (2019).

Results

The assemblage was dominated by root and tuber remains, hazelnut shell and herbaceous stem fragments (Table 1, ESM Tables S2, S3). Seeds were very sparse in the samples and no remains of edible fruits were recovered. A large assemblage of 1,000 + charcoal fragments was also recovered in the 2010–2011 seasons, for which analysis is still ongoing. Analysis of the small charcoal assemblage recovered in the 2001 sampling was dominated by *Corylus avellana* L. (hazel) and *Salix* sp. (willow) fragments (Church et al. 2006), indicative of scrub woodland, which was present in the low-lying areas of the Western Isles at this time (Bishop et al. 2018).

Ficaria verna (*Ranunculus ficaria* L.) root tubers/bulbils

The parenchyma assemblage was dominated by *Ficaria verna* Huds. (*Ranunculus ficaria* L., lesser celandine) root tubers or bulbils. These remains were found in all phases of the site but were concentrated in the middle Mesolithic phase (ca. 6569 – 6088 cal BC). The remains were identified using low-powered microscopy on the basis of their characteristic club-like shape and/or cell structure and arrangement (Hather 1993, pp 22–23; Mason and Hather 2000, p 417). Representative specimens were examined under a SEM to confirm the identifications (Fig. 3). The parenchyma cells are relatively small (0.125–35 mm) and polygonal in transverse section and are arranged irregularly around the central vascular stele. Several fragments which were unidentifiable using light microscopy were also identified as *F. verna* with the SEM.

Hather (2000, pp 14–15) suggests that it may be possible to distinguish the root tubers from the bulbils. He states that the bulbils are usually smaller (< 5 mm) and more pointed at one end than the root tubers, which are usually > 5 mm, but he acknowledges that the size ranges overlap. Although there were several lesser celandine remains which were > 5 mm in length, most of the complete remains were shorter than 5 mm. Therefore, the subspecies represented is uncertain because ssp. *verna* produces bulbils, but ssp. *fertilis* (Lawalrée ex Laegaard) Stace, does not (Stace 2019). Today, *F. verna* is widespread throughout Harris and Lewis, but only one specimen of the subspecies *verna* has been recorded, although notably this was on the south of Harris (Pankhurst and Mullin 1991).

The archaeobotanical assemblage contained a mix of well- and poorly-preserved whole or nearly complete root tubers/bulbils and fragments. Many of the whole or nearly complete tubers/bulbils had exposed transverse sections, so it was possible to consider the state of the material before charring. Hather (1993, pp 22–23) notes that unlike dried specimens, the internal tissues of charred fresh specimens (250 °C, 2.5–5 h) deteriorate, pushing the stele against the epidermis to leave a hollow interior and the charcoal is glassy and hard. It has also been observed that fresh *F. verna* root tubers can preserve well when charred for relatively short periods (300 °C, 2 h) (Klooss et al. 2016, p 26). These contrasting observations may relate to a difference in the water content of the fresh tubers when charred, as well as the length of the charring process (Bishop 2019). Most of the Northton specimens had well-preserved internal tissues with complete cross-sections preserved and few specimens had completely glassy or vesicular cross-sections. This implies that the root tubers/bulbils were mostly dry before charring or that they were charred while fresh for a relatively short time, and that the fragmentation may have mostly occurred after charring.

Lathyrus linifolius (Reichard) Bässler root tubers

Two whole root tubers and one fragment of *Lathyrus linifolius* (Reichard) Bässler (bitter-vetch) were recovered from context 9 (Middle Mesolithic horizon) and one whole root tuber from context 14 (Upper Mesolithic horizon). Tentative identifications of the whole root tubers were made on the basis of the gross morphology, and these identifications were later confirmed under a SEM. The fragment had not been previously identified as *L. linifolius* under light microscopy.

Table 1 Charred plant macrofossil results from Northton 2010 by phase. * indicates figures calculated using a subsample; † indicates estimated values based on calculation. Sample data in ESM. Numbers in brackets indicate fragments

		Context number	16 + 17	9	3 + 14	
		Phase: horizon	5: Lower	4: Middle	3: Upper	
		Sample volume (l)	182.5	431	276.8	
Identification	Common name	Plant part				Total
Roots/tubers/rhizomes/parenchyma						
Ficaria verna Huds.	Lesser celandine	Root tuber/bulbil, whole/nearly complete (frag.)	17 (17)	110 (62)	5 (8)	132 (87)
cf. *F. verna* Huds.	cf. Lesser celandine	Root tuber/bulbil, whole/nearly complete (frag.)	1 (10)	5 (194)	12 (28)	18 (232)
Lathyrus linifolius (Reichard) Bässler	Bitter-vetch	Root tuber, whole/nearly complete (frag.)		2 (1)	1	3 (1)
Indeterminate		Seed/kernel parenchyma frag.	1			1
Indeterminate		Monocotyledon rhizome/stem base frag.	1			1
Indeterminate		cf. Monocotyledon rhizome/stem base frag.		1		1
Indeterminate		Indet. root/tuber/rhizome parenchyma frag. (>1 mm)	3	241	9	253
Indeterminate		Indet. parenchyma fragments (>1 mm)	8	62	5	75
Stems						
Indeterminate	Herbaceous plant	Stem node 2 mm	2	45		47
Indeterminate	Herbaceous plant	Stem node 1 mm	9	99		108
Indeterminate	Herbaceous plant	Stem base 2 mm	2	16		18
Indeterminate	Herbaceous plant	Stem base 1 mm	6	70		76
Indeterminate	Herbaceous plant	Stem frag. (2 and 1 mm)	21	537		558
Nuts, seeds and fruits						
Bromus sp.	Brome	Caryopsis		3		3
Carex sp. (trigonous)	Trigonous sedge	Nut		6		6
Corylus avellana L.	Hazel	Nutshell frag. 4 mm	36	284	4	324
Corylus avellana L.	Hazel	Nutshell frag. 4 mm mass (g)	1.4	10.7	0.1	12.2
Corylus avellana L.	Hazel	Nutshell frag. 2 mm	1,213	9,065*	523	10,801
Corylus avellana L.	Hazel	Nutshell frag. 2 mm mass (g)	9.9	70.5	4.2	84.6
Corylus avellana L.	Hazel	Total 4mm/2mm nutshell frag.	1249	9349	527	11125
Corylus avellana L.	Hazel	Total 4mm/2mm nutshell mass (g)	11.3	81.1	4.3	96.8
Corylus avellana L.	Hazel	Estimated 1 mm nutshell mass (g)	70.6†	167.1*	107.1†	344.9†
Corylus avellana L.	Hazel	Estimated number of whole nuts (using >1 mm frag.)	195†	591*	265†	1,052†
Corylus avellana L.	Hazel	Estimated number of whole nuts (using >2 mm frag.)	27	193	10	231
Fabaceae	Pea family	Seed (frag.)		3 (11)		3 (11)
Galium aparine L.	Cleavers	Mericarp (frag.)	6 (1)	4 (7)	1	11 (8)
Plantago lanceolata L.	Ribwort plantain	Seed			8	8
Poaceae	Grass family	Caryopsis		1		1
Polygonaceae	Knotweed family	Achene	1			1
Rumex acetosella L.	Sheep's sorrel	Achene	1			1
Rumex sp.	Dock	Achene		2	1	3
Stellaria media (L.) Vill.	Common chickweed	Seed	7	8		15
cf. *Stellaria* sp.	cf. Stitchwort	Seed	2	3		5
Vicia/Lathyrus sp.	Vetch/pea	Seed (frag.)		7 (1)	1	8 (1)
cf. *Vicia/Lathyrus* sp.	cf. Vetch/pea	Seed (frag.)		4	1 (5)	5 (5)
Indeterminate		Seed / fruit	2	13	5	20
Indeterminate		Fruiting capsule		1		1
Cenococcum sp.	Fungal sclerotia	Fungal sclerotia (frag.)	5 (2)	3	(2)	8 (4)

The whole specimens had attachment scars, indicative of the detachment of a fibrous root system (Hather 1993, p 52). The attachment scars and the roughly spherical morphology of the specimens resembled those of modern reference material and although the root tubers were small, they were within the size range of the modern reference material examined (Fig. 4). The archaeological specimens were ca. 3–7 mm long and Hather (1993) notes that they can be up to 15 mm long.

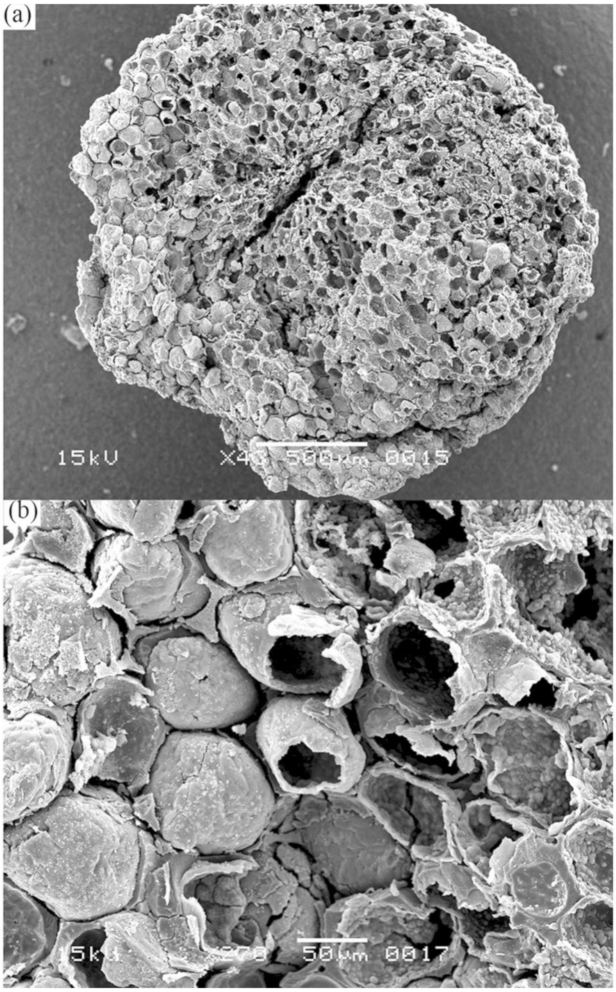

Fig. 3 SEM images of charred parenchymatous tissues of *Ficaria verna* (Huds.) from Northton. **a**, transverse section through a root tuber/bulbil fragment from context 9 (×43); **b**, parenchyma cells within fragment from context 9 (×270)

The archaeological tissues examined under a SEM (Fig. 5) resembled those of reference specimens charred in a fresh state (Fig. 6; Hather 1993, pp 52–53). The central parenchyma tissues had collapsed to form large depressions which were often reduced to solid carbon, and these were pressed against fused xylem vessels which radiated from the centre of the fragment in a star-like arrangement. Within the fused xylem tissue, impressions of xylem vessels were visible (Fig. 5e, h). In some areas, the tracheary elements of the xylem tissue were well-preserved (Fig. 5c, d, g). Impressions of parenchyma cells were also visible in some of the solid depressions (Fig. 5a, b). In contrast, reference specimens charred in a dried state have well-preserved parenchyma tissues with square to rectangular cells 0.04–0.08 mm wide with partially preserved starch grains (Fig. 6 h) and well-preserved vascular tissues (Fig. 6 g, h; Hather 1993, pp 52–53).

Fig. 4 Modern tuber of *Lathyrus linifolius* (Reichard) Bässler collected by the author (RRB) (Photo by Wouter van der Meer); scale bar = 5 mm

Indeterminate rhizome fragments

Two fragments of rhizome parenchyma tissue were identified with the SEM. The first of these fragments was a monocotyledon rhizome or stem base from context 17 (Lower Mesolithic horizon; Fig. 7a, b). The presence of leaf scales on the surface of the fragment (Fig. 7b) and aerenchymous tissue in the cortex area which was surrounded by a thick peridermal layer (Fig. 7a), shows that this rhizome derives from a marsh plant. The inner vascular stele area of the fragment is solid and glassy (due to charring), preventing any further identification. The second rhizome fragment was a probable monocotyledon rhizome or stem base fragment from context 9 (Middle Mesolithic horizon (Fig. 7c, d). Parenchyma cells (Fig. 7c) and vascular tissue are visible in the cortex area (xylem and sclerenchyma tissues) of the specimen (Fig. 7d), but the surviving tissues were not sufficiently well-preserved to allow further identification.

Indeterminate and isolated parenchyma

Over 300 isolated parenchyma fragments lacking vascular tissue were recovered. In most cases, it was possible to determine from the gross morphology of the fragments that these were remains of roots/tubers, but without the vascular tissue, identification to family or genus was not possible. Approximately 70 fragments of isolated parenchyma were also identified, which could not be attributed to a particular tissue type, such as root, tuber, rhizome, fruit or seed.

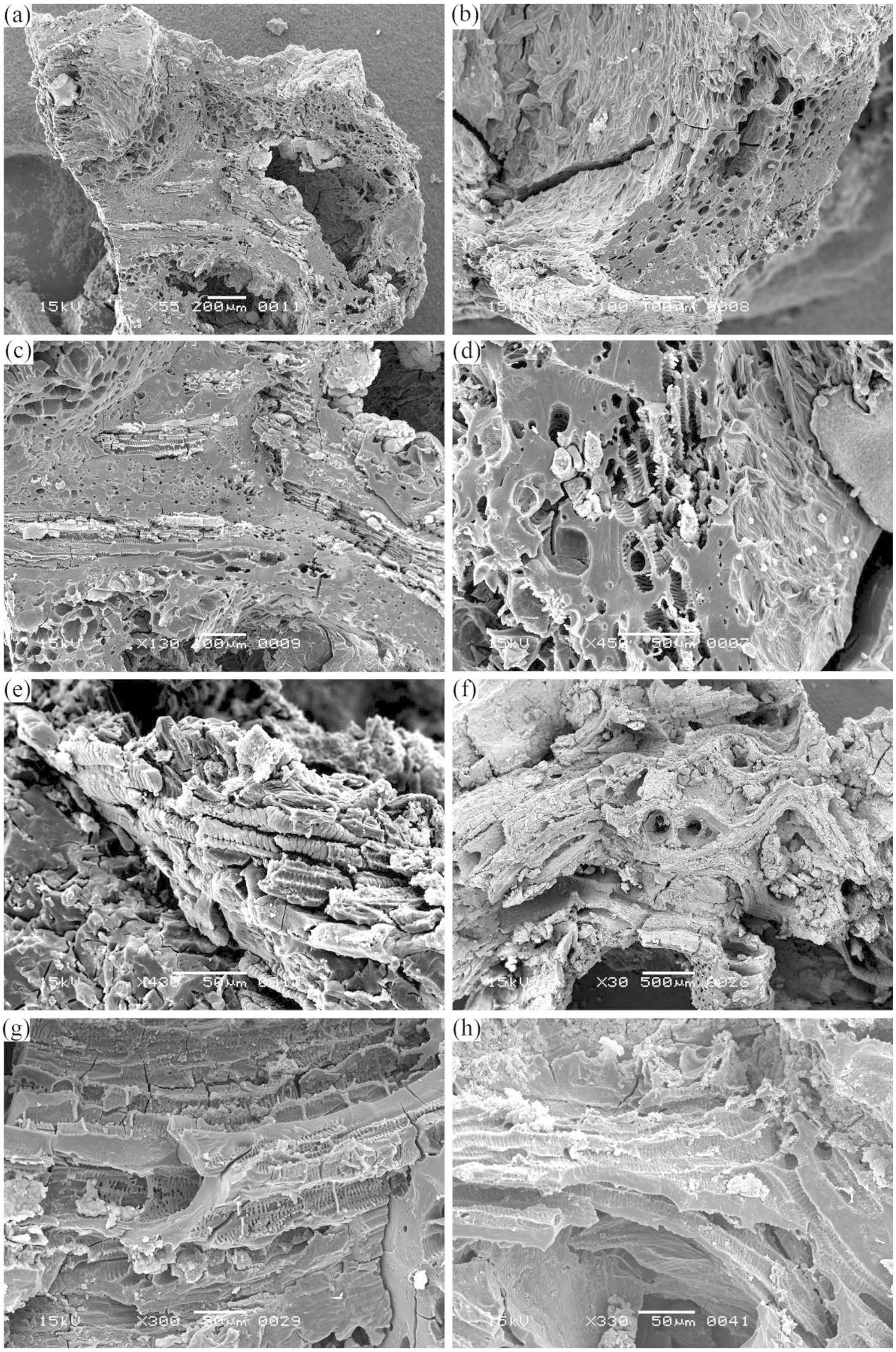

Fig. 5 SEM images of charred *Lathyrus linifolius* (Reichard) Bässler parenchymatous tissues from Northton. **a**, transverse section through tuber from context 14 (×55); **b**, collapsed central area and outer edge of fragment of tuber from context 14 (×100); **c**, fused bands of xylem in tuber from context 14 (×130); **d**, xylem concentration in tuber from context 14 (×450); **e**, impressions of xylem vessels in tuber from context 9 (x430); **f**, fused elements of xylem tissue in tuber from context 9 (×30); **g**, close up of xylem tissue within the fused xylem elements in tuber from context 9 (×300); **h**, impressions of fused elements of xylem in tuber from context 9 (×330)

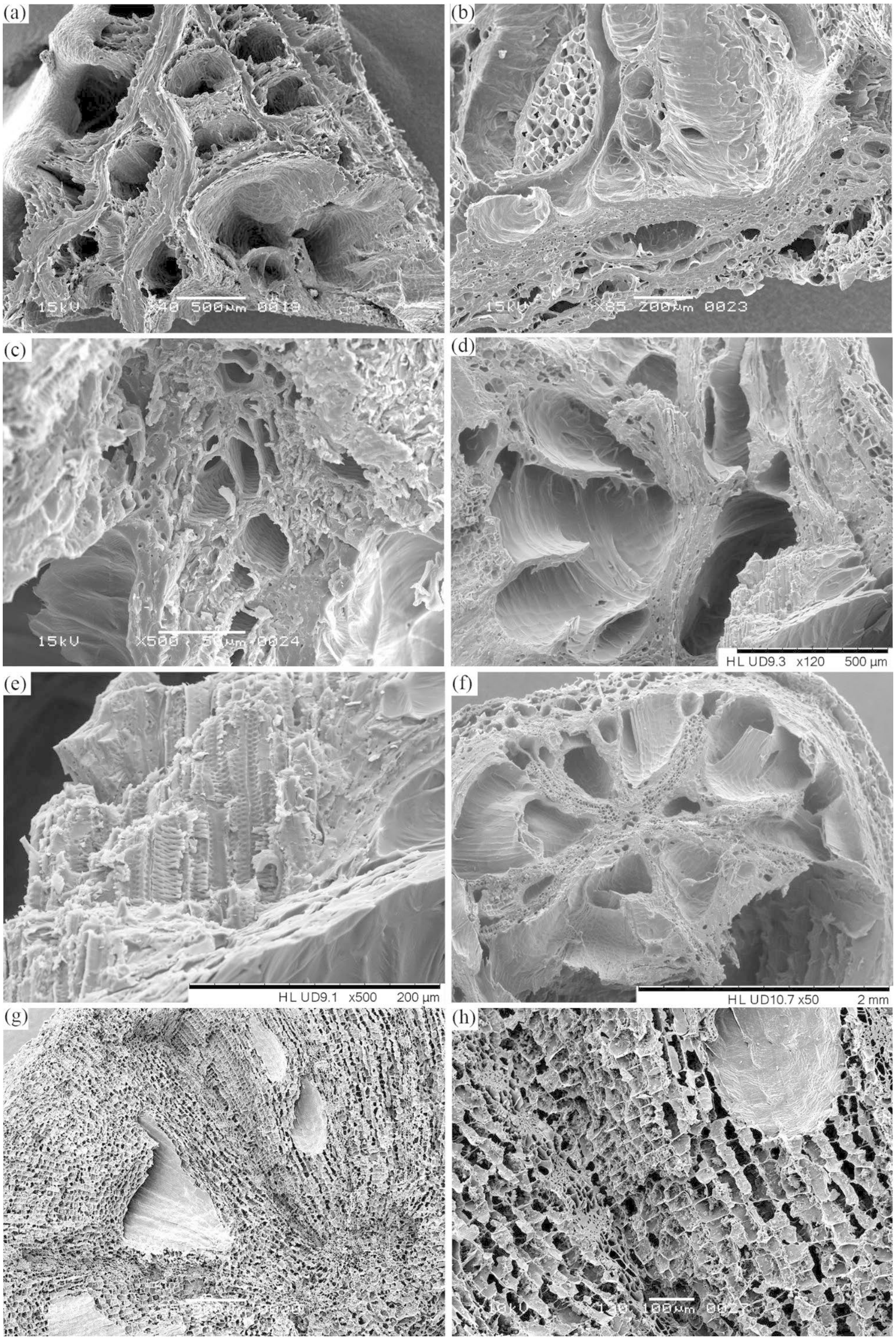

Fig. 6 SEM images of charred modern reference material of *L. linifolius* parenchymatous tissues. **a**, overview of fresh specimen showing fused elements of xylem (×40); **b**, overview of fresh specimen showing fused elements of xylem and depression in central area with cell imprints (×85); **c**, xylem vessel concentration in fresh specimen (×500); **d**, elements of xylem tissue in fresh specimen (×120); **e**, impressions of xylem elements in cavities in fresh specimen (×500); **f**, overview of fresh specimen showing elements of xylem radiating out in a star pattern from centre of fragment (×50); **g**, overview of dried specimen showing well-preserved parenchyma cells (×35); **h**, vascular tissue and parenchyma cells in dried specimen (×130)

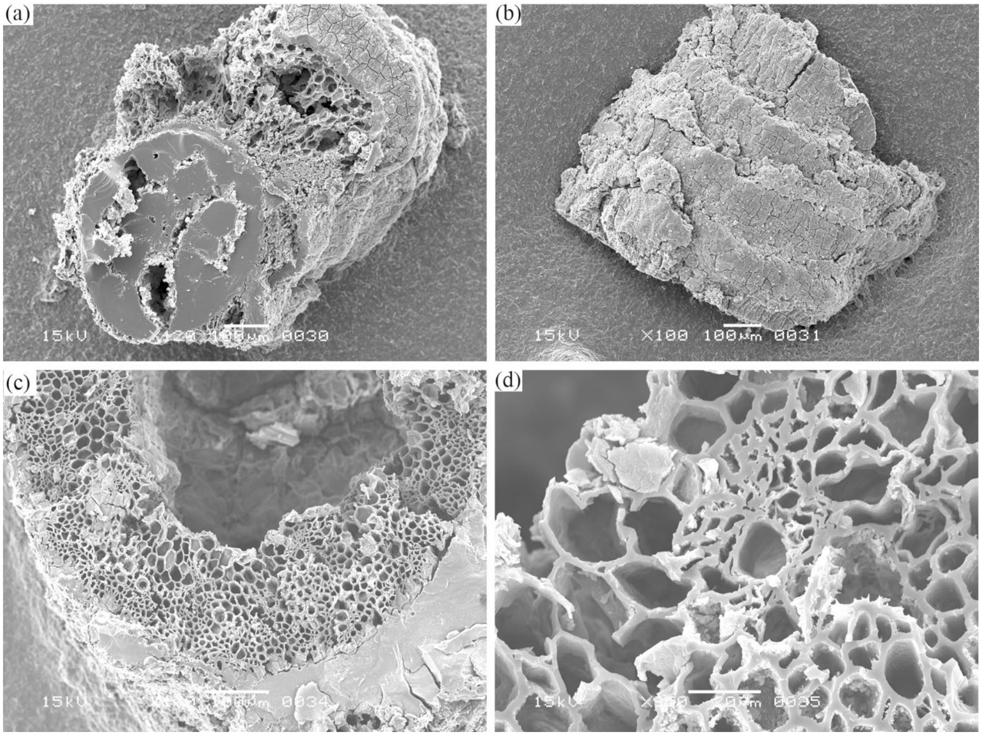

Fig. 7 SEM images of archaeological charred rhizome parenchymatous tissues from Northton. **a**, transverse section through indeterminate rhizome fragment from marsh taxon from context 17 (×120); **b**, leaf-scales on the outside of indeterminate rhizome fragment from marsh taxon from context 17 (×100); **c**, transverse section through possible monocotyledon rhizome/stem base fragment from context 9 (×170); **d**, vascular tissue in cortex of possible monocotyledon rhizome/stem base fragment from context 9 (×950)

Other plant remains examined under a SEM

Herbaceous plant stem nodes, bases and fragments were abundant in the samples. Several specimens were examined under a SEM and the Poaceae family (grasses) was excluded, but the species could not be determined (Fig. 8).

Several of the fragments which had been identified as root or tuber remains using a light microscope were identified as poorly-preserved wood charcoal with the SEM. Three fragments from context 9 and one fragment from context 17 were identified as cf. *Vaccinium* sp. (cf. bilberry genus) charcoal. These fragments could derive from one of the following native taxa, *V. myrtillus* L. (bilberry), *V. vitis-idaea* L. (cowberry) or *V. uliginosum* L. (bog bilberry) (Stace 2019). A further fragment from Context 9 was identified as *Salix* sp. (willow) charcoal.

Corylus avellana L. nutshell

The *Corylus avellana* L. (hazel) nutshell quantification results are shown in Table 1 and ESM Table S3. The assemblage contained over 11,000 fragments of nutshell, incorporating a mix of moderately well- and poorly-preserved fragments of preservation grades P2-P4 (Bishop 2019), in which most fragments retained at least some epidermal surface covering but none had intact epidermal surfaces. The nutshell was highly fragmented and no complete or half shells were recovered. Of the fragments in the assemblage, 99.7% represented < 12.5% of a whole nut and only 4.3% of the fragments were recovered from the > 4 mm fraction. There was no significant difference in the fragmentation of nutshell between the different phases of the site. It is estimated that the remains from the middle Mesolithic phase represented approximately 600 whole nuts, whereas the nutshell from the early Mesolithic and later Mesolithic phases represented approximately 200–300 whole nuts (Table 1).

Seeds

Only a small number of seeds were recovered, despite the large volume of soil processed (Table 1). A small concentration of Fabaceae seeds, including *Vicia/Lathyrus* sp. (vetch or pea), was recovered from the middle Mesolithic horizon. Seeds from *Stellaria* sp. (stitchwort), particularly *S. media* (L.) Vill. (common chickweed) and *Galium aparine* L. (cleavers) were occasionally present in the lower and middle phases. Eight *Plantago lanceolata* L. (ribwort plantain) seeds and one of *G. aparine* was recovered from the upper Mesolithic phase. All other taxa were extremely sparse and comprised: *Bromus* sp. (brome), *Carex* sp. (sedge), *Rumex*

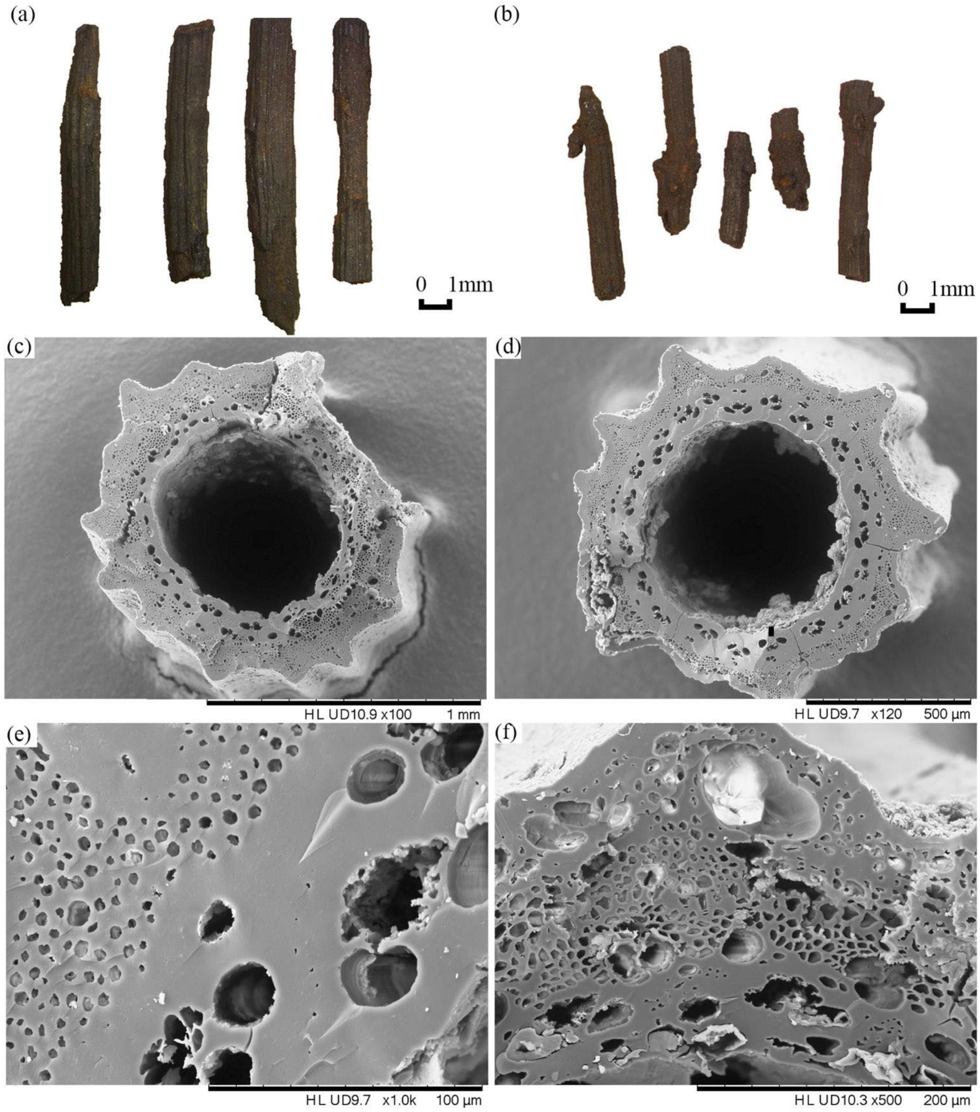

Fig. 8 Charred herbaceous stems from Northton context 9. **a**, light microscope photo of stem fragments; **b**, light microscope photo of stem node and base fragments; **c**, **d**, SEM image showing transverse section through stem fragment, **c**, ×100; **d**, ×120; **e**, **f**, SEM images showing glassy/solid tissues in stem fragments, **e**, ×1000; **f**, ×500

acetosella L./*Rumex* sp. (sheep's sorrel/dock) and Polygonaceae (knotweed family).

Efficiency of the recovery method

There was no obvious difference in the level of recovery of the root and tuber remains from the samples processed using the flotation tank and from the wash-over technique. The quantity recovered reflected the volume of soil processed rather than the processing method (ESM Table S2). Though some fresh modern breakages were noted on the nutshell, no difference was noted in the level of fragmentation between the samples processed using either technique (ESM Table S3).

Mesolithic plant use at Northton

Gathering

The large-scale sampling at Northton produced a sizeable assemblage of archaeobotanical remains, providing evidence for the gathering of a range of plant foods. Both identified root tubers, *Lathyrus linifolius* and *Ficaria verna* are edible, the latter only when cooked or dried, and they were eaten historically in Scotland (Darwin 1996; Irving 2009). In the highlands and Hebrides, *L. linifolius* root tubers were often eaten fresh without cooking. They were also often boiled or dried in bundles hung under the roof and then roasted or used as a flavouring due to their sweet, liquorice-like taste (Darwin 1996, p 113). *Ficaria verna* was collected as a famine food and can be cooked by boiling or roasting (Darwin 1996; Irving 2009). Both taxa could have been readily collected from habitats close to the site, as they grow in woodland and *F. verna* is also found in damp meadows and beside streams (Stace 2019).

It is uncertain if the indeterminate parenchyma fragments represent remnants of deliberately collected foods, but secondary root tubers are rich in carbohydrates and many are edible (Mason and Hather 2000, p 424; Bishop 2021). These remains hint that a wider diversity of plant roots and tubers was collected. The mixture of dry land (*F. verna*, *L. linifolius*) and wetland parenchyma (marshland rhizome) in the samples and the association of the parenchyma remains with a range of other foodstuffs (hazelnuts, fish, mammals and birds) also supports deliberate collection rather than the accidental charring of these plant parts, for example if they were growing in places used for hearths or were brought to the site with turf for other purposes (Klooss et al. 2016, pp 36–37).

A range of other edible plants was present in the assemblage. This included hazelnuts (Howes 1948, p 179), the seeds of *Vicia/Lathyrus* sp. (Mears and Hillman 2007, pp 177–185; Irving 2009, p 231) and *Bromus* sp. (Stoličná 2000, p 19). The *Rumex* sp. and *Carex* sp. nutlets might also represent collected foods because the seeds, roots, leaves and stems of many docks and sedges have ethnographic evidence for their consumption (Moerman 1998; Tardío et al. 2006). *Galium aparine* leaves and stems can also be eaten (Burrows 2005, p 50). The presence of *L. linifolius* root tubers and *Vicia/Lathyrus* sp. seeds in context 9 may suggest that whole *L. linifolius* plants were harvested for food.

Having said this, the seeds were very infrequent in the samples, so it is possible that many were deposited by natural processes. For instance, *Rumex* sp., *G. aparine* and *Bromus* sp. are indicators of waste ground (Clapham et al. 1987), which could have been created by human activities on the site itself. Therefore, they may have been deposited on site by the wind, animals or accidentally transported attached to human hair or clothing.

In contrast, the quantity of *F. verna* remains (115 whole specimens and 256 fragments) and hazel nutshell (representing ca. 600 whole nuts) recovered from the middle Mesolithic horizon is consistent with the intentional gathering and processing of nuts and root tubers in a systematic and intensive manner. This seems to have been more than ‘opportunistic and incidental use of plant food’ as defined by Zvelebil (1994, p 37), especially bearing in mind that the aim would have been to cook rather than char the root tubers and nuts. In terms of the scale of gathering, the quantity of nuts collected appears to have been of a lesser scale than at the site of Staosnaig, on the island of Colonsay, Inner Hebrides, where the large-scale use of hazelnuts has been identified. Here, the remains of an estimated 30–40,000 whole nuts were recovered (Carruthers 2000). The similar quantities of root remains recovered at Northton (Table 1) and Staosnaig, where 70 whole *F. verna* specimens and 344 fragments, eight aquatic aerenchyma fragments, nine tap root fragments, ca. 20 vesicular parenchyma fragments and 12 other parenchyma fragments were identified (Mason and Hather 2000), may suggest a similar scale of root harvesting at both sites. It is important to note, however, that the deposit at Northton may represent several different occupation events, perhaps spanning multiple seasons, years, decades or even centuries. Consequently, the remains may represent repeated, small-scale gathering of roots, tubers and hazelnuts. Nevertheless, the quantity of hazel nutshell and *F. verna* remains recovered suggests that these were key foodstuffs at the site, and the variety of taxa recovered suggest that a range of ecological zones were used, including woodlands, grasslands and wetlands.

Seasonality of gathering

Although roots and tubers can be collected all year round, they are best harvested after flowering and before the new shoots emerge, when the roots and tubers are biggest and have the highest carbohydrate content (Cameron 1977, p 56; Mears and Hillman 2007, pp 106–107). *Lathyrus linifolius* flowers from April to July and *F. verna* in March and April (Clapham et al. 1987). The bulbils of *F. verna* ssp. *bulbilifer* develop during spring after flowering (Clapham et al. 1987, p 50) and could have been collected in May or June. Most of the seeds of *Vicia/Lathyrus* sp., *Galium aparine*, *Bromus* sp., *Carex* sp. and *Rumex* sp. are available during the summer, with some also available in the autumn (Mears and Hillman 2007; Irving 2009). Hazelnuts can only be gathered in September or October (Hill 1941, p 41). Overall, the plant remains appear to have been deposited on site during the summer and autumn, though the seasonality of deposition of the plant remains cannot be established with absolute certainty, because all the edible seeds, roots, tubers and hazelnuts could have been dried for storage and deposited at any time of the year (Dark 2004). Interestingly though, the fish bone data from context 9 supports a summer and/or autumn occupation because the assemblage was dominated by young fish of the cod family which migrate inshore in the summer and autumn (Blake 2011). Therefore, the combined plant macrofossil and fish bone evidence suggests that the site was used in the summer and autumn at least, if not at other times of the year.

Cooking

The abundance of well-preserved herbaceous stem fragments, nodes and bases in the samples provides important evidence for understanding the preservation mechanisms for the archaeobotanical remains. It is unusual for such a large quantity of herbaceous stem fragments to be preserved on a Mesolithic site because this fragile material would be quickly destroyed once in contact with fire. Experiments suggest that plant macrofossils charred in reducing conditions and at lower temperatures are generally better preserved than in oxidising conditions and/or higher temperatures (Boardman and Jones 1990, p 8; Bishop 2019). This implies that the stems were preserved in reducing conditions, probably at a relatively low temperature.

Considering that many of the *F. verna* remains and much of the nutshell from Northton were well-preserved, it also seems likely that some of the plant foods were charred in reducing conditions rather than directly within a fire. One possibility is that the well-preserved herbaceous stems may be the remnants of vegetation from a steaming pit or smoking shelter, which would have allowed the vegetation to be charred without direct contact with fire. Ethnographic literature from the west coast of North America describes the steaming or roasting of edible roots and tubers over heated rocks in pits sealed with layers of vegetation and earth (Turner and Kuhnlein 1982, pp 424–426; Pokotylo and Froese 1983, pp 130–131) and meat and fish may be smoked under wooden racks covered with vegetation (Mears 1992, p 127). The frequent presence of fire-cracked rocks (Bishop et al. 2011) and burnt fish bones (Blake 2011) in the middle Mesolithic horizon supports the idea that steaming or roasting was taking place.

In fact, a cooking or drying accident seems the most likely explanation for the abundance of *F. verna* root tubers/bulbils in the samples. It is necessary to cook or dry *F. verna* before eating it to remove protoanemonin, a poisonous substance found throughout the plant (Frohne and Pfänder 1984, p 309; Mason and Hather 2000, p 422). As Turner and Kuhnlein (1982, p 426) note, “The cooking techniques, especially the pit-cooking, required a great deal of skill and expertise. From the authors’ own experience, the type of soil, the number of rocks used, the amount of water added, and the placement of the food in the pit are all crucial in determining whether the cooking will be successful. Too many rocks and too little water can result in a burned or over-cooked product, whereas too few rocks and too much water will not cook the food adequately”.

As well as steaming/pit roasting, roots and tubers can also be roasted over fire heated stones covered with vegetation on the soil surface without the use of a pit, roasted in the ashes of the fire or using hot charcoal mixed with sand (Yellen 1977, p 143; Turner and Kuhnlein 1982, p 426; Kuhnlein and Turner 1991, p 17) and so the absence of a pit does not exclude these types of cooking methods. The mixed state of preservation of the *F. verna* root tubers/bulbils can be explained by the variable rates of water loss from different specimens during cooking or drying, according to the closeness of the material to the fire or the differential heat within the hot ashes and sand (Mithen 2000, p 438).

Another possibility is that the herbaceous stem remains represent deliberately collected material for flooring, bedding or raw materials for basketry production or fibre string (Hardy 2016, pp 80–81) which was later burnt. However, with the absence of evidence of any definite structures on site and the fact that baskets or string would probably not have been burnt intentionally, charring of the herbaceous plants during some form of cooking as discussed above seems the more likely of these possibilities.

There are other finds of herbaceous remains from Mesolithic sites in Europe which support their association with the pit or hearth cooking method. In one of the Late Mesolithic hearth-pits recently excavated at Voorthuizen, in the Netherlands, numerous charred stem fragments of a herbaceous plant were found together with parenchyma remains derived from stem bases and rhizomes of *Carex* sp. (sedge). Parenchyma remains were interpreted as possible root food remains whilst herbaceous stems would have been used as raw material in construction of this pit or hearth cooking structure, possibly to line the bottom of the pit or as wrapping material used to cover food during cooking (Kubiak-Martens and Kooistra 2020).

Roots and tubers: staple foods in Mesolithic Europe?

Traditionally, plant foods were considered to have had a minor role in hunter-gatherer subsistence in Mesolithic Europe (Clark 1954, pp 15–16). In recent years, however, it has been proposed that hazelnuts were intensively used and possibly managed to increase nut harvests (Regnell 2012; Bishop et al. 2014; Warren et al. 2014), with some proposing that ‘hazelnut economies’ existed in Mesolithic Europe (Holst 2010). The key question here is, where should roots and tubers fit in models of Mesolithic subsistence? Were they staple foods?

There is now increasing evidence that root foods were key resources for hunter-gatherers in Europe and the new evidence from Northton adds to this growing body of evidence, providing the first evidence from Europe for the use of *Lathyrus linifolius* root tubers by hunter-gatherers and one of the largest Mesolithic concentrations of *Ficaria verna* root tubers from the area (150 whole specimens and

319 fragments). Remains of archaeological parenchyma have been recovered and identified from at least 28 hunter-gatherer sites across Europe, suggesting that root foods, including true roots, tubers, rhizomes and bulbs of various plants would have contributed significantly to the Mesolithic diet (Table 2). The most frequently encountered species is *F. verna*, with finds of the root tuber remains recovered from 11 hunter-gatherer sites. The only other large concentration with > 50 specimens of Mesolithic *F. verna* root tuber remains (Klooss et al. 2016) was recovered from Staosnaig, also in Western Scotland, with 70 whole specimens and 344 fragments (Mason and Hather 2000). At least 16 different edible root and tuber taxa have been identified from Mesolithic sites across Europe, hinting at the wide range of plant roots and tubers used (Table 2). Most likely, far more were gathered, as there are over 90 native plants with edible roots and tubers in Europe (Mears and Hillman 2007, p 105) and ethnographic evidence shows that hunter-gatherers regularly consume a wide diversity of roots and tubers (Kuhnlein and Turner 1991; Moerman 1998).

Clearly, though, even with systematic sampling, finds of Mesolithic root and tuber remains are far less frequent than hazel nutshell (Table 1; Bishop et al. 2014). Preservation and depositional factors are important here: hazelnut shell is extremely robust (Bishop 2019), whereas roots and tubers are relatively moisture-rich and fragile and are likely to be under-represented in the archaeological record (Kubiak-Martens 2016, p 117). Root and tuber remains would also only be charred accidentally because this is the part consumed, whereas nutshell is the waste material and would have been deliberately discarded, often onto fires (Mithen 2000, p 437). Indeed, hazel kernels are recovered extremely rarely in the archaeological record. Since they are the edible component they would have been rarely deposited, and they also survive charring poorly compared to nutshell (Bishop 2019). The processing method is also relevant here, as ethnographic evidence suggests that roots and tubers were often pounded or ground into flour before cooking, which would reduce the chances of intact specimens being preserved (Vanhanen and Pesonen 2016, p 50). Therefore, we should not expect to recover root and tuber remains in the same quantity as hazel nutshell. Indeed, despite the comparatively small amounts of root and tuber remains recovered, it has been proposed that root foods may have been just as significant as hazelnuts for hunter-gatherer subsistence at Staosnaig, considering the biases in preservation and that these remains were recovered from almost the same number of samples as hazelnut shell (Mason 2004, p 135). Here, nutshell estimated to be from ca. 30–40,000 whole hazelnuts was recovered, compared to just ca. 414 *F. verna* specimens (Mason and Hather 2000). At Northton, parenchyma remains and hazelnut shell were recovered from all contexts sampled, highlighting the significance of the more fragile root and tuber remains. Arguably, therefore, the wide range of root food taxa recovered from Mesolithic sites and the number of samples containing their remains from well-sampled sites suggests the regular harvesting of roots and tubers for food.

Recent experimental research also emphases the potential calorific and nutritional significance of wild roots and tubers (Bishop 2021). Carbohydrates perform a critical role in the human diet and European roots and tubers are extremely rich sources of carbohydrates (Butterworth et al. 2016; Bishop 2021). They would have been amongst the most easily accessible carbohydrate-rich resources available to European hunter-gatherers as they would have been available year-round, producing reliable yields which were not susceptible to inter-annual fluctuations (in contrast to acorns for example), and could be easily harvested and dried for storage, as well as requiring minimal processing before consumption (Hardy 2007, p 6; Bishop 2021). Many roots and tubers such as those of *F. verna* would also have been suited to intensive gathering as they reproduce vegetatively and are spread by digging (Bishop 2021). It is notable that *F. verna* root tubers are extremely high in carbohydrates (41.4 g/100 g), protein (15.5 g/100 g) and energy (231 kcal/100 g), containing higher values than in cultivated potatoes (carbohydrates: 20.45 g/100 g; protein: 1.87 g/100 g; energy: 127 kcal/100 g: Bishop 2021). The frequent discovery of *F. verna* root tubers from those Mesolithic sites where systematic sampling and identification methods have been used suggests that they were regularly consumed, and when one considers the nutritional significance, they seem in keeping with the definition of a ‘staple food’ in terms of the “the principal or basic food on which a community lives” (OED 2021). Arguably, therefore, roots and tubers should be considered to have been important staple foods in Mesolithic Europe in areas of sufficient local availability.

Sampling and representation of archaeological parenchyma remains on Mesolithic sites

Despite increasing discoveries in recent years, systematic sampling for plant remains on Mesolithic sites is still infrequent in some parts of Europe. Detailed synthesis of Mesolithic and Neolithic archaeobotanical evidence from across Scotland highlights the consequences of low levels of sampling (Bishop et al. 2010, 2014). Only ca. 16% of the sampled Mesolithic site blocks (sites sub-divided according to period and area where more than one period and site area present, see Bishop et al. 2010, 2014 for detailed

Table 2 Charred parenchyma remains recovered from Mesolithic hunter-gatherer sites in Europe. X, presence of a particular taxon; Y, yes; N, no; NL, the Netherlands; *n*, number of sites

Taxa	*Ficaria verna* (root tuber/bulbil)	Cyperaceae/*Carex* sp. (rhizome/stem base)	*Beta vulgaris* ssp. *maritima* (root)	*Equisetum* sp. (rhizome)	*Typha* sp. (rhizome)	*Polygonum* sp./cf. *P.* sp. (tuber/stem)	*Dryopteris filix-mas* (rhizome)	*Eriophorum vaginatum* (stem base/corm)	*Sagittaria* cf. *sagittifolia* (tuber)	*Arrhenatherum elatius* var. *bulbosum* (tuber)	*Allium* cf. *ursinum* (bulb)	*Cladium mariscus* (rhizome)	*Conopodium majus* (tuber)	*Lathyrus linifolius* (tuber)	cf. *Potentilla erecta* (root)	*Schoenoplectus lacustris* (rhizome)	cf. *Schoenoplectus tabernaemontani* (rhizome)	*Schoenoplectus* sp. (rhizome)	cf. *Sparganium* (rhizome)	*Pteridium aquilinum* (rhizome)	Pteridophyta (rhizome)	Indet. tap root/fleshy secondary root	Indet. wetland/aquatic rhizome/storage tissue	Indet. rhizome	Unidentified/unidentifiable parenchyma/vesicular material	References*
Potentially edible	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	?	Y	Y	?	Y	Y	Y	Y	Y	Y	?	?	?	?	
Northton, Scotland	X													X									X	X	X	This paper
Staosnaig, Scotland	X																					X	X		X	Mason and Hather 2000
Burry Holms, Wales	X																									Walker and Davis 2022
Lough Boora, Ireland		X																								Warren et al 2014
Lough Kinale, Ireland	X																									McClatchie 2018
Sømme III[a], Norway	X																									Fredh and Westling 2020
Tågerup, Sweden										X																Regnell 2012
Halsskov, Denmark											X		X												X	Kubiak-Martens 2002
Møllegabet II, Denmark																						X			X	Mason 2004
Smakkerup Huse, Denmark				X																					X	Price et al 2001
Tybrind Vig, Denmark			X																							Kubiak-Martens 1999
Hardinxveld-Giessendam, De Bruin, NL	X																									Bakels et al 2001
Hardinxveld-Giessendam, Polderweg, NL	X																									Bakels and van Beurden 2001
Hattemerbroek, NL		X					X													X					X	Kubiak-Martens 2011
Hoge Vaart-A27, NL	X																									Brinkkemper et al 1999
Kampen-Reevediep, NL								X							X		X		X		X					Kubiak-Martens 2019a
NP3, NL			X	X	X													X				X				Perry 1999, 2002
NP9, NL																						X				Perry 2002
Soest-Staringlaan, NL								X				X														Kubiak-Martens 2019b
S51, NL			X		X		X																			Perry 1999
Voorthuizen, NL		X																								Kubiak-Martens and Kooistra 2020
Rotterdam-Beverwaard Tramremise, NL	X																									Zijl et al 2011
Rotterdam-Randstadrail, NL	X																									Guiran et al 2007
Yangtze Harbour, NL	X	X														X										Kubiak-Martens et al 2015
Całowanie, Poland		X				X			X																X	Kubiak-Martens 1996, Kubiak-Martens and Tobolski 2014
Łajty, Poland				X		X			X																	Kubiak-Martens 1999
Tłokowo, Poland					X																					Kubiak-Martens 1999
Schela Cladovei[b], Romania																									X	Mason et al 2002
Roc de Migdia, Catalonia						X																	X		X	Holden et al 1995
Aizpea[b], Spain																									X	Zapata et al 2002
Cova Fosa and 6 sites in NE Spain[b]																									X	Mason et al 2002
Franchthi Cave[b], Greece																									X	Mason et al 2002
Sites (*n*)	11	5	3	3	3	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	4	3	1	12	

* in addition the following references on edibility: Darwin 1996; Irving 2009; Kuhnlein and Turner 1991; Mears and Hillman 2007; Moerman 1998

[a] Sømme III: Root tubers dated to 3936-3695 cal BC, but are included here because they are from a pre-agricultural phase in this area of Norway

[b] Preliminary assessment of material/parenchyma not analysed

explanation) in Scotland had more than ten samples, compared with ca. 38% of the sampled Neolithic site blocks. As a result, the quantity and range of taxa recovered was far more restricted for the Mesolithic (13% site blocks with > 50 identified specimens) compared to the Neolithic period (49% site blocks with > 50 identified specimens). Hazel nutshell was the main species recovered from the Mesolithic sites and only the sites of Staosnaig and Northton (this paper) have analysed parenchyma.

The recovery of the sizeable archaeobotanical assemblage from Northton further emphasises the significant potential of Mesolithic sites for recovering plant macrofossils, and in particular parenchyma remains. In some respects the potential of the site for plant macrofossil recovery appears to be less than ideal in terms of location and range of context types. The site consists of a series of featureless old ground surfaces in a coastal erosion section, and if only a couple of small samples had been collected from the site, then this diversity and quantity of remains would not have been recovered. For example, the limited sampling in the 2001 season amounted to only 94 L of soil from all of the sampled contexts and no parenchyma remains were recovered (Church et al. 2006). It was only with the much greater volume of bulk sampling in the 2010–2011 seasons that the material reported in this paper was recovered. Therefore, archaeological investigations where Mesolithic deposits are predicted or encountered should plan for larger sample volumes than those generally taken from later agricultural sites.

Whilst 100% sampling is unfeasible for most sites due to logistical considerations, the relatively low density of plant remains per litre of soil at Northton highlights the importance of taking a larger sample volume. Perry (2002) has also noted that large samples are required for Mesolithic sites. He sampled and floated 85 and 127 L from two occupation horizons and 100% sampled hearth-pits (ca. 10 L each) from sites in the *Veenkoloniën* (peat district) in the Dutch province of Groningen and recovered a range of parenchyma fragments, but few seeds. An extended sampling strategy for plant macrofossils, including charred archaeological parenchyma, was also applied more recently at a number of Mesolithic sites in the Netherlands, including Rotterdam-Yangtzehaven, Kampen-Reevediep, Soest-Staringlaan and Voorthuizen to mention just a few, and at all sites remains of root foods were revealed in addition to other wild plant foods (Kubiak-Martens et al. 2015; Kubiak-Martens 2019a, b; Kubiak-Martens and Kooistra 2020). Ideally excavations of known Mesolithic sites should take at least 20 L of soil, and preferably > 40 L per excavation unit, unless smaller features are encountered, and employ total (sample from each excavation unit) or random sampling (samples from random selection of excavation units) (Jones 1990) to produce a statistically valid sample of the remains (van der Veen 1985). If large areas of lithic-containing occupation horizons are excavated, a grid system should be used, with randomly selected grid squares selected for sampling and flotation. It is also critical here to emphasise the importance of flotation with fine sieves, because in some regions of Europe water sieving with large-meshed sieves is a common method of recovery from Mesolithic sites (even if some flotation is done). Mason et al. (2002) assessed plant remains from a number of Mesolithic sites across Europe and observed that “Where both wet-sieving and flotation samples were available from the same sites it was clear that the former were much less likely to contain parenchyma. This is probably in part a function of the larger sieve sizes generally used for recovery of wet-sieved material, together with the less gentle handling accorded such samples”.

The possibility of recovering root and tuber remains should also be anticipated. As at Northton, seeds tend to be rare in comparison to archaeological parenchyma on Mesolithic sites across Europe, and so approaches which concentrate on the identification of seeds may fail to recognise the diversity of edible plant remains at hunter-gatherer sites (Mason et al. 2002, p 192). Though machine flotation did not have a detrimental impact on the samples analysed here, it seems a reasonable precaution to undertake targeted bucket flotation, in addition to machine flotation, to test the recovery of root and tuber remains until this has been tested on a wider range of soils. If analyses are done by a team of specialists, close communication is recommended between the different specialists analysing the seeds, wood charcoal and parenchyma, as well as those sorting the samples. Ideally, unidentifiable specimens should be passed between specialists to maximise the extraction and identification of archaeological parenchyma (Mason et al. 2002).

Conclusions

The analyses of the plant macrofossils from Northton have provided new evidence for the significance of root foods in hunter-gatherer diets in Mesolithic Europe, producing the first evidence for the use of *Lathyrus linifolius* tubers at a hunter-gatherer site in Europe. *Ficaria verna* root tubers/bulbils were particularly abundant at Northton, and the new finds add to the growing body of evidence for the importance of these carbohydrate and energy-rich foods in hunter-gatherer diets. The new analyses also highlight the importance of the systematic sampling of Mesolithic sites for archaeobotanical remains, and in sampling a larger volume of soil on hunter-gatherer sites compared to agricultural ones. The detailed sampling at Northton has allowed the discussion to move beyond discussing the presence of hazelnuts, allowing more detailed questions about hunter-gatherer lives to be considered, such as the nature of their seasonal rounds and cooking practices. The increasing evidence for the gathering of edible roots and tubers at Mesolithic sites across Europe shows the dietary diversity in the region at this time and suggests that roots and tubers were staple foods in areas of sufficient local availability. Further sampling and analysis of plant remains from Mesolithic sites across Europe has considerable potential to extend the picture described here, particularly in regions where research into Mesolithic plant use is still developing.

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Declarations

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