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The Potential of Palynology with Regard to the Archaeology of Medieval Monastery Sites in Iceland

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Abstract: In 2014, as part of the Kortlagning klaustur á Íslandi (Mapping Monasticism in Iceland) archaeological project, bulk samples retrieved from various archaeological sites associated with Icelandic monasticism were subsampled for pollen analysis. The objective was to discern something about the character of the past vegetation that surrounded the sites under archaeological investigation as well as to detect the presence of exotic pollen derived from plant species with medicinal, culinary, and other utilities. Two methods were applied: a standard pollen count (up to 300 pollen grains) and rapid scanning (where all pollen were examined but only exotics were recorded). The pollen surveys showed mixed results in achieving the intended insights, mostly due to taphonomic processes (wind and depositional environments), exacerbated by poor chronological resolution. However, there was sufficient data to suggest that careful selection and analysis of subsamples from archaeological contexts can allow some reconstruction of past vegetation communities and land use practices. The presence of cereal type pollen might suggest cultivation and/or storage of grain in association with medieval archaeological contexts. Furthermore, palynology was able to discern some evidence of the importation of plants for medicinal purposes to Iceland.

Keywords: pollen; grasses; cereals; taphonomy; archaeology; monasteries; Iceland

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1. Introduction

Until recently, the impact of monasteries on Icelandic society and environment has largely been dismissed. This has been attributed to nationalistic and sectarian historical perspectives prevailing in the Nordic sphere long after the Lutheran Protestant Reformation of the 16th century (Kristjánsdóttir 2023). It is now understood that the establishment of these monasteries in Iceland was part of the wider development of the Roman Church across Scandinavia and the North Atlantic in the 12th century (Clark 2021). Nor can it be unrelated to a broader renaissance in European monasticism at that time, a movement that has been implicated as a key agent in significant alterations to the European landscape in the name of agricultural improvement (Aston 2000; Bond 2004; Gilchrist 2014).

Icelandic monasteries began accumulating property from foundation. By the 14th century, they were among the largest landowning entities in medieval Iceland, with many maintaining large numbers of livestock on their landholdings (Júlíusson 2014; Kristjánsdóttir 2023). This underpinned their most enduring legacy; the production of manuscripts, e.g., at Helgafellsklaustur (Drechsler 2021) and Þingeyraklaustur (Jensson 2021), artefacts that have since become fundamental to the national identity of Icelanders (Loftsdóttir 2019). Without a doubt, this must have had an impact on the vegetation of the monastic landholdings. Indeed, with reference to pollen studies for Þingeyraklaustur and Viðeyjarklaustur (Figure 1), Icelandic monasteries were actively engaged in altering vegetation on their landholdings e.g., scrub clearance (Riddell et al. 2022) and the introduction or intensification of cereal cultivation (Hallsdóttir 1993). Such activity reflects that of their European contemporaries, i.e., woodland clearance (assarting) and the development of pastoral and arable agriculture (Wimble et al. 2000; Noël et al. 2001; Lomas-Clarke and Barber 2004; Breitenlechner et al. 2010; Hjelle et al. 2010; Stolz and Grunert 2010).

There is also evidence from various sources in Iceland that its medieval monasteries were engaged in the importation of exotic plants for culinary, medicinal, and dyeing purposes (Kristjánsdóttir et al. 2014; Åsen 2021). That there was knowledge of the application of such plants is apparent in an Icelandic manuscript from the 15th century, "The Leechbook of Þorleifr Björnsson", a copy of a Norwegian herbal that lists an array of plants with medicinal properties (Larsen 1927). To this day, relict populations of some of these plants survive at former monastic sites in Iceland (Åsen 2021; Kristjánsdóttir 2023), e.g., *Allium oleraceum* (field garlic) at Bær (in this instance, also present in the local toponymy, i.e., *Laukaflatir*, literally "onion flats"). Meanwhile, limited palynological investigation gives us tantalising glimpses of introduced medicinal plants in association with the archaeology of the Icelandic medieval cloister, e.g., *Artemisia*-type (wormwood/mugwort), *Valeriana officinalis* (valerian), *Sanguisorba officinalis* (great burnet), and *Urtica* spp. (nettle) at Viðeyjarklaustur (Hallsdóttir 1993) and *A. oleraceum*, *Plantago major* (greater plantain) and *Urtica dioica* (common nettle) at Skriðuklaustur (Kristjánsdóttir et al. 2014; Åsen 2021).

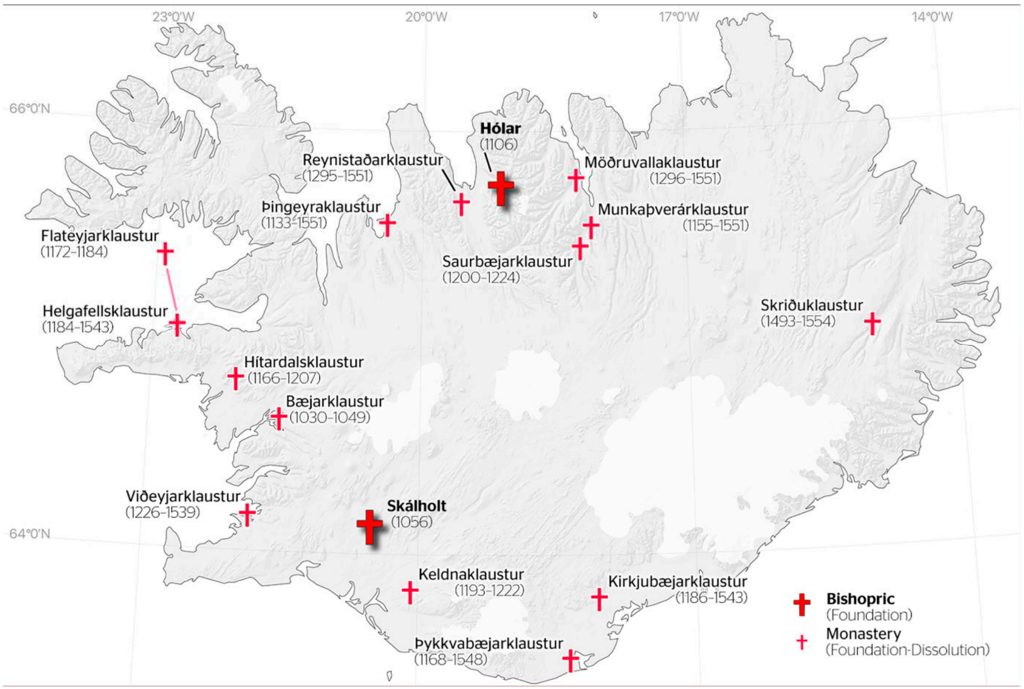

Figure 1. Map of medieval monastic sites in Iceland (courtesy of Benjamin Hennig, University of Iceland).

The incorporation of palynological analysis into wider environmental archaeological surveys is a well-established practice (Bakels 2020; Lechterbeck and Jensen 2020). Most commonly, sediment cores are taken from wetlands or waterbodies in relative proximity to archaeological features, and by marrying the chronologies of the two, vegetation and land use practices are interpreted in relation to the material remains under archaeological investigation (e.g., Einarsson 1962; Hallsdóttir 1993; Erlendsson 2007; Riddell et al. 2018). Alternatively, pollen can be extracted from within the archaeological context, e.g., floor layers, middens, drains, wells, barrels, and other containers in order to gain information about the surrounding landscape or to provide insight into the utilisation of plants in association with the archaeological context (Bakels 2020). Compared to the more conventional evaluation of pollen from wetland or lake sediments, this approach has featured much less in Iceland, only at Gjögur and Svalbarð (Zutter 1999), Skriðuklaustur (Kristjánsdóttir et al. 2014), and

Reykholt (Sveinbjarnardóttir et al. 2007). The palynological material is primarily derived from midden contexts with pollen either sampled directly from the archaeological context or subsampled from bulk samples acquired for other palaeoecological purposes, e.g., macrofossils (with variation in the refinement of stratigraphies).

Here, a crude version of the latter approach is applied, and while it cannot be expected to provide any long-term palynological insight into the evolution of the vegetation communities associated with the archaeology, it can provide a general impression alongside evidence of introduced utilitarian plants. The three sites investigated at the behest of the Kortlagning klaustra á Íslandi (Mapping Monasticism in Iceland; KKÍ) archaeological project are Bær, Reynistaður, and Viðey, all formerly occupied by monasteries in the medieval period, i.e., Bæjarklaustur, Reynistaðarklaustur, and Viðeyjarklaustur, respectively (Figure 1).

2. Methodology

2.1. Study Sites

Bær is a hamlet in Borgarfjörður in western Iceland on the floodplain of the Hvítá. It is situated within an agricultural landscape comprising semi-improved hayfields (formerly wetlands), beyond which are extensive areas of Cyperaceae (sedge) wetland (Ottósson et al. 2016). To the east (c. 1 km), there are marine terraces from c. 14000 BP (Thorarinsson et al. 1959) that have experienced some degree of erosion in the past, portions of which are now naturally recolonised by *Betula* (birch) woodland and actively planted with introduced conifers. Bær is the location of the earliest attempt to found a monastery in Iceland, c. AD 1030 (Figure 1; Bæjarklaustur), by Rúðólfur (Rudolf), an English missionary sent at the behest of the Archbishop of Lund, Sweden. Rúðólfur was apparently a man who literally "knew his onions" according to a legend attributing the introduction of *A. oleraceum* at Bær to him. Bæjarklaustur failed to last more than 20 years with Abbot Rúðólfur, departing for Abingdon, England, c. AD 1049 (Kristjánsdóttir 2023). In 2014, construction work on the church at Bær allowed KKÍ archaeologists a brief opportunity to excavate a small exploratory trench beneath its concrete floor (Kristjánsdóttir and Gunnarsdóttir 2014a). A bulk sample was taken from a 2 cm thick dark brown floor layer (Figure 2A), dated to the medieval period based on associated masonry features, i.e., a carved church foundation stone (Kristjánsdóttir 2017).

Reynistaður is a farm lying on the floodplain of Héraðsvötn in Skagafjörður, northern Iceland. Semi-improved hayfields (formerly wetlands) surround the farm within a wider matrix of heath (*E. nigrum*) and Cyperaceae fen (Ottósson et al. 2016). A Benedictine convent (Figure 1; Reynistaðarklaustur) was founded there in AD 1295, lasting until AD 1551. In 2014, KKÍ archaeologists dug a 2 × 1 m test trench within the remains of what is thought to have been a medieval structure located within the current farmstead (Kristjánsdóttir and Gunnarsdóttir 2014b). A bulk sample was taken from a peat ash and turf layer (34 cm thick), with the turves incorporating tephra from the Hekla eruption of AD 1300 (Figure 2B). The archaeological context is considered to be relatively contemporary with the medieval convent (Kristjánsdóttir 2017).

Viðey is an island just off the north coast of Reykjavík in southwest Iceland. It is no longer farmed and is primarily a recreational area serving the city. It is dominated by Poaceae (grass) with pockets of drained Cyperaceae wetlands (Ottósson et al. 2016). Previous pollen studies have identified a similar prevalence in grassland on Viðey in association with Viðeyjarklaustur (Figure 1) in the medieval period, along with evidence of introduced medicinal plants and the cultivation of cereal crops (Hallsdóttir 1993). The Augustinian house of Viðeyjarklaustur was founded in AD 1226, the institution persisting until AD 1539. Archaeological excavation (Hallgrímsdóttir 1991) has situated the cloister just north of Viðey House, the island's visitor centre. In 2014, KKÍ archaeologists returned to Viðey and dug a 2 × 1 m test trench to the south of Viðey House (Kristjánsdóttir and Gunnarsdóttir 2014c). A bulk sample (between 40 and 60 cm) was taken from a midden (2 m thick) comprising a mix of charcoal, peat ash, burnt bone, and earth (Figure 2C). Based on clay pipes and concrete, the material in the midden was subsequently dated to between the years 1500 and 1950 (Kristjánsdóttir 2017).

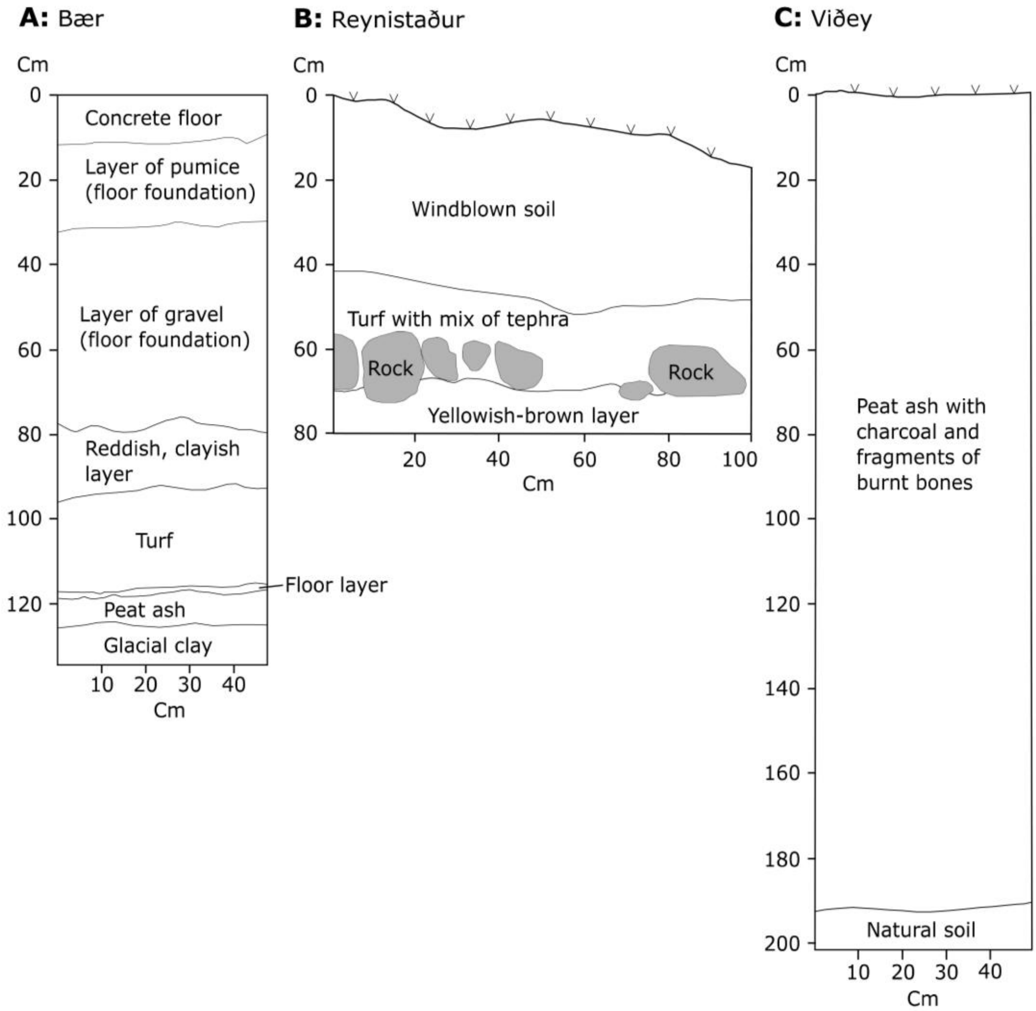

Figure 2. Section drawings of the archaeological contexts from which the bulk samples were acquired for each study site: (**A**) Bær (trench 1), (**B**) Reynistaður (trench 2), (**C**) Viðey (trench 3). The images were redrawn and rescaled from Kristjánsdóttir and Gunnarsdóttir (2014a), Kristjánsdóttir and Gunnarsdóttir (2014b), and Kristjánsdóttir and Gunnarsdóttir (2014c), respectively.

2.2. Pollen Sampling

The bulk samples acquired by the KKÍ archaeological project in 2014 from the three sites described were subsampled in the laboratory for pollen analysis. Preferably, the pollen samples should have been acquired directly from the respective sections in situ and from within an established chronology. However, as this was not the case, the subsampling was limited due to uncertainty about whether or not such mixed material would produce meaningful results (Edwards et al. 2015), compounded further by the limited understanding of the chronological contexts (at the time of subsampling).

The volume of the pollen samples (2 cm^3) was determined by displacement in 10% HCl (Bonny 1972). One *Lycopodium clavatum* tablet (Batch No. 1031) was added to each sample (Stockmarr 1971). Each tablet contained c. 20848 spores and acted as a control for the calculation of palynomorph concentrations in standard counts and rapid scanning. Samples were then rinsed in 10% HCL to remove residual glue derived from the tablet and in 10% NaOH to break down humic material before being sieved (150 µm) to remove coarse material (Moore et al. 1991). Minerogenic material was removed by dense media separation with LST Fastfloat, density 1.92 g/cm^3 (Björck et al. 1978). Acetolysis released the pollen grains from the remaining organic material (Moore et al. 1991). Pollen grains were slide mounted with silicone oil (12,500 cSt) and counted using a microscope at ×400 and ×1000 magnification, enhanced where necessary by oil immersion (refractive index 1.518) according to Moore et al. (1991). Two counting methods were applied:

(1) A standard count where a minimum of 300 pollen grains were counted. Where one or other taxa was overly dominant, i.e., Poaceae, Cyperaceae, or *Betula*, it was necessary to count beyond 300 grains in order to ensure sufficient pollen representation of other taxa (Moore et al. 1991; Caseldine and Hatton 1994).

(2) A rapid scanning approach, where all pollen grains were examined and the taxa were identified. However, only the exotics were recorded in an effort to detect the presence of introduced plant species to Iceland. This entailed examining a minimum of 1500 pollen grains at ×200 magnification (Moore et al. 1991; Tweddle et al. 2005).

In both instances, Moore et al. (1991) was used as the primary pollen key supplemented by the reference collection of the Icelandic Institute of Natural History (Náttúrufræðistofnun Íslands) currently housed in the Faculty of Life and Environmental Sciences, University of Iceland (Háskóli Íslands). Pollen and spore taxonomy and nomenclature were adapted to Icelandic circumstances (Kristinsson 1986; Erlendsson 2007). All Poaceae pollen were evaluated according to Andersen (1979) as potential *Hordeum*-type (barley), i.e., grain size > 37 µm and annulus diameter > 8 µm, or *Avena*-type (oats), i.e., grain size > 45 µm and annulus diameter > 10 µm. Coprophilous fungal spores (CFS) were also incorporated as indicative of livestock presence (van Geel et al. 2003; Cugny et al. 2010).

3. Results

Data (pollen, spores, and CFS) from standard counts are shown in Table 1. Following Kristinsson (1986), these data (excluding CFS) were refined broadly into land use categories for each site (Figure 3). Pollen types that could not be identified to species level, e.g., Brassicaceae (cabbages and mustards), or that are known to occupy more than a single land use type, e.g., *Thalictrum alpinum* (alpine meadow-rue), were removed. As *Betula* can be indicative of either *Betula pubescens* (downy birch) or *Betula nana* (dwarf birch), i.e., woodland and/or heathland, it was treated as a separate category (Karlsdóttir et al. 2007). Apophytes are indigenous taxa that benefit from agricultural practices (Edwards et al. 2011). Indeterminate represents damaged pollen grains that could not be identified to taxa. Rapid scanning data for Bær, Reynistaður, and Viðey are shown in Table 2. The presence or absence of taxa is indicated, and numbers are presented for exotic and/or potentially introduced plant species. Following Andersen (1979), Poaceae pollen grains from Bær are categorised according to annulus and grain size in Table 3 and similarly for *Hordeum*-type from Reynistaður in Table 4.

Table 1. Standard pollen count data for vascular plants, cryptograms, and CFS (percentage of total plant pollen and spores are in parentheses).

Taxa/Monastery	Bær	Reynistaður	Viðey
Pollen			
Anthemis-type	9 (1.8)	-	-
Betula (undiff.)	329 (68)	5 (1.2)	45 (4.4)
Brassicaceae	-	-	-
Caryophyllaceae	-	-	-
Cerastium-type	1 (0.2)	15 (3.6)	6 (0.6)
Cyperaceae	58 (12)	22 (5.2)	123 (12)
Drosera-type	-	1 (0.2)	-
Empetrum nigrum	3 (0.6)	-	3 (0.3)
Ericales	1 (0.2)	-	-
Filipendula ulmaria	1 (0.2)	-	5 (0.5)
Galium	-	-	3 (0.3)

Table 1. *Cont.*

Taxa/Monastery	Bær	Reynistaður	Viðey
Hordeum-type	2 (0.4)	-	1 (0.1)
Lactuceae	1 (0.2)	8 (1.9)	123 (12)
Montia fontana	-	24 (5.7)	-
Plantago maritima	-	-	1 (0.1)
Poaceae	43 (8.9)	250 (59.4)	583 (57)
Polygonum aviculare	2 (0.4)	-	-
Potentilla-type	-	2 (0.5)	1 (0.1)
Ranunculus acris-type	-	3 (0.7)	8 (0.8)
Rumex acetosa	1 (0.2)	1 (0.2)	16 (1.5)
Rumex longifolius	-	-	3 (0.3)
Salix	-	-	-
Thalictrum alpinum	1 (0.2)	7 (1.7)	7 (0.7)
Indeterminate pollen	12 (2.5)	76 (18)	18 (1.7)
Total	464	414	946
Spores			
Botrychium	-	1 (0.2	-
Diphasiastrum alpinum	-	2 (0.5)	-
Equisetum	5 (1)	-	29 (2.8)
Lycopodium annotinum	3 (0.6)	-	1 (0.1)
Pteropsida (monolete) indet.	5 (1)	1 (0.2)	6 (0.6)
Selaginella selaginoides	-	2 (0.5)	2 (0.2)
Sphagnum	8 (1.6)	1 (0.2)	44 (4.3)
Total	21	7	82
CFS			
Sordaria-type (HdV-55a)	-	4	70
Sporormiella-type (HdV-113)	-	-	1
Podospora (HdV-368)	-		1
Total	-	4	72

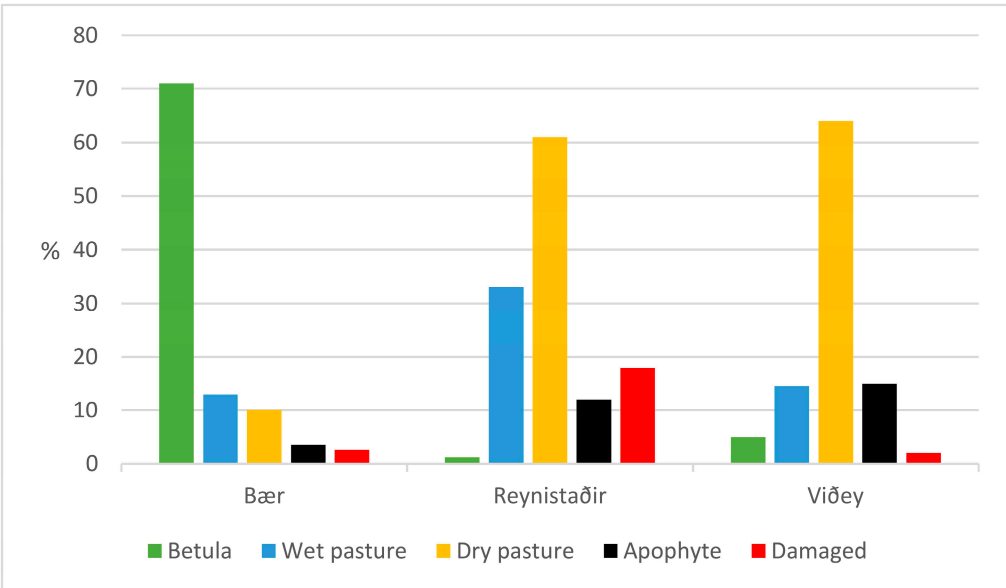

Figure 3. Indicative land use and pollen condition at Bær, Reynistaður, and Viðey.

Table 2. Additional pollen and spore data derived from rapid scanning.

Taxa/Monastery	**Bær**	**Reynistaður**	**Viðey**
Pollen			
Ambrosia-type	-	2	-
Angelica-undiff.	●	-	-
Artemisia-type	-	-	-
Avena-type	3	-	-
Brassicaceae	●	●	-
Calluna vulgaris	●	-	-
Caltha palustris	●	-	-
Caryophyllaceae	●	●	-
Cornus suecica	-	-	-
Drosera-type	-	●	●
Empetrum nigrum	●	●	●
Filipendula ulmaria	●	●	●
Galium	●	●	●
Hordeum-type	70	10	1
Lychnis viscaria-type	●	●	-
Parnassia palustris	-	-	-
Pinus	1	-	-
Plantago major	-	-	1
Plantago maritima	●	-	●
Polygonum viviparum	-	-	-
Potentilla-type	●	●	●
Rumex acetosella	●	-	-
Sagina	-	●	-
Salix	●	-	-
Saxifraga stellaris/nivalis	-	-	●
Sorbus aucuparia	●	-	-
Vaccinium-type	●	-	-
Valeriana officinalis	-	-	1
Spores			
Diphasiastrum alpinum	●	●	-
Lycopodium annotinum	-	●	●
Polypodium vulgare	-	-	-
Selaginella selaginoides	●	●	●

Table 3. *Hordeum*-type and *Avena*-type pollen grains from Bær.

Pollen-Type	Annulus Size (µm)	Grain Size (µm)	Pollen-Type	Annulus Size (µm)	Grain Size (µm)
Hordeum-type	≥8 and ≤10	≥37 and ≤45	*Hordeum*-type	≥8 and ≤10	≥37 and ≤45
	9	38		9	40
	8	37		9	38
	8	45		8	42
	8	38		9	38
	8	42		10	45
	9	38		9	38
	8	43		8	40
	8	38		9	42
	9	41		10	38
	8	38		9	44
	9	45		8	39
	9	40		8	41
	9	43	Average	8.5	40
	8	39			
	8	37	cf. *Avena*-type	>10	>45
	8	42		12	46
	10	41		10	49
	8	39		10	50
	9	40	Average	10	48
	8	43			
	9	39	*Hordeum*-type and *Avena*-type traits		
	8	38		9	47
	8	37		9	46
	8	40		11	37
	8	38		8	46
	8	42		11	43
	8	39		8	46
	8	45		9	49
	8	38		9	50
	8	38		11	44
	9	38		8	46
	10	44	Average	9.3	45.4
	10	38			
	8	37			
	8	38			
	9	45	Summary		
	8	40	*Hordeum*-type	52	80%
	8	42	cf. *Avena*-type	3	5%
	8	37	Shared traits	10	15%
	10	38	Total	65	-

Table 4. Ten *Hordeum*-type pollen grains from Reynistaður.

Hordeum-Type	Annulus (≥8 and ≤10 µm)	Grain Size (≥37 and ≤45 µm)
	9	45
	8	38
	8	38
	8	41
	8	37.5
	9	37
	10	38.5
	10	37
	8	37
	8	37
Average	8.6	38.6

4. Discussion

Before evaluating the individual pollen samples, it is important to consider how the said pollen may have arrived at the sampling sites. Some pollen can be derived from plants that rely on insects for pollination (entomophilous). Such pollen tends to not travel far from the parent plant due to its large size, while pollen productivity is also low (Moore et al. 1991; Hjelle 1997; Bakels 2020). Therefore, the majority of the pollen evaluated in palynological studies are wind-dispersed (anemophilous) and derived from both local and regional vegetation communities, especially within an open landscape such as that found in Iceland following human colonisation, c. AD 877 (Moore et al. 1991; Edwards et al. 2021). A further factor is the pollen that originates from farther afield, which can be described as exotic (Berglund 1985; Moore et al. 1991). If Saharan dust can reach the shores of Iceland (Varga et al. 2021), anemophilous pollen may travel with it from Africa and Europe. For example, the *Pinus* (pine) pollen found at Bær (Table 2) is a feature common to many Icelandic Holocene pollen assemblages (Björck et al. 1992; Hättestrand et al. 2008). However, there is no other evidence from the Holocene that any species of *Pinus* has ever colonised Iceland prior to the establishment of modern forestry in the early 20th century. As a general rule, such pollen rarely alters the character and interpretation of indigenous pollen assemblages (Hättestrand et al. 2008), although it is a factor that will be considered here in relation to the pollen of plants that may (or may not) have been introduced to Iceland through human agency. With regard to the two types of archaeological context from which the pollen of this study are derived, the midden from Viðey is perhaps the most vulnerable to capturing far-travelled pollen, exposed as it was to the elements (Moore et al. 1991). In theory, pollen found within structures at Bær and Reynistaður are more likely to reflect local or regional vegetation given the containment of the depositional context (Edwards et al. 2015), although this does not preclude infiltration by far-travelled, exotic pollen types, e.g., *Pinus* at Bær.

On top of the complications imposed by plant pollen dispersal mechanisms, archaeological contexts comprise material from a wide range of sources that are regularly disturbed by human actions (Edwards et al. 2015). Pollen can be delivered into a building accidentally via footwear, clothing, livestock, fodder, flooring, roofing (e.g., reeds, straw, heather etc.), and construction material. The latter has particular resonance in Iceland as many buildings until the 20th century were constructed or partially constructed of turves and peats. These building materials, especially peat, will harbour pollen derived from a much earlier period than that of the archaeological depositional environment. This also applies to archaeological deposits that contain soot and ash derived from burnt peats as the pollen contained within the peats is resilient to fire and will persist in the ash (Morgan et al. 2014). Other than the descriptions of the archaeological contexts, in this instance, the only means of discerning whether or not pollen assemblages have been compromised is the prevalence of damaged, indeterminate pollen grains as representative of older, reworked pollen (Edwards et al. 2015). However, it should be borne in mind that high levels of indeterminate, damaged pollen grains might reflect the pollen preservation conditions (aerobic/anaerobic) of the archaeological context itself (Moore et al. 1991; Edwards et al. 2015). The infiltration of pollen assemblages by older pollen may also be intimated by a disproportionate representation of Cyperaceae, *E. nigrum*, *Sphagnum* moss, and *Betula*, which is characteristic of pre-AD 877 vegetation communities, e.g., wetland and/or woodland (Hallsdóttir 1995).

Note that there are native and naturalised Icelandic plants in all of the aforementioned assemblages (Tables 1 and 2) that have utility with regard to medicine, cooking, and dyeing (Kristjánsdóttir et al. 2014; Åsen 2021), e.g., *Angelica*, *Filipendula ulmaria* (meadowsweet) and *Anthemis*-type (e.g., *Achillea millefolium*; yarrow). As these are common and widespread taxa in Iceland (Kristinsson 1986), it is impossible to say with certainty that their presence in pollen assemblages from archaeological contexts is exclusively down to human agency.

4.1. Land Use and Cereals at Bær

As shown in Table 1 and Figure 3, only a very limited percentage of the pollen from Bær was indeterminate (2.5%), i.e., there was little influx of older, reworked pollen from elsewhere. This is unsurprising as neither turves nor peat ash are described in relation to this archaeological context. Tentatively, the conclusion is that the pollen within the Bær assemblage is relatively contemporary with the depositional environment. *Betula* values (70%) were unexpectedly high for a medieval context given that woodland was considerably reduced in Iceland following settlement in the late 9th century (e.g., Einarsson 1963; Hallsdóttir 1987; Erlendsson 2007). However, based on the aforementioned indeterminate pollen values for Bær (Figure 3), there is little to suggest that this *Betula* pollen is reworked from peats (Cyperaceae and *Sphagnum* values are also much lower in comparison). It is possible that this *Betula* pollen might have been derived from *B. pubescens* woodlands in nearby Skorradalur, which survived land clearance and grazing impacts until the 16th century (DI-VI 1857–1986; DI-VII 1857–1986; DI-VIII 1857–1986; DI-X 1857–1986), the pollen being delivered to Bær by prevailing south easterly winds (Icelandic Meteorological Office 2014). On the other hand, *B. nana* may have been a component of the wetland vegetation communities that surrounded Bær in the middle ages as it is currently, e.g., in black sedge–brown moss and common cotton-grass fens (Ottósson et al. 2016). Otherwise, in relation to other pollen and land use categories (Table 1 and Figure 3), wet and dry pastures occur, somewhat akin to that present within the landscape surrounding Bær today. This interpretation is largely based on Poaceae and Cyperaceae values, with low values for apophytic taxa including *Anthemis*-type, *Cerastium* (chickweeds), *Hordeum*-type, *Polygonum aviculare* (common knotgrass), and *Rumex acetosa* (common sorrel). Of Abbot Rúðólfur's onions, nought was found, perhaps due to the entomophilous nature of *Allium*-type (onion) pollen.

With regard to the rapid scanning data for Bær, this process revealed a very high number of Poaceae grains (65) that might be considered as derived from cereal crops, i.e., *Hordeum*-type and cf. *Avena*-type (Table 3). This is a large number by Icelandic palynological standards, with *Avena*-type being particularly rare (Edwards et al. 2011). The distinction between *Hordeum*-type and *Avena*-type remains ambiguous as there is significant overlap in pollen grain and annulus size between these genera (Tweddle et al. 2005). Furthermore, in order to draw any firm conclusions concerning the presence of cereals at Bær, it is first necessary to eliminate the possibility that these cereal-type pollen grains are actually representative of wild grasses.

Hordeum-type could potentially be characteristic of *Leymus arenarius* (Lyme grass), a common grass in Iceland occupying dynamic and mobile sands by the seashore, glacial outwash plains (sandur), volcanic areas, and the Highland interior (Kristinsson 1986; Greipsson and Davy 1994). More recently, it has naturally colonised areas of severe erosion and has been actively used in land reclamation projects in Iceland from the early 20th century (Greipsson and Davy 1994). These habitat preferences are in stark contrast to those available in the immediate vicinity of Bær today and prior to the extensive drainage networks introduced in the 20th century were presumably even further removed from the needs of *L. arenarius* in the past. In the wider region, Bær is located some distance from environments commonly associated with *L. arenarius*, although there are some areas of exposed marine terrace (Thorarinsson et al. 1959) to the east of the hamlet (c. 1 km or more). Such erosion in lowland Iceland is considered to have arisen as a consequence of land use practices and deteriorating climate conditions from c. AD 1500 (Dugmore et al. 2009), i.e., from the end of the medieval period. In relation to pollen identified as cf. *Avena*-type, with reference to Tweddle et al. (2005), the greatest confusion likely to arise in Iceland pertains to *Glyceria fluitans* (floating sweet-grass). This species is widespread in southwest Iceland in ditches and small waterbodies (Kristinsson 1986) and may have been present in the vicinity of Bær in the medieval period, e.g., oxbow lakes associated with the Hvítá.

Bearing in mind the dispersal limits of large-grained Poaceae pollen (Vuorela 1973) and the habitat conditions (and their evolution) within the vicinity of Bær, the *Hordeum*-type and cf. *Avena*-type pollen grains are unlikely to be derived from wild grasses. A concurrent pollen assemblage that is agricultural in character (forgoing the *Betula* signal; Figure 3) and the fact that these grains are derived from the interior of a building also favours the possibility that they originate from domestic cereals. It is conceivable that cereals were grown in the fields surrounding this building, with such cultivation persisting in southwest Iceland into the 16th century (Ólsen 1910; Karlsson 2000). Alternatively, on the premise that as self-pollinators *Hordeum*-type and cf. *Avena*-type pollen are unlikely to travel more than a few metres from the parent plant (Tweddle et al. 2005), grain or straw (either grown locally or imported) was stored inside the building (Hald et al. 2018).

The archaeological context is thought to lie within a church building. It is not a place one would expect fodder or grain to be stored, but churches in Iceland were sometimes used as storehouses in the past (Vésteinsson 2009). Whether or not it is indigenous or imported in origin, it is difficult to place this material within a monastic context given the short duration of Bærjarklaustur (AD 1030–1049) and the unrefined chronology (broadly medieval) of the original bulk sample. There is a reference to 18 small barrels of "*miöl*" from Bær in AD 1480 (DI-VI 1857–1986) that might provide some context for these cereal pollen; "*miöl*" (modern Icelandic: *mjöl*) translates as "meal", which in its widest sense can refer to any ground plant material but is most commonly used to refer to milled grain, especially barley and oats (Árnarson 2002). Note though that *L. arenarius* was gathered by Icelanders until relatively recently to make a flour in lieu of conventional cultivars. It is not impossible that this occurred at Bær in the medieval period, but this harvest is more commonly associated with farms close to the coast and sandur of southern Iceland (Guðmundsson 1996).

4.2. Land Use and Cereals at the Convent at Reynistaður

With regard to the wider landscape at Reynistaður, a pastoral regime appears to have held sway after AD 1300 (Table 1 and Figure 3). Poaceae values are high and accompanied by a suite of apophytes, including *Cerastium*, *Montia fontana* (blinks), *R. acetosa*, and *T. alpinum*, with the addition of *Sagina* (pearlwort) via the rapid scan (Table 2). Indeterminate values are relatively high (18%), perhaps unsurprisingly given an archaeological context comprising turves and peat ash. If this is an indication of infiltration by older pollen grains, it is likely that this elevates the Cyperaceae signal the most as the peats will be derived from the wetlands where Cyperaceae was dominant.

Hordeum-type pollen (10) was identified at Reynistaður through rapid scanning (Table 4); this would have been entirely missed using a standard count alone. Again, given its presence within a structure and the limited propensity for pollen dispersal by cleistogamous cereal plants (Vuorela 1973), it is possible that *Hordeum*-type entered the building with imported grain or following a harvest (Hald et al. 2018). The fact that apophytes mostly comprise taxa associated with disturbed ground (Kristinsson 1986), e.g., *Cerastium*, *Sagina*, with *M. fontana* particularly well represented, lends some weight to this interpretation (although not definitively). It is also worth noting that *Hordeum vulgare* (six-row barley) was grown at Reynistaður between the late 9th century and the 11th century based on macrobotanical evidence, i.e., kernels, rachis, and glumes (Trigg et al. 2009). In terms of eliminating the presence of *L. arenarius*, the land in the immediate vicinity of Reynistaður is dominated by wetland and grassland with pockets of exposed glacial till (Ottósson et al. 2016). Wetlands were presumably more extensive prior to 20th century agricultural improvement, while it is possible that the erosion of the moraines in this lowland context only arose after AD 1500 (Dugmore et al. 2009). Even if the erosion occurred earlier, the gravels (as opposed to sand) of glacial moraines are not favoured by *L. arenarius* (Kristinsson 1986).

Two exotic *Ambrosia*-type (ragweed) pollen were identified in the pollen assemblage of Reynistaður via rapid scanning (Table 2). This could represent the Mediterranean plant *Ambrosia maritima* (sea ragweed), which has been long known to harbour medicinal properties (Abu-Rabia 2012). However, the majority of the species of the genus originate in North America and have evolved as specialists with regard to pollen dispersal by wind, including the ability to clump pollen together to maximise pollen circulation (Martin et al. 2009; Bullock et al. 2013). This means that a large number of *Ambrosia*-type pollen can travel some distance from the point of origin, with wind dispersal the most likely explanation for its presence in medieval Iceland.

4.3. The Midden at Viðey

A less chronologically refined set of circumstances applies to the pollen assemblage from the peat ash midden at Viðey (16th–20th century). Effectively an anthrosol, this midden context is heterogeneous, having likely received pollen from various sources, i.e., pollen contained within dumped material (ash, straw, dung, and household waste); regional and continental windblown pollen; and pollen from its immediate environs, especially from plants growing on the midden. In broad habitat and land use terms (Table 1 and Figure 3), the island about the midden was dominated by grassland supporting a range of apophytes, e.g., *Galium* (bedstraw), *R. acetosa*, and *T. alpinum*, with pockets of Cyperaceae wetland. This is consistent with the vegetation associated with Viðey prior to AD 1500 (Hallsdóttir 1993; Bjarnadottir 1997) as well as that of the present (Ottósson et al. 2016). As a measure of how much older or reworked pollen has infiltrated the sample via peat ash, low values of indeterminate pollen tells us little (Table 1 and Figure 3). *Pinus*, as an indicator of long-distance pollen dispersal, is limited to a single pollen grain (Table 2), suggesting that pollen from farther afield does not influence the general character of the pollen assemblage (Hättestrand et al. 2008). High CFS values (72) are probably derived from animal dung being cast on the midden or grazing on and around this nutrient-rich habitat (Table 1).

More specifically, as a waste heap, the midden provided the perfect conditions for colonisation by particular types of plants (Kristinsson 1986), i.e., *P. major* (Table 1) and *Rumex longifolius* (northern dock; Table 2). Both species are considered introduced, now naturalised, with the former recorded from the 17th century and the latter from the 18th century (Wasowicz 2018). In terms of pollen types (Moore et al. 1991), *Rumex longifolius* is favoured over *Rumex obtusifolius* (bitter dock), which is considered a casual alien species in Iceland (Wąsowicz 2020). Despite the chronological differences, it is notable that *P. major* has been identified in the pollen record from the medieval monastic context of Skriðuklaustur (Figure 1). With this in mind, it is possible that the presence of *P. major* at Viðey is a legacy monasticism, having arrived there as a result of its medical applications (Samuelsen 2000; Kristjánsdóttir et al. 2014), and especially because it is not the only pollen from a plant with utilitarian properties that has been found there. A single grain of *V. officinalis* pollen was detected in the Viðey midden pollen assemblage via rapid scanning and is of interest as it has been identified in another pollen assemblage from Viðey (Hallsdóttir 1993), while a relict population of *V. officinalis* survives on Viðey to this day (Kristjánsdóttir et al. 2014). A clear continuity is apparent with regard to the presence of *V. officinalis* on the island since the medieval period and it is believed to have originated from a monastic milieu. The case in favour of *R. longifolius* as a deliberately introduced plant is weaker, but it has been used for dyeing wool in Iceland in the past (Pluenneke 2017). It must also be acknowledged that *P. major*, *R. longifolius*, and *V. officinalis* occur in other, nonecclesiastical pollen assemblages from Iceland and might have been first introduced to Iceland at the time of settlement, c. AD 871 (Edwards et al. 2011). Of final note is the presence of a single *Hordeum*-type pollen grain in the midden of Viðey (Table 1). Little can be said of this other than to remark that Hallsdóttir (1993) has shown that barley was grown on Viðey from before as well as during the monastic period.

5. Conclusions

The standard counts allowed some insight into the nature of the phytosocial context surrounding the sites of Reynistaður, and Viðey, although based on the chronologies, only Bær and Reynistaður are representative of the medieval period and only the latter site might pertain directly to a monastic context. Furthermore, this provides nothing more than a mere snapshot of the vegetation communities found in the near vicinity of the sampling sites, with no sense of their development, irrespective of the time period. The solution here would be to secure a sequence of pollen samples with a more clearly defined chronology and a refined sampling process akin to the approach of Zutter (1999) or Erlendsson (2007). Concerning taphonomy, older pollen originating from turves and peat ash do not seem to have overly influenced the interpretation of the samples, although the measure applied (indeterminate pollen) is crude.

Both the standard count and rapid scanning method were successful in identifying exotic plant species at Reynistaður (*Ambrosia*-type) and Viðey (*P. major*, *R. longifolius* and *V. officinalis*). *Ambrosia*-type probably arrived at Reynistaður via the wind while at Viðey we might be reasonably confident of a legacy of monastic agency, i.e., *V. officinalis* and possibly, *P. major*, with *R. longifolius* inconclusive. Note that some of these species would have been missed using the standard count method alone.

The application of rapid scanning with regard to Bær and Reynistaður was revealing in relation to cereal-type pollen grains, detecting material that would also have been entirely missed through the standard count. This is important in relation to the ongoing scholarly discourse on cereal cultivation in medieval Iceland (Ólsen 1910; Sveinbjarnardóttir et al. 2007; Zori et al. 2013; Riddell et al. 2018; Mooney and Guðmundsdóttir 2020). However, although it is certainly possible that barley and oats were being grown at Bær and Reynistaður, it remains uncertain, and *Hordeum*-type and *Avena*-type pollen could equally be representative of imported grain (Sveinbjarnardóttir et al. 2007). In this instance, perhaps the pollen is more informative archaeologically concerning the use of these structures (van Amerongen 2020). At Bær, the building is understood to be a church, but this does not preclude its use as a storehouse. The case is less clear-cut at Reynistaður as its *Hordeum*-type pollen could be from an outhouse or a domestic context.

This very small dataset has perhaps provided more insight than would be generally expected. It has allowed some comprehension of past land use practices at three different localities, two of which are situated in the medieval period and one potentially contemporary with a monastic institution (Reynistaður). The presence of cereal-type pollen at these two medieval sites is of particular interest (within limits) and has provided some understanding of their respective archaeological contexts. In relation to exotic plant species, there is nothing contemporaneous with Iceland's medieval monasteries but continuity in their legacy is apparent at Viðey, i.e., *V. officinalis*. Overall, with careful consideration, more pollen sampling, and firmer chronologies, there is much scope for continued pollen studies in association with monastic sites and other archaeological investigations in Iceland, more so if considered alongside other palaeoecological material, such as invertebrate and/or plant macrofossils, e.g., Zutter (1999); Sveinbjarnardóttir et al. (2007); Erlendsson et al. (2009).

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