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Flavours of Pictish life: using starch grains and phytoliths to trace late Roman and early medieval culinary traditions

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A R T I C L E I N F O

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A B S T R A C T

Understanding the seasonal and daily aspects of late Roman and early medieval life in northern Britain has been hugely challenging due to a dearth of excavated sites and poor preservation of settlement features where identified. This problem has been compounded by a very limited historical record for this era and region. But a new generation of archaeological data has begun to illuminate the Picts, a group first mentioned in late Roman sources and one that went on to become the dominant kingdom of early medieval northern Britain. These new datasets include innovative microbotanical analyses that can shed light on Pictish foodways, including culinary traditions, and specific plant foods consumed. This study employs non-destructive microbotanical analysis of pot sherds from Pictish settlement contexts and human teeth from Pictish burials, examining the presence of starch grains and phytoliths from six prominent sites spanning the Pictish period (AD~300 – 900). Our research confirms that cereals such as oats and barley were the primary plants cultivated, cooked, and consumed in northeast Scotland during the late Roman Iron Age and early medieval period. These microbotanical residues add detailed evidence to previous studies of isotopic, pollen, and trace macrobotanical proxies, but also offer fresh insights into the potential composition of specific Pictish meal types. The approaches outlined here have greatly expanded and enriched our understanding of the dietary habits and lifestyle of the Picts, an important, but under-researched group.

1. Introduction

The inhabitants of northeastern Scotland in the first millennium, known as the Picts, have long remained an enigma, with few historical sources to draw upon and an archaeological record that has been traditionally diffuse and very difficult to identify (Wainwright 1955; Driscoll et al. 2010; Noble and Evans 2022:1). The term "Pict" originates from the first mention of these people in late Roman sources in AD 297 as a collective name for troublesome, "barbaric" peoples, living north of the Roman frontier (Fraser 2009; Woolf 2007). They were a noted enemy of Rome and were involved in major events of raiding and plunder of Roman Britain such as the 'Barbarian Conspiracy' of AD 367–8 (Fraser 2009: 54–58; Morris 2015:425). In the post-Roman era, the Picts went on to become the dominant kingdom of northern Britain, forming the precursor to the medieval kingdom of Alba and latterly of Scotland itself (Woolf 2007; Noble and Evans 2022). Efforts to better understand the Picts in recent decades, include investigations which have dramatically improved our understanding of the archaeology of the Picts through increased identification of major settlement sites (primarily fortified enclosures including upland hillforts, lowland ringforts, and coastal promontory forts) and cemeteries using survey, remote sensing technology and targeted excavation programs (e.g. Cook 2010, Noble and Evans 2019, 2022). Despite this, our understanding of aspects of the seasonal lifeways and daily activities of the Picts continues to be difficult to address. Given the predominant use of ephemeral materials in architecture such as turf walling (Prado and Noble 2022), poor preservation of floor layers (Reid et al. 2023), acidic soils leading to poor organic preservation and more general difficulties in identifying settlements of this period (Noble and Evans 2022:28–36), there is a need to explore alternative and innovative means of tracing Pictish foodways and culinary traditions. In this study, microbotanical proxies (phytoliths and starch grains) were utilised in the Pictish research region to target human teeth and pottery sherds. Through these studies we were able to ascertain which plant foods the Picts were cultivating, preparing, cooking, and consuming. Using a non-destructive three–layer wash method (Chandler-Ezell and Pearsall 2003; Pearsall et al. 2004) food

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residues were retrieved from five recently excavated Pictish sites (four settlement sites and one cemetery), and one cemetery previously excavated in the 1960s (Fig. 1).

In the United Kingdom and Ireland, microbotanical residues typically involve pollen analysis (e.g., Jones et al. 2021) while phytolith (e.g., Wade et al. 2021; Power 2018; Powers et al. 1989; Prado 2023; Prado and Noble 2022) and starch grains studies (e.g., Hardy et al., 2009; Hart 2007) are in their infancy. Phytoliths are plant microfossils made of biogenic silica, created when silica is drawn up from the soil and groundwater through the plant's vascular system and deposited in the cell wall. Once the plant dies and decays, these siliceous phytoliths are re-deposited into the soil through a decay-in-place mechanism. This mechanism is more direct than airborne deposition pathways of other microbotanical residues like pollen. In this study, the decay-in-place mechanism of food residues is traced by examining archaeological contexts understood as places of contact with food (e.g., pot sherds and dental surfaces). The morphology of these microfossils can be diagnostic to a variety of taxonomic levels (e.g., Family – Genus) (Pearsall 2015:253; Piperno 2006), and although not all plants produce phytoliths, these environmental proxies are useful for understanding past human-plant relationships, use of space, architectural traditions, and agricultural practices (Cabanes et al. 2010; Dal Corso et al. 2018; Portillo and Albert 2011; Portillo et al. 2009; Prado and Noble 2022; Sullivan and Kealhofer 2004). Starch grains are part of the energy storage system of many plants, and like phytoliths can be taxonomically diagnostic. Specific physical characteristics of starch grains, such as the location of the hilum, shape of the grain, surface texture, presence/absence of lamellae, and extinction cross shape help to identify which plant produced the starch grain (Barton 2007; Hart 2011; Henry et al. 2009; Pearsall 2015: 370; Torrence and Barton 2006). Furthermore, distinct damage patterns observed in starch grains can suggest specific food preparation and cooking methods (Henry et al. 2009). For the study of plant foods in Pictland, phytoliths and starch grains retrieved from pot sherds and dental surfaces provide direct evidence for food consumption in a region where macroscopic organic preservation of plant foods is rare due to preservation biases. Starch grains and phytoliths do not require specific pathways for preservation, unlike macrobotanical remains which often require events of charring, waterlogging, desiccation, or freezing for their preservation in the archaeological record.

There are relatively few optimal contexts for starch grain and

Fig. 1. Estimated territory of Pictland (green) and Pictish archaeological sites in study (white). Modern cities Edinburgh and Inverness in black. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

phytolith extraction from Pictish archaeological materials. Locally made pottery was thought to be absent from Pictish settlement practices in northeast Scotland, but excavations at Dunnicaer, Rhynie [Craw Stane complex], and Tap o' Noth, all in Aberdeenshire, have uncovered evidence for local pottery traditions (Fig. 1) (Noble and Evans 2022:85). This new evidence provides unique contexts to investigate Pictish food storage, preparation, and consumption. In this study, eleven pot sherds were selected from four Pictish sites for microbotanical analysis: Dunnicaer (n = 3), Mither Tap (n = 2), Rhynie [Craw Stane complex] (n = 3), and Tap o' Noth (n = 3) (Table 1). These samples come from sites that span coastal, lowland, and upland settlement contexts, and the entire Pictish period (AD~300 – 900). It is important to emphasize that locally made pottery has only been recovered in Pictish contexts from fortified settlements. Historic and ongoing cultivation (e.g., ploughing) and modern development in lowland contexts has impacted the preservation of possible non-fortified Pictish settlement remains; therefore, it is unknown whether locally made pottery may have been present in non-fortified settlements. Although the sample size of pot sherds in this study is small, all available unwashed pottery sherds were selected for analysis. These pot sherds were excavated in 2016, 2017, 2019, and 2022; sampled in 2021–2022. Microbotanical study was not planned from the start of these excavations; however, upon the retrieval of these pot sherds consultation between researchers in the Northern Picts project agreed the sherds should remain unwashed for microbotanical analysis to maximize the potential for residue preservation.

The oldest site in this study, Dunnicaer, is a coastal promontory fort and one of the earliest identified fortified enclosures of the first millennium AD in this region (dated 2nd – 4th centuries AD). Fortified settlements of this kind became central to elite culture in Pictland (Noble and Evans 2019:39–57). Contact with the Roman world is evident at Dunnicaer through the presence of rare and unusual Roman glass vessel sherds and Roman pottery including samian vessel sherds (Noble et al. 2020; Noble and Evans 2022:49, 246).

The later Craw Stane complex (Rhynie) and Tap o' Noth are two very important sites for illuminating the development of the Pictish kingdoms. The name Rhynie includes the place-name element, *rīg, 'king', and archaeological fieldwork suggests the Rhynie landscape was an elite Pictish centre from the 4th to 6th centuries AD (Noble et al. 2019b). The Craw Stane complex appears to have been the focus of high-status activity. An enclosure complex consisting of ditches and a complex outer wooden palisade and post-setting, the site was found to enclose multiple timber buildings and an extensive metalworking assemblage was found here including evidence for refining silver (Noble et al. 2019b). The pottery sherds used in this study came from ditch fills of the enclosure complex at the Craw Stane. The elite centre at Rhynie appears to have been supported by a huge hilltop settlement on the contemporaneous site of Tap o' Noth which overlooks the Rhynie valley. At Tap o' Noth over 800 house platforms have been identified within a 17 ha hillfort enclosure, with settlement here extending from the 3rd to early 7th centuries AD. Later Pictish settlement is represented by the hillfort Mither Tap o' Bennachie (Noble and Evans 2019:45–46, 2022:106), dated 7th – 9th centuries AD, consisting of a small upper citadel situated upon a craggy granitic tor. Excavations at Mither Tap have uncovered internal settlement platforms, an elaborate well, metalworking evidence, extensive middens, and locally produced pottery (Noble and Evans 2022:106–107).

Along with materials from the newly excavated settlements, this study examined human teeth from two Pictish-era cemeteries. Cemetery sites have been poorly attested in this region, but more have been identified in recent years from aerial photography, development-led archaeology and research excavation. Often, however, human remains are poorly preserved, again due to the acidic soils of the region (Mitchell et al. 2020; Noble and Evans 2022:35, 190; Noble et al. 2019a). This study targeted the remains of one individual from Croftgowan, Inverness-shire, where recent excavations uncovered a small number of poorly preserved graves within a monumental cemetery of square and round barrows. Archived remains of four individuals from Lundin Links, Fife, the best preserved Pictish cemetery known, were also sampled (Tables 1 and 2).

The sampling of the human teeth was carried out with care and respect in a non-destructive manner. Several microbotanical studies have investigated dental calculus, a solidified build-up on teeth which is known to trap phytoliths and starch grains (Hardy et al., 2009; Henry et al. 2011; Juhola et al. 2019; Scott Cummings and Magennis 1997; Weber and Price 2016). In absence of calculus, other studies have used surface residue analysis (Boyadjian 2007; Piperno and Dillehay 2008) to identify meals consumed at the very end of an individual's life. In the case of the Pictish individuals, dental calculus was not observed on any of the teeth and therefore surface residue analysis was deemed the most appropriate method to investigate what these individuals consumed in their final days.

2. Materials and methods

Microbotanical residues were targeted in this study using a three–layer wash method (Chandler-Ezell and Pearsall 2003; Pearsall et al. 2004) to track residues adhering to artifact and dental surfaces from the outermost to innermost layer (dry wash, wet wash, sonicated wash). Similar studies of microbotanical surface residues have been successful in archaeological investigations of pot sherds (Morell-Hart 2015; Morell-Hart et al. 2014, 2019), lithic tools (Barton 2007; Bérubé et al. 2020; Pearsall et al. 2004; Zarrillo and Kooyman 2006), and human teeth for dietary analysis (Boyadjian et al. 2007; Lalueza-Fox et al. 1994). This method allows for residues from each layer to be comparatively examined. The approach is useful for estimating the degree of contamination, as the outermost sample (i.e., dry wash) is assumed to have the highest likelihood of contamination, while the innermost sample (i.e., sonication wash) is assumed to have a lower chance of contamination (Hart 2011:3247).

Estimating and mitigating for potential contamination is essential in

Table 1
Sample contexts in this study.

Site name	Pot Sherds # of sherds sampled (# of washes/ samples)	# of contexts	Human Teeth # of teeth sampled (# of washes/ samples)	# of individuals
Croftgowan			2 (4)	1
Dunnicaer	3 (6)	3		
Lundin Links			4 (8)	4
Mither Tap	2 (4)	1		
Rhynie [Craw Stane Complex]	3 (6)	3		
Tap o' Noth	3 (8)	3		
TOTAL	11 (24)	10	6 (12)	5

Table 2
Sampling context of Pictish individuals. Washes include (D) Dry, (W) Wet, and (S) Sonicated.

Sample #	Sex	Sampling context	Site	Washes		
				D	W	S
MB-22-CR021	Unidentified	Inset molars	Croft Gowan	N	Y	Y
MB-22-LL-1	Male	Lower right M2	Lundin Links	N	Y	Y
MB-22-LL-2	Unidentified	Lower M2	Lundin Links	N	N	Y
MB-22-LL-3	Female	Lower left M2	Lundin Links	N	N	Y
MB-22-LL4	Male	Lower M2	Lundin Links	N	N	Y

residue analysis as many studies have identified soil, airborne, and surface contamination in archaeological residues and laboratory contexts, especially regarding starch grains (Crowther et al. 2014; Hart 2011). In this study, care was taken to use sterile consumables and freshly excavated material where possible. Sampling was conducted in archaeological laboratory spaces (McMaster Paleoethnobotanical Research Facility [MPERF] and University of Aberdeen Zooarchaeology Lab) where food was not permitted. At the time of sampling, consumables were not tested for contamination. However, the same brands of consumables had been used in previous studies associated with the MPERF laboratory spaces, where no contamination was detected in using these same consumables.

The sampling of the outmost layer involved a dry wash process using a powder-free nitrile gloved hand to gently brush off remaining soil adhering to the artifact or dental surface. In the case of pot sherds, the inner cooking surface was sampled, and for dental contexts, the tooth crown. The soil from each context was caught in a clean petri dish and transferred to a sterile container (e.g., 2 mL centrifuge tube). The next layer was sampled through a wet wash process, again using a gloved hand to gently brush off residue, with ultrapure water added. This wet wash was again caught in a petri dish and transferred to a sterile container using a pipette. The innermost layer and final step was the sonication wash. Ultrapure water was again added to the inner artifact surface and the tip of a handheld sonication device (Kinga ultrasonic spatula; 24 kHz) was dipped into the pooled water. This sonication process works similarly to a sonicating toothbrush and gently dislodges adhering or trapped microscopic residue from the artifact's pores and crevices. The process was timed for five minutes (Pearsall 2015:360) and again the wash was collected in a petri dish and transferred to a sterile container. For dental residues, teeth were held by the base or root of the tooth, the crown was submerged in ultrapure water within the petri dish, and the sonication device was submerged next to the crown to dislodge residues. This sampling strategy involved no damage to the teeth or pot sherds.

One challenge in this study was the inability to capture three washes in most contexts. Only the Tap o' Noth pot sherds (MB22_Tap1–3) produced sufficient residues to be collected as a three-part sample; therefore, only two washes were possible for most sample contexts (Tables 1 and 2). This is because most of the artifacts and teeth had already been brushed off by the excavators and laboratory workers prior to microbotanical sampling. In an ideal scenario, artifacts would be sampled immediately after excavation while some of the surrounding soil was still adhering to the surface.

Washes were directly mounted onto microscope slides using a sterile pipette and covered with a glass coverslip. One slide was examined per sample using a Zeiss Axiolab A.10 light microscope at 400 – 630x magnification using transmitted and cross-polarized light. Microbotanical specimens were identified, tabulated, measured, and photographed. All microbotanical residues present on each sample slide were analyzed and tabulated, instead of reaching a minimum count of 200 morphotypes per sample as is typical in phytolith analysis (e.g., Albert and Weiner 2001). Each specimen was tabulated in Microsoft Excel with morphological descriptions including size and diagnostic features (e.g., lamellae, hilum location, extinction cross form).

Phytolith morphotypes were described following the International Code for Phytolith Nomenclature (ICPN) 1.0 and 2.0 where possible (Madella et al. 2005; Neumann et al. 2019). Grass phytoliths were identified following Ball et al. (1999), Barboni and Bremond (2009), Dal Corso et al. (2017), Fahmy (2008), Fredlund and Tieszen (1994), Lancelotti and Madella (2012), Madella (2007), Novello and Barboni (2015), Neumann et al. (2009), Piperno (2006), Portillo and Albert (2011), Portillo et al. (2006), Rosen (1992), Strömberg et al. (2007), and Twiss et al. (1969). Cereal starch grains were identified following Hart (2011), Henry et al. (2009), and Yang and Perry (2013). A comparative reference database compiled by Prado, the McMaster Microbotanical Research Database (macmicrobot.omeka.net, last accessed June 2024) was also consulted for both phytoliths and starch grains. Occasional micro-algae were also retrieved in this study, and were tentatively identified following ICPN 2.0, Jüttner et al. (2022), Spaulding et al. (2021), and Stone and Yost (2020). Micro-algae analysis in archaeology is under-utilised and these proxies are extremely diverse, making it challenging to confidently make taxonomic identifications (Battarbee 1988; Prado and Noble 2022:2; Stone and Yost 2020:23).

3. Results

A total of 239 micro-residues including phytoliths, starch grains, microalgae (e.g., diatoms and chrysophytes) and one cf. radiolaria (unicellular zooplankton) were recovered in this study. Starch grains represented 51 % of residues recovered, chrysophytes 25 %, and phytoliths 21 % (Fig. 2). Most of these starch grains were lenticular in form, a diagnostic morphotype for cereal grains (Yang and Perry 2013:3172). Higher quantities of microbotanical residues were extracted from pot sherds than human teeth (Fig. 3), and this discrepancy could be due to the previous cleaning of some of the teeth in preparation for isotopic analysis which was known at the outset of sampling. Very little evidence of possible contamination was present as easily identifiable foreign (modern) starches noted in starch contamination studies, such as maize (*Zea mays*), were not present. Barley is no longer considered a widely consumed grain in Scotland and the high representation of this taxon from archaeological contexts may further suggest low modern contamination. Lastly, the types of microfossils and identifiable taxa present in each sample were largely redundant across contexts and washes which adds confidence to the lack of contamination in this study (Fig. 8).

The starch grains identified as barley were lenticular (sub-circular to circular in plane view, biconvex side view), with a centric hilum, straight extinction cross arms, faint or not visible lamellae, smooth to slightly dimpled surface texture and had a mean size of 11.9 μm. While there is a good degree of overlap in morphological characteristics within the Triticeae botanical tribe (subfamily Pooideae), barley is noted to have a smaller mean size than other genera (Yang and Perry 2013:3172). These smaller than average lenticular grains matched observations of *Hordeum vulgare* var. *Bere* in the McMaster Microbotanical Research Database (macmicrobot.omeka.net). Oat starch grains were lenticular with at least one faceted edge (Fig. 4). Lenticular starch grains identified as cf. ('*conferre*', provisional identification) wheat (*Triticum* sp.) exhibited surface pockmarks described by Yang and Perry (2013); however, there is a possibility that these grains are barley, as dimpled surface features are also noted in *Hordeum* sp. therefore this identification is tentative. These pockmarked starch grains were recovered exclusively from the Craw Stane complex (Rhynie) pot sherd contexts, potentially suggesting wheat was only present at this site within this study. This single occurrence of wheat would further contribute to the characterisation of Rhynie as a high-status Pictish site, as wheat has not been recovered from any other Pictish site. Wheat is referenced as a high-status cereal in early Irish law texts, while other cereals such as barley and oat were characterized as lower rank, associated with commoners (McClatchie et al. 2015:180). Overall, the majority representation of cereal starch grains in this study parallels palynological and macrobotanical evidence which suggest cereals were the focus of agricultural production in Pictland (Jones et al. 2021; Niehaus 2021; Ramsay 2019).

Non-lenticular starch grains were recovered in small quantities and could not be accurately identified. This included one 13-μm pyriform starch grain with a centric hilum and centric x-shaped fissure, one 5-μm triangular starch grain with an open centric hilum and blurred extinction cross, one 9-μm polyhedral starch grain with a centric hilum and straight-armed extinction cross, and several small spherical starch grains with centric pitted hila (cf. transitory starches).

Approximately 54 % of starch grains in this study were damaged which suggest these vessels were used for cooking (at least in part). However, it is difficult to conclude if food was cooked in these vessels or

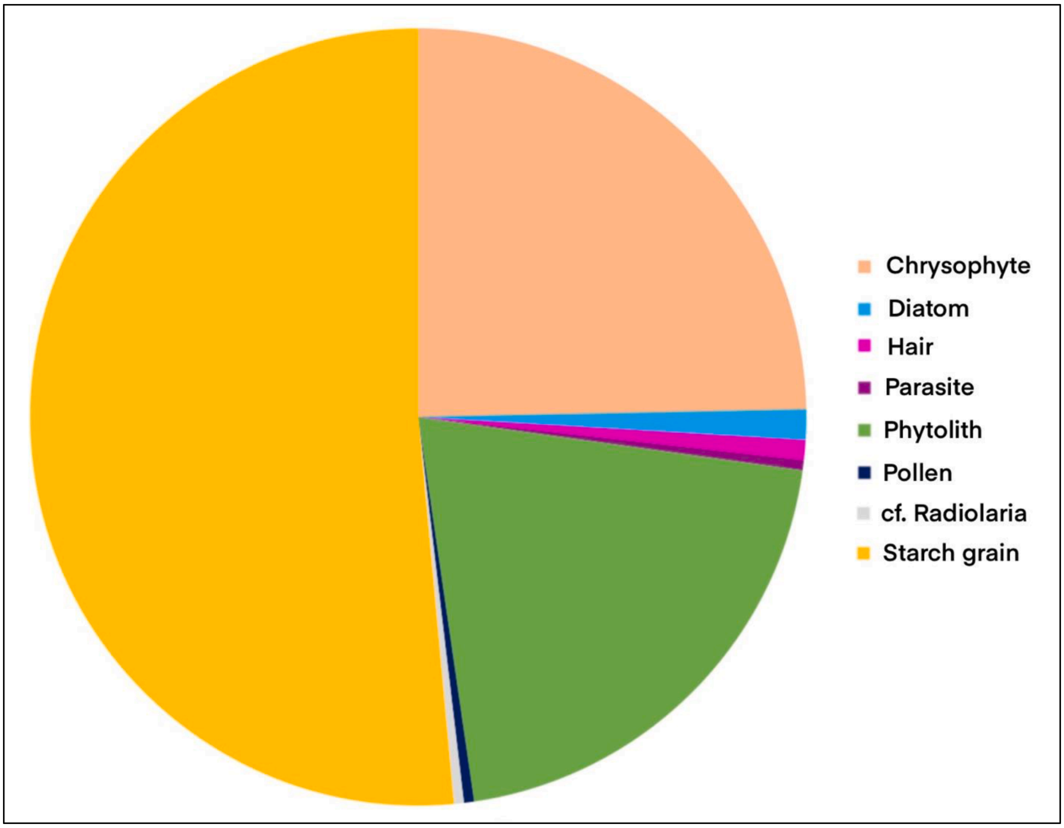

Fig. 2. Relative proportions of micro-residues from pot sherd and human dental surfaces.

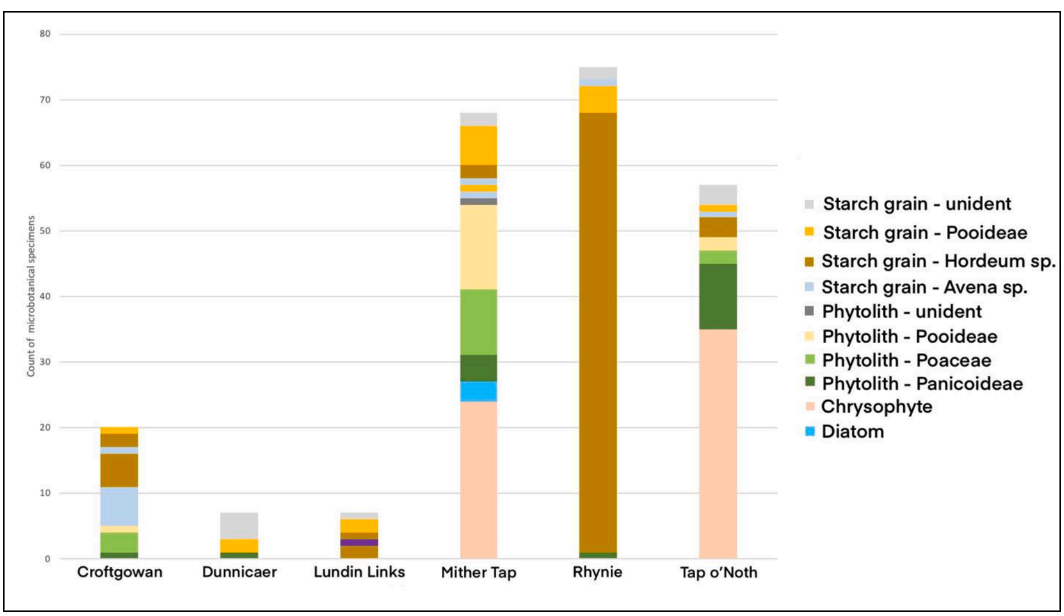

Fig. 3. Total microbotanical and microalgae residues by site.

if cooked food was placed in these vessels after preparation (i.e., for consumption, serving, or storage). The starch grains with damage suggested cooking processes of boiling, parching, and possibly fermentation (Fig. 5; see Henry et al. 2009). Boiling damage was the most common, with observations of swollen grains, loss of extinction cross and reduced birefringence. Parching damage was suggested where grains were observed with encrustations or smaller starch grains fused to the larger diagnostic grains (Henry et al. 2009:918). In addition, possible fermentation damage (e.g., from brewing practices) was observed in one starch grain from Dunnicaer and two from Tap o' Noth which showed enzymatic damage, where the center of the starch grain had a "hollowed out" appearance while the outer edge appeared undamaged (Fig. 5G–H). This damage pattern was observed by Henry et al. (2009) in their experimental study of cooking damage to starch grains where yeast had been added to starch and resulted in this hollowed out morphotype (Henry et al. 2009:921). However, damage from fermentation was

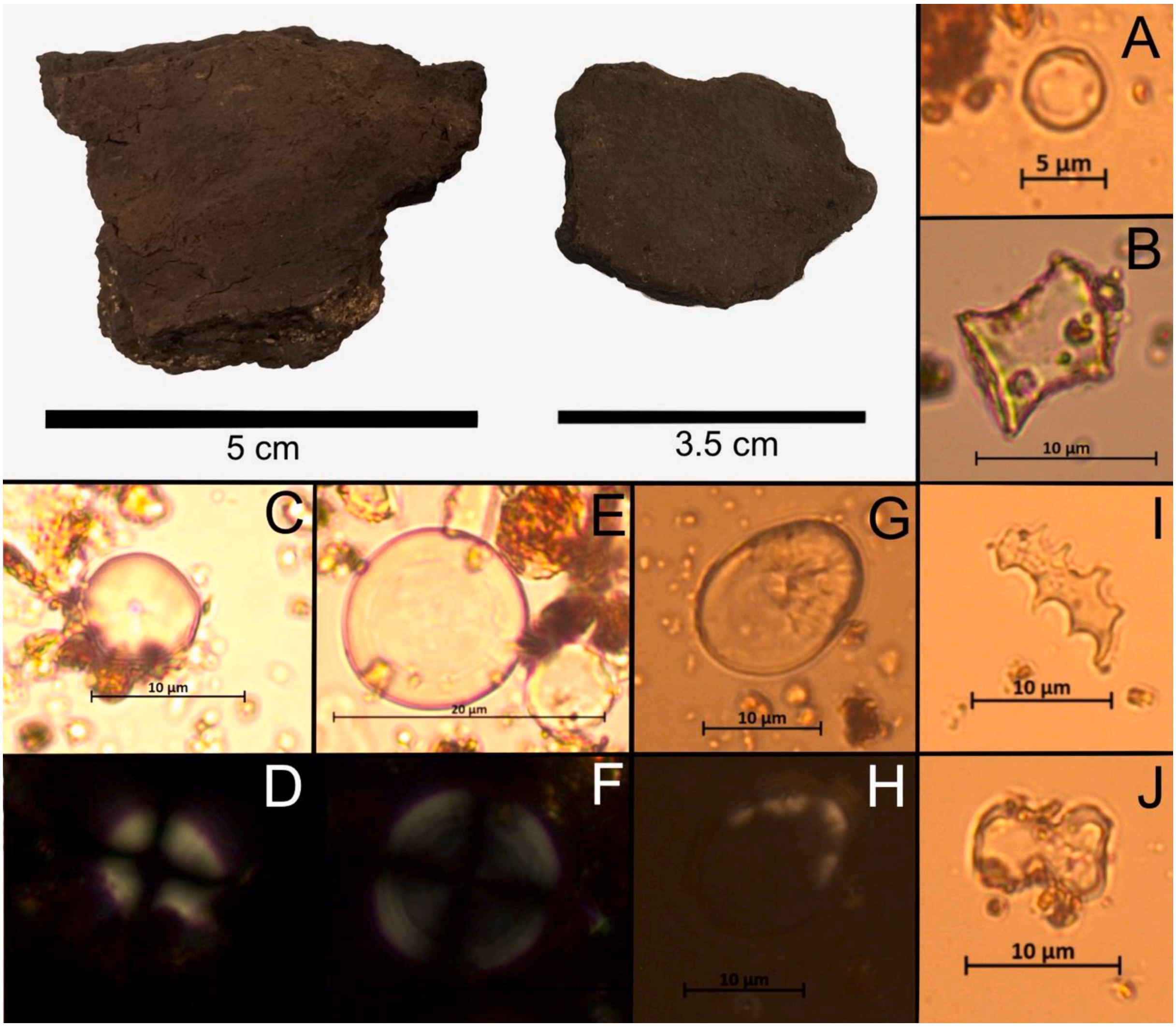

Fig. 4. Mither Tap pot sherds (MT-LG left, MT-SM right) and examples of residues retrieved viewed under 400x magnification. A) chrysophyte (micro-algae), B) rondel phytolith (Pooideae), C–D) *Avena* sp. starch grain with pressure facets under transmitted and cross-polarized light (dark) showing extinction cross, E–F) cereal-type starch grain, likely *Hordeum* sp. or *Triticum* sp., G–H) damaged cereal-type starch grain, I) elongate dendritic phytolith (Pooideae), J) bilobate phytolith (Panicoideae).

extremely rare even in experimental contexts (1–2 % of observed starch grains) and therefore this finding is tentative.

4. Discussion

Of the pot sherds tested in this study, the majority contained both phytoliths and starch grains from cereals such as barley and oats (Fig. 6, Table 3). Starch grains with observable cooking damage were present across all pot sherd contexts and were almost equal in quantity to undamaged grains. This pattern suggests that pots could have been used as multi-purpose vessels (i.e., for cooking and storage of plant matter). Rare occurrences of microalgae such as chrysophytes and diatoms were also observed from the pot sherd contexts; however, given the low frequency we argue these are likely to be from post-depositional contamination from the surrounding soil. Microalgae were largely recovered from the outermost wash in this study (wet wash, 66 %) and to a lesser degree from the innermost sonicated wash (33 %), supporting that view.

The pot sherd residues and teeth residues were comparable regarding types of identifiable plant taxa (i.e., barley, oat, and cf. wheat) but divergent in quantity of phytoliths. Phytoliths were retrieved in higher quantities from the pot sherds than the teeth surfaces (only one individual from Croftgowan, see Fig. 7). One explanation for this difference is that phytoliths are siliceous and very hard; therefore, humans are less likely to consume plant parts which are phytolith dense (e.g., grass leaves) except in extreme circumstances (e.g., famine; see Minnis 2021). The higher representation of phytoliths in pot sherds likely represent storage contexts; although, it could also reflect cooking events where cereal inflorescence bract structures were still intact during food preparation. The culinary implications of this may have been a less refined food product, with more fibrous and rustic qualities.

Starch grains retrieved from dental surfaces on human teeth (Fig. 7) are likely to represent meals eaten during the end-of-life period. In terms of the plant-based component of their diet, individuals from Croftgowan and Lundin Links appeared to have consumed mostly cereals before death, as evidenced through lenticular-cereal type starch grains. Two non-cereal starch grains (one small swollen triangular morphotype and one pyriform morphotype) were also retrieved but are likely non-diagnostic forms. Over half of the total starch grains retrieved in these dental contexts had evidence of cooking damage, and very few grains appeared to be uncooked/raw.

From the tooth residues, the meals consumed shortly before death were likely cereal-based and could have included meals of pottage, stew, oatmeal, oatcakes, or bread. It is very challenging to distinguish between baked and boiled starch damage patterns particularly in wheat and

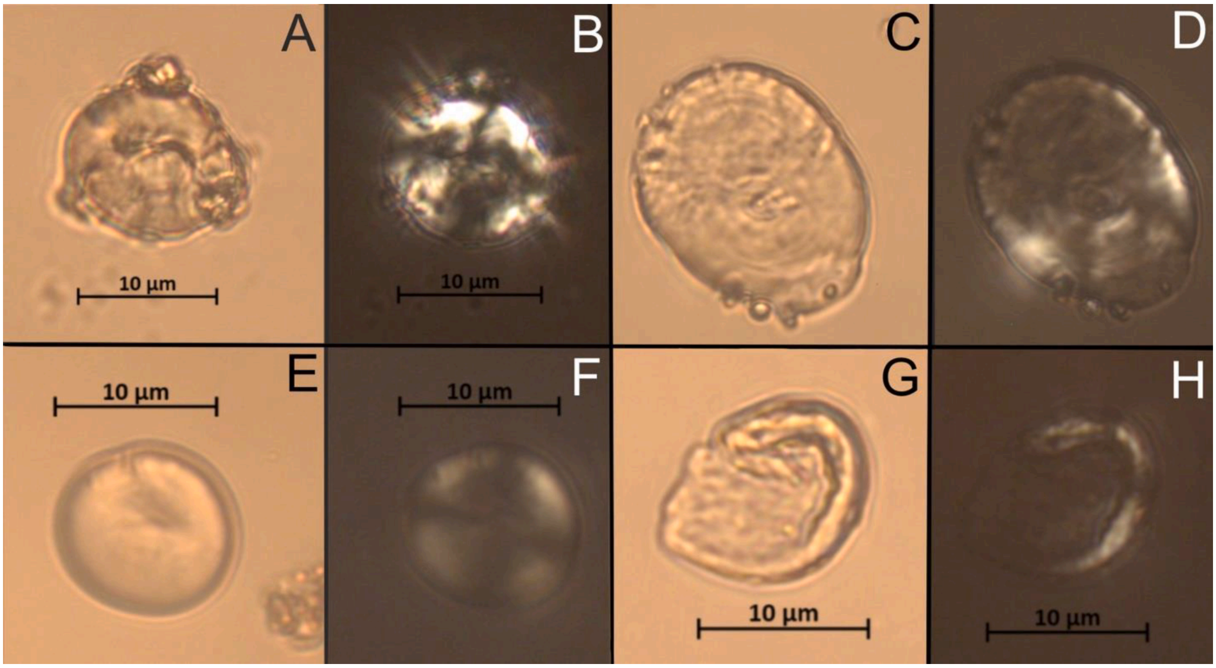

Fig. 5. Examples of damaged cereal-type starch grains from this study (unidentified but likely *Hordeum* sp.). A–B) fold at center of grain, uncharacteristically rugose surface, damaged extinction cross, and encrustations C–D) reduced birefringence, damaged surface texture, and encrustations E–F) indented center of grain and reduced birefringence, G–H) possible fermentation damage, eroded center of grain and pockmarked surface.

barley (*T. aestivum* and *H. vulgare*) as baked starch grains appear similar to boiled grains in these taxa (Henry et al. 2009:918). However, historical accounts from medieval England and Ireland may offer some insight toward the kinds of meals such cereal-based products could have been used for. Boiled foods such as pottage, porridge, and gruels are possible types of foods observed in this study through starch residues. In medieval Ireland and England pottage and porridge were widely consumed as an everyday food for many people (McClatchie et al. 2015:4; Monk 2011:39; Peters 2015:92; Qin 2017:3). Regarding end-of-life meals, it is interesting to note that in medieval Ireland cereal-based pottage was often used for feeding the sick as it was a simple, easily consumed, and nutritious food (Kelly 1997; O'Sullivan et al. 2014:74). Due to the lack of robust preservation of the individuals from Croftgowan, the pathologies of these individuals are unknown; however, some details from the Lundin Links individuals are available in an article by Greig et al. (2000). Notably, one individual showed periodontal disease of the lower jaw (LL18, Greig et al. 2000:629; sample LL3 in this study) a condition where soft yet nutritious meals like porridge may have been preferred.

Barley was the most common cereal identified in the Pictish samples. Yet, barley consumption is not often foregrounded in our discussions of agriculture and food in first millennium AD Britain. In the Roman period, barley was sometimes referenced as a 'punishment ration' and its consumption by humans, rather than its use in animal feed or other purposes, has been questioned. However, direct evidence from fecal remains found at settlements on the Roman frontier in Britain has shown barley was consumed widely in both military and civilian contexts (Britton and Huntley 2011). Other obvious uses for the cereals include the production of bread, implied by the presence of rotary querns on most Pictish settlements, and the tentative evidence of fermentation as outlined in the results above. There is a rare reference embedded in a contemporaneous poem, to the ales of the Pictish plain of Circin (a Pictish region in eastern Scotland) tasting like wine (Evans 2013:19–20), a testament to arable farming and a vibrant drinking culture in southern Pictland. Whether the types of analyses conducted here show ale consumption and preparation would require further research.

Barley and oats have continued to be important plant foods in Scotland and are central ingredients for Scottish food (e.g., bannock, porridge, oatcakes, sowans, and haggis) and beverages (e.g., ale, beer, and whisky); although, local agricultural production of these cereals have fluctuated over time (Dickson and Dickson 2000:232–235). Archaeobotanical remains from medieval town contexts in Scotland (e.g., Aberdeen, Perth, Elgin, St. Andrews, and Edinburgh Castle) have demonstrated the continuation of cereal consumption which predominately consisted of barley and oats; however, rye (*Secale cereale*) and wheat (*Triticum* sp.) were also present (Dickson and Dickson 2000:179–203). Wheat is suggested to have replaced barley as the most important cereal in Scotland in the medieval period, and pulses such as peas and beans also appear to have grown in popularity during this time (Dickson and Dickson 2000:213–214).

We also need to ascertain to what extent plant-based consumption was truly central to diet. Where animal bone is well preserved in Pictish-era middens, the assemblages tend to be dominated by domesticated animals, particularly cattle at high status sites (Masson-MacLean et al. 2023). Isotope results also suggest a mixed human diet of plant and animal protein (Curtis-Summers et al. 2014, 2020; Modzelewski 2008). Cereal-based meals, such as pottage, could have been accompanied by meat; however, the method employed in this study is unable to detect animal derived food residues.

To date, evidence of Pictish foodways has included pollen, isotope, starch, phytolith, and trace macrobotanical residues (Curtis-Summers et al. 2020; Hardy et al. 2009; Jones et al. 2021; Niehaus 2021; Prado and Noble 2022; Ramsay 2019). This study generally corroborates those lines of evidence, which also suggest barley and oats were the focus of agricultural production in Pictland. Pollen analysis of samples taken from the Craw Stane Complex at Rhynie confirmed the presence of agricultural activity during the Pictish period in the Upper Strathbogie valley (containing Pictish sites Tap o'Noth, Cairnmore, and the Craw Stane Complex) through the recovery of cereal type pollen grains including barley and trace amounts of oat and/or wheat pollen (Jones et al. 2021:904–906). The pollen record suggested that overall, the Upper Strathbogie valley was a "considerably wet" area from AD 220–800 (Jones et al. 2021:903). During the period of Pictish inhabitation (AD~220–560) samples from the Craw Stane Complex suggest a

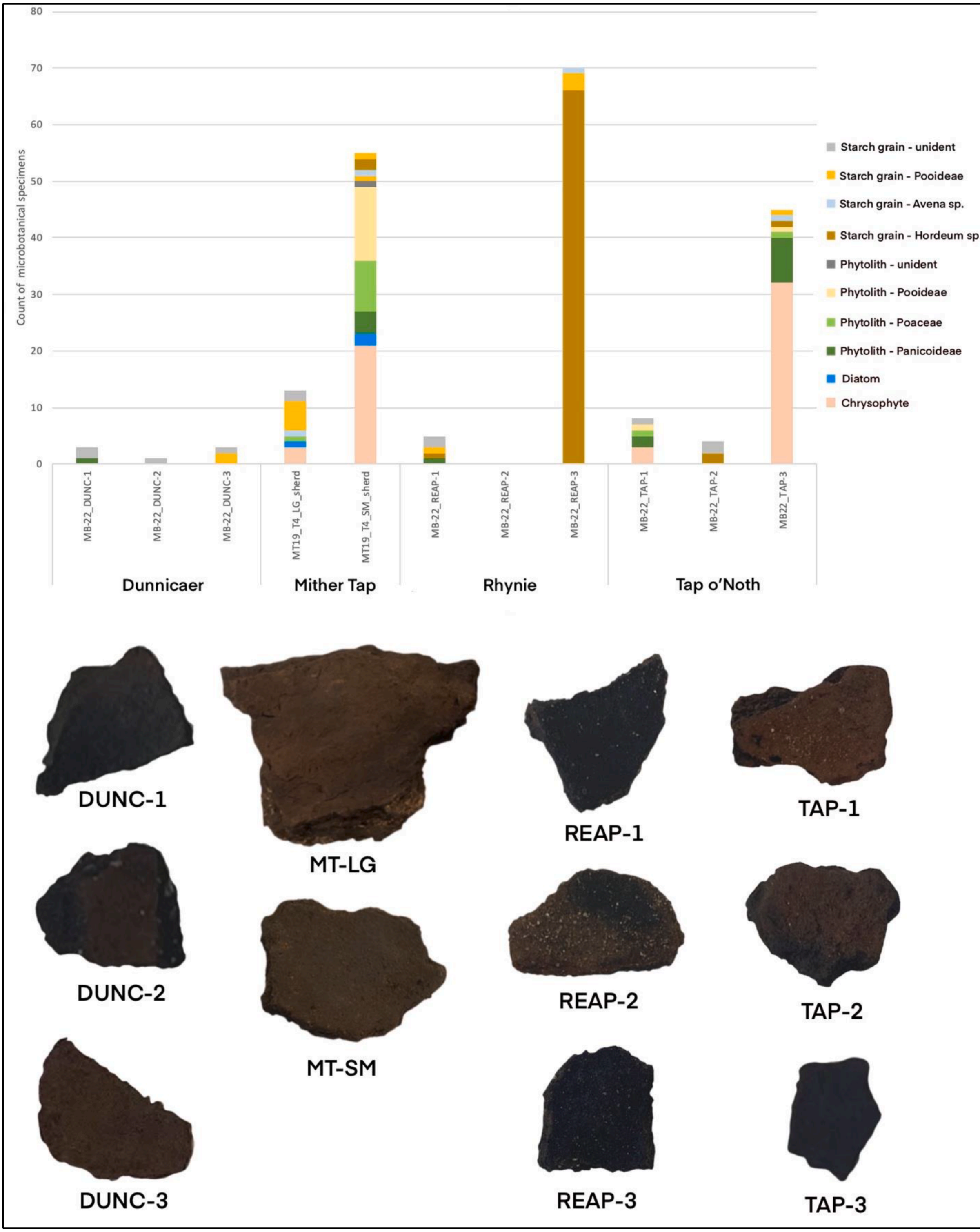

Fig. 6. Phytolith, starch grain, and micro-algae residues from pot sherds. Average pot sherd size 2 cm. MT-LG and MT-SM were slightly larger, 5 cm and 3.5 cm respectively).

mixed pastoral and cereal agricultural economy (Jones et al. 2021:903). Curtis-Summers et al.'s (2020) isotopic study from Portmahomack suggested that during the Pictish period, the inhabitants at this coastal monastery consumed a mixed diet of terrestrial animal protein and predominantly C_3 plants, with a low-level of fish consumption amongst some individuals (see also Modzelewski 2008 for similar conclusions at Lundin Links).

The advantage of the methods and samples outlined here is that they provide direct archaeological evidence of consumption identifiable to specific taxa. Furthermore, starch grain analyses can also (at least tentatively) interpret preparation methods vis-à-vis cooking and serving vessels. In this study, starch damage patterns suggest cereal grains were stored, cooked, and probably consumed via locally made pottery vessels. The locally made Pictish pottery assemblage is extremely limited in quantity. Furthermore, the size of the sherds was on average approximately 2 cm. Very little variation in pottery manufacture was observed

Table 3
Microbotanical residues from Pictish pot sherds. DW – Dry wash, WW – Wet wash, SW – Sonicated wash.

Site	Potsherd	# Phytoliths			# Starches			Identified Taxa
		DW	WW	SW	DW	WW	SW	
Dunnicaer	DUNC-1		1	0		2	0	Panicoid grass
	DUNC-2		0	0		1	0	N/A
	DUNC-3		0	0		3	0	*Hordeum* sp.
Mither Tap	MT-LG		0	1		5	3	*Hordeum* sp., *Avena* sp.
	MT-SM		16	11		3	2	*Hordeum* sp., *Avena* sp.
Rhynie [Craw Stane complex]	REAP-1		1	0		4	0	*Hordeum* sp.
	REAP-2		0	0		0	0	N/A
	REAP-3		0	0		2	68	*Avena* sp., *Hordeum* sp., or *Triticum* sp.
Tap o' Noth	TAP-1	1	3	0	0	1	0	Panicoid and Pooid grasses
	TAP-2		0	0		3	1	*Hordeum* sp.,
	TAP-3	2	1	7	1	2	0	*Hordeum* sp., *Avena* sp., Panicoid and Pooid grasses

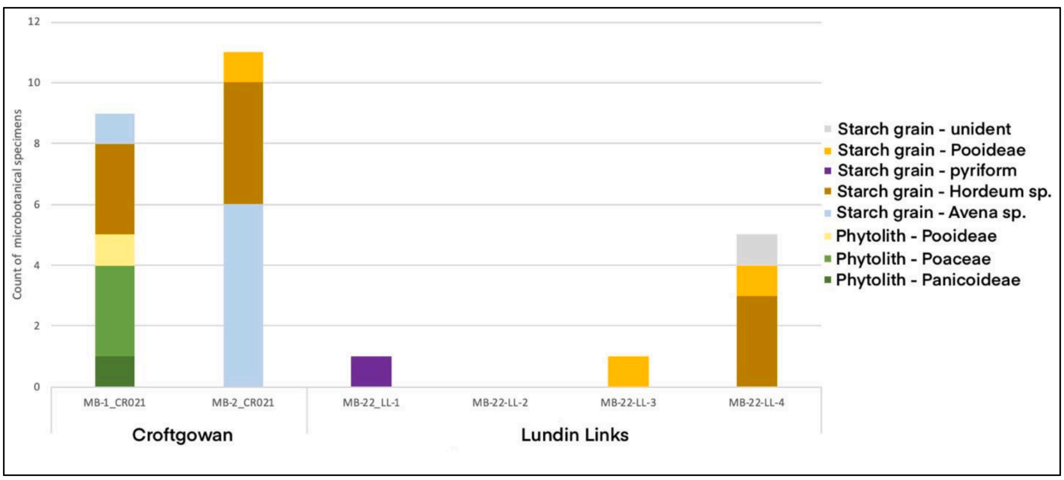

Fig. 7. Phytolith and starch grain residues from human teeth.

in this assemblage (fabric colour range from reddish brown [Mither Tap] to dark brown [all other sites]), and no decoration was observed. Given the scarcity of pottery remains and lack of variation observed in this assemblage we cannot yet interpret a typology of Pictish pottery to assess the presence of dedicated storage or cooking vessels.

Overall, the various strands of evidence point toward cereal-based agricultural foods as the major plant-based elements of Pictish diet, similar to the evidence for post-medieval Scotland when oats and barley were also the dominant plant foods for the majority of the population (Gibson and Smout 2005:59–60; Robertson 2003:255–257). The preference for growing barley and oats, rather than wheat, is well suited to Scotland's cooler temperate climate and highly acidic soils (in addition to cultural preference) as barley and oats typically fare better in these environmental conditions than wheat (Dickson and Dickson 2000:233–234). Surprisingly, no legume starch grains were identified in this study. This is unexpected given the contemporaneous evidence for the regular consumption of legumes (e.g., peas and beans) in medieval Ireland and Anglo-Saxon England (McCormick et al. 2011:46; McKerracher 2018:83,117; O'Sullivan et al. 2014; van der Veen et al. 2013:160). Furthermore, legume family (Fabaceae) starch grains are easily identifiable due to their distinctive reniform or kidney shape and bold longitudinal fissures (Henry et al. 2009). It could be that legumes were processed in different ways or eaten less regularly in the far north of Britain. Extending the study to a wider range of sites and evidence may help corroborate or alter the patterns identified in this study.

5. Conclusions

Pot sherds and human teeth represent two direct lines of evidence for Pictish food consumption and cooking processes vis-à-vis plant remains. The results show a consistent presence of oats and barley within these contexts which suggests cereals were a major component of Pictish diet. One notable difference between the pot sherd and human dental residues was the recovery of cereal inflorescence bract phytoliths almost exclusively from the pot sherds. This potentially suggests that pot sherds were used not only for cooking practices but also for storage. Alternatively, some inflorescence bract phytoliths could have accidentally been added during the cooking process (e.g., grains were not thoroughly dehusked). The results from all sites across the entire Pictish period (c. AD~300–900) were remarkably consistent. The evidence suggests that cereals were a major focus for consumption across social classes, even at what may have been elite settlements (e.g. the Craw Stane complex, Rhynie), and across time and space from c. the 2nd century AD to the 9th century AD and from Inverness-shire to the southern edges of Pictish dominion in Fife.

Future approaches to Pictish pottery analysis could include lipid and protein residue analyses (e.g., Baeten et al. 2013; Cramp et al. 2015; Greenwood et al. 2023). Although these approaches are destructive in comparison to the methods utilised here, the data retrieved from such analyses would be complementary, potentially providing evidence for the animal protein and fat components of Pictish diet (see Correa-Ascencio and Evershed 2014; Evershed 2008). Regarding dental contexts, further comparison with isotopic analyses and potential new datastreams such as aDNA (e.g. Goude et al. 2020; Modi et al. 2020; Rawlence et al. 2014), could also be beneficial to illuminate broader dietary, mobility, and environmental contexts. Such studies would create a more nuanced understanding of individual and community foodways and economy, and the relationship between the plants consumed in Pictish diets and ingredients from animal sources, including dairy and meat products.

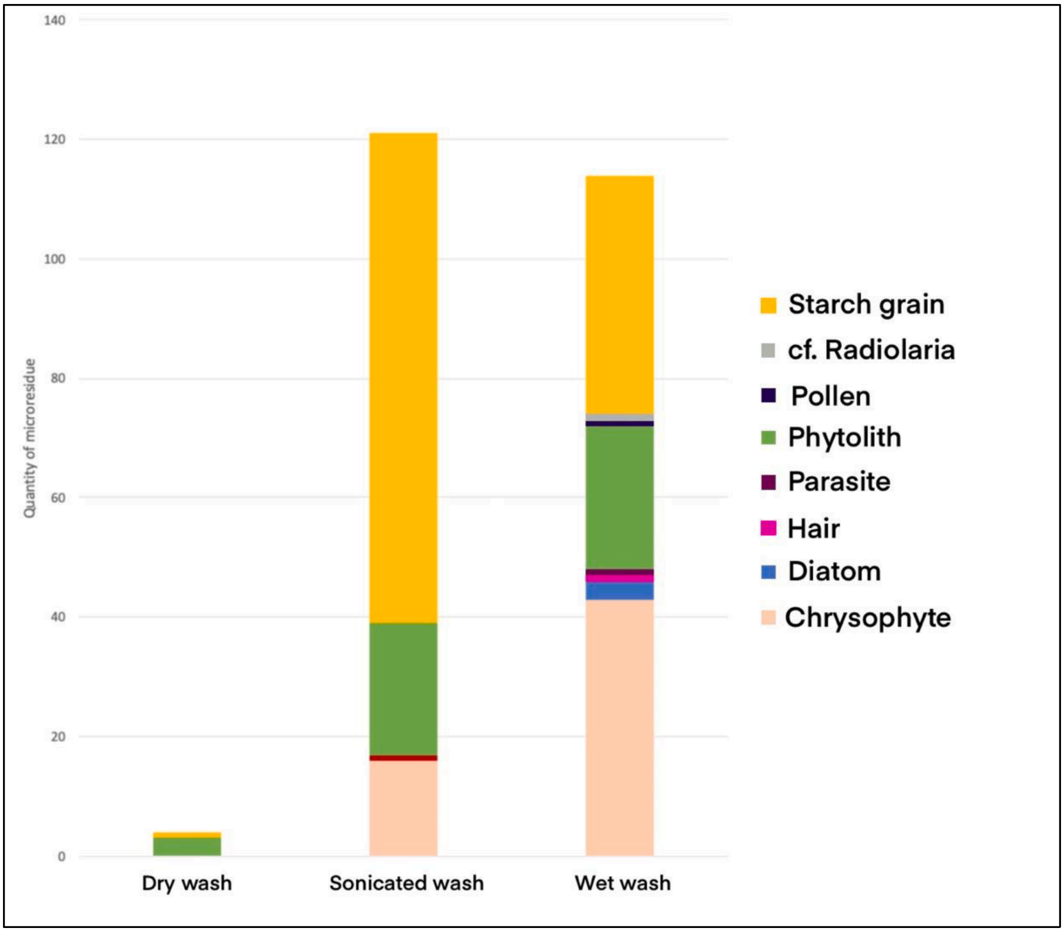

Fig. 8. Quantity of microresidues recovered by wash type (all sites in study).

Expanding this study would also be advantageous if more Pictish pot sherds are recovered in future excavations. Opportunities to sample in other Pictish regions (e.g., Northern Isles Pictish-era settlements) and across the economic spectrum (e.g., more non-elite contexts) would be especially welcome, to provide a broader overview of regional, temporal, and social patterns. Given the rarity of locally made pottery from late Roman Iron Age and early medieval mainland northern Britain, and the potential for post-excavation contamination, we recommend that pot sherds be minimally handled during and after excavation if microbotanical analysis is desired. Rather than brushing off the adhering sediment, this material can be left intact or minimally brushed off by the excavator and placed directly into a sterile sample bag. Sampling from other food related material culture such as quern stones would present other ideal contexts to investigate plant food processing in Pictland.

In sum, this study captured microbotanical evidence of Pictish foodways through the recovery and analysis of starch grains and phytoliths. These proxies suggest that cereals, including oat and barley, were central to Pictish plant use and consumption. Interestingly, no evidence of non-cereal agricultural crops was identified (e.g., legumes), nor was there evidence of other non-cereal foods such as tubers. The cooking methods observed through starch grain damage patterns suggested parching, boiling, and possibly fermentation of cereals. Last meals consumed by the individuals at Lundin Links and Croftgowan could have resembled cereal-based foods such as pottage, porridge, stews, bread, or oatcakes. Through these findings, we get our first glimpse of how the Picts may have cooked and consumed locally grown cereal crops that appear to have been a major feature of Pictish diet and economy.

CRediT authorship contribution statement

Shalen Prado: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Gordon Noble:** Writing – review & editing, Writing – original draft, Project administration, Funding acquisition.

Declaration of Competing Interest

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

Data availability

Supplementary data provided (excel spreadsheet)

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residues from human teeth. Microbotanical sampling was carried out at the University of Aberdeen and microscopic analysis was completed at the McMaster Paleoethnobotanical Research Facility.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2024.104695.

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