

Title

Food production, processing and foodways in Neolithic Ireland

Authors

Meriel McClatchie^{1*}, Rick Schulting², Rowan McLaughlin³, Nicki Whitehouse⁴, Sue Colledge⁵, Amy Bogaard² and Phil Barratt⁶

* Corresponding author

1 School of Archaeology, University College Dublin; meriel.mcclatchie@ucd.ie, ORCID 0000-0001-6371-333X

2 School of Archaeology, University of Oxford; ORCID0000-0002-4444-766X; 0000-0002-6716-8890.

3 School of Geography, Archaeology and Palaeoecology, Queen's University Belfast; ORCID 0000-0003-4923-1339

4 School of Geography, Earth and Environmental Sciences, University of Plymouth; ORCID 0000-0002-7044-6492

5 Institute of Archaeology, University College London; ORCID 0000-0002-1112-0978

6 Cognition Institute, University of Plymouth

Meriel McClatchie is an Assistant Professor in Archaeology, University College Dublin. Her primary research interests are environmental archaeology, archaeobotany, food, settlement and later prehistory. Meriel is currently undertaking research in north-west and south-east Europe, and previously worked in east Africa.

Rick Schulting is an Associate Professor in Scientific and Prehistoric Archaeology, University of Oxford. He has a long-standing interest in the Mesolithic-Neolithic transition across western Europe, and particularly in Ireland and Britain, which he has approached primarily through radiocarbon dating and stable carbon and nitrogen isotope analyses. Other active research areas include prehistoric southern Siberia and Japan.

Rowan McLaughlin is a Research Fellow, Queen's University Belfast with wide interests in archaeology, palaeoecology and population history.

Nicki Whitehouse is an Associate Professor/Reader in Physical Geography, University of Plymouth. She is an environmental archaeologist interested in the processes of physical and ecological development of the Holocene landscape, and the transition to agriculture to answer questions around food production, land use and adaptations to new conditions.

Sue Colledge is an Honorary Senior Lecturer, Institute of Archaeology, UCL. Her main research interests are the origins, spread and development of farming in SW Asia and Europe and quantitative methods in archaeobotany.

Amy Bogaard is a Professor of Neolithic and Bronze Age Archaeology, University of Oxford. Her research interests include Neolithic and Bronze Age archaeology, archaeobotany, early farming practice and land use in Europe and western Asia, present-day traditional farming practice, stable isotopes and palaeodietary studies, and social inequality

Philip Barratt is a Research Facilitator for the Cognition Institute at the University of Plymouth. His principle research interest is in chronology: developing models to provide new frameworks for interrogating environmental and archaeological data.

Abstract

When compared with earlier periods, the Neolithic period in Ireland (4000–2500 cal BC) witnessed enormous changes in the types of foods being produced, and the work involved in production and processing of these foods. Several new crops were introduced – archaeobotanical studies indicate that emmer wheat became the dominant crop, with evidence also for barley (hulled and naked) and flax. Gathered resources were not abandoned when farming arrived into Ireland. On the contrary, there is substantial archaeobotanical evidence for a variety of nuts, fruits and leafy greens. Zooarchaeological studies indicate that new animals were also brought into Ireland, including domesticated cattle, pig and sheep. Recent studies have provided substantial information on the timing and nature of these new ways of farming and living, but the focus is often on ingredients rather than processed food products. There are many challenges in determining which foods were being made with these new crops and animals, and in assessing their dietary and social importance. While cereals have been found at many Neolithic sites in Ireland, for example, it is not clear if they are being ground, boiled or other techniques are used for their processing. In this paper we explore aspects of food production, processing and foodways in Neolithic Ireland, drawing upon evidence from archaeobotany, zooarchaeology, human skeletal remains and artefacts.

Keywords

Neolithic, agriculture, archaeobotany, zooarchaeology, food, quern, isotope

Introduction

The arrival of agriculture into Europe has long been a focus for archaeological and palaeoecological research (College et al. 2005; Colledge et al. 2013). Recent years have seen a great increase in research, reflecting the emergence of enlarged datasets, new scientific techniques for analysis of remains, and more integrated studies that draw together archaeological, anthropological and ethnographic approaches. There is clear evidence for the presence of agriculture in Ireland soon after 4000 cal BC (Cooney et al. 2011; Whitehouse et al. 2014), later than many other regions of Europe (Colledge et al. 2005), although it is possible that there was small-scale activity and perhaps ‘failed’ events during the preceding centuries (Sheridan 2010). The arrival of farming coincided with new ways of living, including the introduction of pottery, grinding stones such as saddle querns, substantial rectangular houses and mortuary monuments for the dead (Cooney 2000; Smyth 2014). Ceramic vessels provided new ways of storing, processing and presenting foods, while querns enabled new ways of processing foods. Houses provided new arenas for the storage, preparation and consumption of foods, introducing new engagements with commensality and the ways in which people came together to share a meal. In the case of Ireland, food studies have often focused on evidence from archaeobotanical and zooarchaeological remains, usually drawing on the rather small datasets available (Monk 2000; McCormick 2007).

Many large-scale excavations have taken place in Ireland over the past three decades. These excavations were associated with a boom period of infrastructural, housing and industrial development from the mid-1990s to late-2000s. Excavations often included environmental analyses and radiocarbon-dating programmes, which has resulted in much enlarged, high-quality archaeobotanical and zooarchaeological datasets. Analysis of these datasets is transforming our understanding of many aspects of past societies in the prehistoric and

historic periods throughout Ireland. Pertinent to this paper is the wealth of new data now available from excavations of Neolithic sites. The *Cultivating Societies* project was established in 2008 with the support of the Heritage Council's INSTAR programme to examine the nature, timing and extent of agricultural activity in Neolithic Ireland through collation and analysis of different strands of published and unpublished archaeological and environmental evidence, with a focus on plant macro-remains, pollen, settlement and ^{14}C data. Several project papers have already been (Whitehouse et al. 2014; 2018; McClatchie et al. 2014; 2016; McLaughlin et al. 2016; Schulting et al. 2017). In this paper we present results from an integrated analysis of archaeobotanical and zooarchaeological data. We also consider other aspects of material culture, such as grinding stones (querns) and ceramics, as well as evidence from stable isotope analyses, to provide explore plant and animal foods and foodways in Neolithic Ireland.

Materials and methods

Archaeobotanical and zooarchaeological data were collated from 52 excavated sites (Figure 1). The focus of the original study was archaeobotanical data, which meant that all collated sites contained archaeobotanical remains, and some, but not all, contained zooarchaeological remains. A targeted approach was taken to data collation, focusing on sites where the final excavation report had been completed and radiocarbon dates were available, or datable material was available for a new programme of radiocarbon dating. As well as collating available radiocarbon dates from excavation reports, the *Cultivating Societies* project undertook an extensive, targeted AMS ^{14}C dating programme, which provided 187 new determinations to refine site chronologies further (Whitehouse et al. 2014). The dates were obtained from short-lived species (mainly cereal grains and hazelnut shell, *Corylus avellana* L.). Where possible, two new dates were achieved from the same context (paired dates) to

increase precision through modelling, using the Bayesian-based OxCal programme (Bronk Ramsey 2008). Based on these results and associated archaeological evidence, five chronological phases were defined: Early Neolithic (I & II), Middle Neolithic (I & II) and Late Neolithic (Table 1; Whitehouse et al. 2014). The present analysis has combined Middle Neolithic II and Late Neolithic sites due to the small number of sites available (five Middle Neolithic II, four Late Neolithic and two Middle Neolithic II/Late Neolithic). Where calibrated date ranges spanned different periods, sites were assigned to a broader Neolithic category (NEO).

In the case of plants, most of the data were derived from charred remains, with occasional waterlogged remains. While charring does enable preservation of organic remains, it is not a complete record of people's engagement with plants in the past. Charred plant remains are often biased in favour of plants that are more likely to come into contact with fire, such as cereal grains being dried before storage, or nutshell being used as fuel or burnt as waste. Plants that are less likely to come into contact with fire, such as fruits eaten raw, are less apparent in the archaeological record (Colledge and Conolly 2014).

In the case of animal bone, records of burnt and unburnt bone were collated. The quantity of specimens (NISP; Number of Identified Specimens) had been reported in most cases, while MNI (Minimum Number of Individuals) estimations were reported only occasionally. Assemblages were often small, which affected the types of analyses that could be completed in the current study. Elsewhere in Neolithic Europe, determination of age/death in zooarchaeological specimens is often undertaken to assess slaughter patterns and farming and consumption practices (College et al. 2013), but unfortunately the Irish assemblages were too small for such investigation. The small assemblages are likely to reflect recovery techniques

in Ireland, where sieving of archaeological deposits to recover bone is not standard practice; this means some bones and bone fragments, particularly smaller specimens, are likely to have been missed.

Analyses were undertaken to explore the frequency of different categories of plants and animals across time and context. Changing husbandry patterns through the course of the Neolithic were explored. The context in which plant and animal remains were evident was also investigated. The presence of quern-stones and ceramics was assessed to further consider food preparation. New insights could be gleaned from detailed analyses of the collated archaeobotanical and zooarchaeological data, and the results of these analyses are detailed below.

Results

Archaeobotany

Detailed archaeobotanical evidence has been presented elsewhere (McClatchie et al. 2014; 2016; Whitehouse et al. 2014) and will just be summarised here. Plant remains were recorded at 52 sites (all collated sites; Table 2). Interestingly, plant remains were found to be absent from very few sites where environmental sampling had been undertaken. Plant remains were not recorded at any EN I sites. Plant remains were most often found at EN II sites, many of which were rectangular structures ('houses'). MN I sites often comprised pit and post-hole complexes – some of which may represent structures –while MN II/LN sites were more varied, comprising pit/post-hole complexes, structures and passage tombs. Plant remains were also recorded at three NEO sites that could not be dated to any specific sub-period.

While cereals were most often found at ‘domestic’ structures and pit/posthole complexes, cereals were also found at burnt mounds, a burial and a causewayed enclosure, suggesting that cereals played a role in a wide range of activities. Cereals were recorded at 86% (24/28) and 90% (9/10) of EN II and MN I sites, respectively (Figure 2). EN II cereals were most often associated with rectangular structures, while MN I cereals were recorded mainly at pit and post-hole complexes (McClatchie et al. 2016). This level of engagement with cereals did not persist, however. A very different picture emerged during the MN II/LN period, when cereals were recorded at only 36% of sites (4/11; 2 MN II sites and 2 LN sites), all of which were structures/possible structures. None of the cereals from MN I/LN sites have been directly radiocarbon dated, and it is possible that some records may not actually be Neolithic (see McClatchie et al. 2016, 305 for discussion of residual material).

Wild plants, including hazelnuts and fruits, were also recorded at many EN II and MN I sites (Figure 2; McClatchie et al. 2016). A decrease is evident in the MN II/LN period, but the decrease is not as sharp as that observed with cereals. Flax was present at a small number of EN II sites (2/28) but not recorded in later deposits. Flax was discovered, however, and directly ¹⁴C-dated at another MN I site (Tullahedy, Co. Tipperary) after data collation was completed (McClatchie 2011).

Where quantified data were available for sites with cereal grains, most sites contained between one and 25 grains. Large cereal assemblages (>100 grains) were recorded at six sites, most of which were EN II (four EN II, one MN I and one NEO; these comprise five sites listed in McClatchie et al. 2014, plus an assemblage from the MN I passage tomb that was later quantified; Schulting et al. 2017). Wheat (often *Triticum dicoccum*; emmer wheat) dominated EN II and MN I sites, but barley (*Hordeum* spp.) was also recorded. Barley was

recorded at slightly more MN II/LN sites when compared with wheat, but this is based on a very small number of sites (four) and may not be significant. Oat (*Avena* spp.) was recorded but is unlikely to have been cultivated during the Neolithic period, instead reflecting wild oat as a weed of wheat and barley crops (Zohary et al. 2012).

Zooarchaeology

Animal bone was recorded at 23 sites (44% of all examined sites). Animal bone was not recorded at any examined EN I sites. Animal bone was most often found at EN II sites (65%; 15/23), but also present at MN I sites (9%; 2/23), MN II/LN sites (17%; 4/23), and undated NEO sites (9%; 2/23). NISP data to species level were provided for only 11 of the 23 sites. At other sites, only indeterminate animal bone was recorded, and in these cases, it is not clear how it was determined that the bone was animal rather than human; such records may be better regarded as possible animal bone, therefore.

Where NISP data were recorded, a very small number of bones was noted in many cases (Figure 3). MNI calculations were provided for only six sites, reflecting the sparsity of remains. In all cases, the MNI at individual sites for each species was below five. These small assemblages are likely to reflect recovery strategies (specifically the lack of sieving) and acidic soil conditions at many Irish sites, which is not conducive to preservation of bone. Small assemblages may also reflect the absence at many sites of well-sealed, deep features (such as large pits or ditches) that could accommodate whole bones and enable long-term preservation. Slightly larger assemblages (NISP >100) were occasionally recorded, for example at burnt mound deposits (EN II Cherryville and Clowanstown).

It was noted previously that cereals were most often associated with EN II ‘domestic’ structures and MN I pit/posthole complexes. By contrast, animal remains were often absent from EN II ‘domestic’ structures (absent from 9/17) and from all MN I pit/post-hole complexes. Animal remains were instead present at EN II, MN I and MN II burials/barrows, and EN II burnt mounds and a causewayed enclosure. At one EN II site (Clowanstown) a cattle skull was placed as a ‘sealing deposit’ on a large burnt mound, suggesting that ‘food remains’ did not reflect only domestic or everyday activity. The animal bone record does partially derive from domestic sites, therefore, but not wholly. In this context, the dominance of certain animal categories may not reflect everyday consumption patterns, but instead provide insights into the types of animals incorporated into a variety of activities.

Cattle, followed by sheep/goat and pig, were predominant in the EN II period (Figure 4). Wild animal (red deer and hare) and dog were recovered from a small number of EN II sites. Although red deer is considered a wild animal, it appears to have been introduced to Ireland during the Neolithic period (Schulting 2013). Birds were present at three EN II sites, but fish were not recorded at any sites. Animal bone was present at a small number of MN I sites but none was identified to species. During the MN II/LN period, only domesticates were identified, comprising cattle and pig. A relatively wide range of animals (three or more species) was recorded at five sites in total (all EN II).

Assessment of which animal category was dominant at individual sites was difficult because of small quantities. At sites where >100 NISP were recorded, cattle was dominant at one EN II site (Cherryville), while sheep/goat was predominant at another (Clowanstown; Figure 3). A notable exception is the recent discovery of a very large assemblage at another MN I site (Kilshane, Co. Dublin; Moore 2009; this site was not included in the *Cultivating Societies*

dataset because the final report was not accessible). Bones from at least 58 cattle were deposited into the ditch of an enclosure. Articulated and disarticulated bone were recorded, with apparent selection of certain bones for deposition together, such as vertebra or long bones, and the removal of other bones before deposition (including tails and horns). In one segment of the ditch, a large cattle skull was placed at the ditch terminal. Overall, the bones appear to have been deposited on separate occasions, rather than having accumulated gradually. In his analysis of the assemblage, McCormick (2009) noted that the virtual absence of animal bone from other contemporary sites posed a problem. There are many ‘peculiar’ aspects to Kilshane, but it is difficult to decide if these are unique, or unusual, or even perhaps a common feature.

Food processing and preparation: grinding stones and ceramics

Returning to plant foods, an assessment was undertaken of the evidence for saddle quern-stones at the 52 examined sites. Querns are often interpreted as a proxy for plant-food processing, particularly cereals, which may have required grinding to produce bread and other products (Connolly 1994; Wright 1994). Querns were only recorded at two EN II sites: possible structures (Ballinaspig More) and a causewayed enclosure (Magheraboy). At both sites, quern-stones were placed in what might be termed ‘unusual’ deposits. A complex of post-holes, pits, stake-holes and a possible hearth was interpreted as possible structures, but not clearly identifiable as a house or houses (Danaher and Cagney 2004). A possible hand-held grinding stone, which would have been used in conjunction with a lower quern, was recorded within a pit. At the causewayed enclosure, a quern was recorded in a ditch fill (Danaher and Cagney 2005). A ‘ritual deposit’ was also recorded in same ditch section, consisting of a pristine mudstone axe ‘cocooned’ by quartz fragments, Carinated Bowl sherds, a flint arrowhead, a chert arrowhead, a polishing stone, hammer stone and cremated

animal bone. Another saddle quern was discovered incorporated into a MN I passage tomb (Baltinglass; Cooney 1981; Connolly 1994), but re-consideration of the chronology of this site suggests that the quern may reflect later activity associated with a nearby hillfort (Schulting et al. 2017). In Ireland, demonstrably Neolithic quern-stones are rare, despite the fact that people were clearly processing cereals (Connolly 1994).

Quern-stones were absent from EN II rectangular ‘houses’ examined as part of this study, but they have been recorded at other sites whose final excavation report was not available. Amongst the best-known finds of saddle querns from Neolithic Ireland are the examples from EN II rectangular houses at Ballygalley, Co. Antrim. Initially, three saddle querns were associated with Neolithic contexts at this site (Connolly 1994) but subsequent excavations uncovered a further 18 querns (Moore 2004). This assemblage is distinctive because of the large number of quern-stones recovered, along with 20 rubbing (upper) stones. The quern-stones were apparently used over the period of occupancy of the three EN II house structures, where they were used in specific processing areas (Moore 2004). For example, one quern was found within the annex area of a house, where a quantity of unprocessed cereal remains was also found (Moore 2004).

The introduction of ceramic vessels is a key feature of lifeways in Neolithic Ireland. The use of these vessels for dairy and meat foods is well established (Smyth and Evershed 2015). Cereal-based and other plant-food ‘wet’ meals could also have been prepared and served in such vessels – perhaps in the form of porridges, gruels and stews – although in the absence of clear evidence for this, such a suggestion is currently speculative. Of the 52 examined sites, ceramics were recorded at 42 sites (81%). Carinated Bowl sherds were dominant, with occasional evidence for Carowkeel Ware, Globular Bowls, Grooved Ware and other styles.

The minimum number of vessels was substantial (>50) at several sites, including EN II rectangular structures (Monanny) and a LN structure (Knowth GWC). Cereals were present at a high proportion of sites where ceramics were present (37/42 sites). At sites where ceramics were absent (10 sites), cereal were often also absent (7/10 sites). While this does not automatically imply that ceramics were being used to prepare cereal-based wet dishes, the potential association between ceramics and cereals is interesting and merits further exploration.

Discussion

Overview

Analysis of existing data – published and unpublished – along with a new programme of radiocarbon dating has enabled significant refinement of our understanding of the nature, timing and extent of early farming in Ireland. The Neolithic in Ireland was traditionally thought to have commenced c. 4000 cal BC. Based upon short-lived samples, there is little radiocarbon-dated evidence for Neolithic activity in Ireland before 3750 cal BC (Cooney et al. 2011; Whitehouse et al. 2014). While there are a few sites dated to the period between 4000 and 3750 cal BC (McLaughlin et al. 2016), domesticated cereals were not recorded. It is not until the EN II period (from 3750 cal BC) that we see the earliest evidence for cereals in Ireland.

A variety of plant remains has been recorded, most often at EN II and MN I ‘domestic’ sites. Emmer wheat dominated, with barley also recorded. Einkorn wheat (*Triticum monococcum*) – a feature of many other Neolithic cereal economies in continental Europe (Colledge and Conolly 2007) – is largely absent from Ireland. Substantial cereal assemblages were occasionally recorded, but most assemblages tended to be small. Plant remains continued to

be recorded at later Neolithic sites (MN II/LN), but cereals were often absent, suggesting a shift away from arable agriculture or perhaps a change in the processing of cereal foods or deposition of food remains that has left little trace in the archaeological record (McClatchie et al. 2014; 2016).

Animal bone was recorded at a smaller number of sites than plant remains, probably reflecting inadequate recovery methods, such as no sieving. In common with cereals, animal bone was most often found at EN II and MN I sites. In many cases, assemblages were very small and were not identified further than indeterminate animal bone, particularly so in the case of calcined (burnt) bone. Where identifiable, cattle and sheep/goat were dominant, closely followed by pig. Dog and wild animal were recorded at small number of sites. While cereal remains were most often associated with domestic structures, animal bone was often absent from domestic structures.

Grinding stones – in the form of saddle querns – were recorded at a small number of sites and sometimes deposited in unusual circumstances, paralleling examples in Britain (Pryor 1998), or in concentrations. It is unclear if this reflects an avoidance of ground cereal products for many communities in Neolithic Ireland. At sites where cereals were recorded, ceramic vessels were often present, and at sites where cereals were absent, ceramics were often absent.

The *Cultivating Societies* review of plant and animal remains is the largest survey yet undertaken for Ireland. Previous perspectives were based on a published archaeobotanical dataset of at most 10 sites (Monk 2000; Colledge et al. 2005; Jones and Rowley-Conwy 2007). More extensive reviews of animal bone had been undertaken, but none as large as the

present study and none with such attention to radiocarbon dating. McCormick previously investigated faunal remains from prehistoric burials (1986) but acknowledged that dating of deposits was an issue. Burial sites are often the location of secondary insertions, so it can be unclear if animal remains in a 'Neolithic' burial are actually contemporary (Schulting et al. 2012). McCormick found evidence for deposition of the three main domesticates at burials (cattle, sheep/goat and pig), with occasional evidence for wild animals. He argued that the bone appeared to be 'token' deposits or feast debris rather than substantial joints of meat that could be regarded as 'food for the dead'. In a later study on animal remains from prehistoric Ireland, McCormick (2007, 82) noted 'because of the dearth of Neolithic faunal material, very little is known about the exploitation of animals, domesticates or wild, during this period'. A more substantial review was undertaken by Schulting (2013), based upon data from six excavations. Schulting discussed in detail evidence for the 'standard triumvirate' of cattle, sheep and pig, much like the suite recorded in Neolithic Britain. The current study confirms McCormick's and Schulting assertions that zooarchaeological assemblages from the Irish Neolithic tend to be small, with relatively few species recorded, but also highlights the recovery of animal bone from a wide range of activities and a concentration of evidence from the earlier Neolithic.

Isotope analyses

While assessment of the categories of plant and animal species is relatively straightforward, investigation of food preparation, products, consumption and broader foodways is more complex. Isotope analysis is increasingly undertaken to determine the relative contribution of terrestrial and marine sources of protein to human diets ($\delta^{13}\text{C}$) and the trophic level of protein component of diet ($\delta^{15}\text{N}$). There is clear patterning in the published human bone/tooth collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ data from Neolithic Ireland, all of which have been directly AMS ^{14}C

dated to between ca. 3800 and ca. 2900 cal BC (Figure 5; Schulting et al. 2012; 2017; Bayliss and O’Sullivan 2013; Ditchfield 2014; Schulting 2014; Kador et al. 2018). Excluding three infants of less than ca. 3 years of age (subject to a nursing effect raising $\delta^{15}\text{N}$ values in particular), the results from coastal/near-coastal sites (defined as within 10 km of the coast; cf. Schulting and Borić 2017) exhibit significantly higher $\delta^{13}\text{C}$ values on average than inland sites (coastal: $-21.1 \pm 0.2\text{‰}$, $n = 22$; inland: $-21.9 \pm 0.5\text{‰}$, $n = 39$; Mann-Whitney U-test, $Z = 5.58$, $p < 0.001$). If this were the result of a minor contribution of marine foods for coastal communities, then it would be expected that their $\delta^{15}\text{N}$ values would also be higher on average, when in fact the opposite trend is observed (coastal: $9.6 \pm 1.2\text{‰}$; inland: $11.0 \pm 0.5\text{‰}$; heteroscedastic Student’s t-test, $t = 5.42$, $p < 0.001$). While the coastal group includes measurements made on four first molars (since bone collagen was often poorly preserved), which might be subject to a nursing effect, they do not have significantly higher $\delta^{15}\text{N}$ values than those on two second molars and on bone collagen from a site in the same region where preservation was adequate for analysis (Millin Bay, Co. Down; MN I–II; see discussion in Schulting et al. 2012).

The explanation for this unexpected difference between coast and inland sites is not yet clear, but it is important to note that the low coastal $\delta^{15}\text{N}$ average is entirely driven by the values for 13 individuals from a portal tomb (EN I–II Poul nabrone located near the west coast, where there are few contemporary settlements with securely-dated plant/animal remains). That said, the inland average in Ireland is high compared to that in Britain, and this certainly warrants further investigation (Schulting and Borić 2017, fig. 7.8). It is possible but unlikely that freshwater resources were exploited to any significant extent in Neolithic Ireland, despite the considerable mean difference of 6.4‰ between the faunal and inland human $\delta^{15}\text{N}$ results (Figure 5). While manuring of crops is a possibility (cf. Bogaard et al. 2013), this would be

expected to affect both inland and coastal sites. Here again, it is Poul nabrone portal tomb that is the outlier: excluding it raises the coastal average to $10.6 \pm 0.7\text{‰}$ ($n = 9$), no longer differing significantly from the inland sites ($t = 1.26, p = 0.237$).

Despite the small sample size, the pattern of higher average $\delta^{13}\text{C}$ values on coastal sites compared to inland sites remains significant even without Poul nabrone portal tomb (Mann-Whitney U-test, $Z = 2.59, p = 0.001$). A potential explanation that arises is that coastal areas were less heavily wooded, which could be expected to lead to ^{13}C -enrichment in plants – and in the animals feeding on them – relative to ^{13}C -depletion in more heavily wooded areas as a result of the so-called ‘canopy effect’ (Bonafini et al. 2013). This is certainly likely to have been the case for Poul nabrone portal tomb, given the exposure of the west coast of Ireland to Atlantic gales and the thin soils of the Carboniferous limestone of the region known as the Burren, within which the site is located. But there are three problems with this interpretation. Firstly, there is no significant difference in $\delta^{13}\text{C}$ values between Poul nabrone portal tomb ($-21.1 \pm 0.2\text{‰}$) and the other coastal sites ($-21.2 \pm 0.3\text{‰}$), all located in Co. Down on the east coast, which available palaeoenvironmental evidence indicates was more forested than the west (Whitehouse et al. 2018, fig. 2). Secondly, two of the inland sites (passage tombs at Knowth and Mound of the Hostages), date to the late Middle Neolithic centring on c. 3000 cal BC, by which point there is evidence for open grassland (indeed, some of these passage tombs are partly constructed of turves; Eogan and Cleary 2017). Finally, another late Middle Neolithic passage tomb complex (Carrowkeel), the other major contributor to the inland dataset, is located on Carboniferous limestone near the west coast of Ireland, where, as for Poul nabrone, forest cover would be expected to have been less dense than in the east – likely up to c. 20–30% of the land was open at this time (Whitehouse et al. 2018). That said, there is evidence for widespread reforestation at the end of the fourth millennium across Britain and

Ireland (Stevens and Fuller 2012; Whitehouse et al. 2014), including the Carrowkeel region specifically (O’Connell et al. 2014; Whitehouse et al. 2018). Clearly, resolving the observed patterns will require further research.

One of the problems with developing a faunal baseline is that later re-use of sites means that samples often need to be directly radiocarbon dated to be securely placed in the Neolithic (Schulting et al. 2012). Thus, few isotopic data for Irish Neolithic fauna are available, but it can be noted that five cattle and sheep/goat directly dated to EN II at one site in the east of the island (Clowanstown) do not differ significantly from five EN II–MN II cattle and sheep/goat from near the west coast (Poul nabrone) in either $\delta^{13}\text{C}$ ($-22.1 \pm 0.8\text{‰}$ vs. $-22.4 \pm 0.4\text{‰}$ respectively; Mann-Whitney U-test, $Z = 0.940$ $p = 0.347$) or in $\delta^{15}\text{N}$ ($5.1 \pm 0.5\text{‰}$ vs. $4.0 \pm 1.1\text{‰}$; $Z = 1.78$, $p = 0.076$). Thus, there is no obvious explanation for the human results as regards baseline faunal values differing between the west and east sides of the island. The interpretation is complicated, however, by the fact that humans from several of the eastern and western sites post-date the eastern fauna (Clowanstown) by some centuries.

There is no clear trend through time in $\delta^{15}\text{N}$ values (or in $\delta^{13}\text{C}$ values) once the seemingly anomalous position of Poul nabrone is taken into account (Figure 6). While there is a significant increase in $\delta^{15}\text{N}$ over the ca. 800 years represented by the data ($r^2 = 0.477$, $p < 0.001$), this is entirely due to Poul nabrone providing the majority of the earliest Neolithic individuals, dating c. 3800–3600 cal BC (Schulting 2014). When analysed separately, neither Poul nabrone ($r^2 = 0.110$, $p = 0.268$) nor the remainder of the Neolithic data ($r^2 = 0.027$, $p = 0.259$) show significant correlations.

Thus, while the Irish Neolithic isotopic data do present some very useful information (e.g., the lack of any appreciable contribution of marine foods), it is fair to say that at present they raise as many or more questions than they answer.

Our daily bread?

While isotope analysis can provide a useful indicator of dietary breadth and relative intake of protein types, this approach informs more on ingredients than meals. The remains of actual foodstuffs are rare in the archaeological record. In recent years, residue analysis has been carried out on ceramic vessels from Neolithic sites in Ireland, providing clear evidence for predominantly dairy products and, less often, meats in vessels (Smyth and Evershed 2015). It is not clear if vessels were used for cereal preparations also, such as porridges, gruels, stews and brewing. Unfortunately, many plants (including cereals) contain substantially lower lipid concentrations than animal products, and plants can be ‘drowned out’ by animal lipids (Hammann and Cramp 2018). It is possible that some of the dairy products recorded through lipid analyses reflect cereal use also, perhaps in the form of ‘wet-dishes’ of fermented milk combined with cereal porridges/gruels or the resting/proving of breads in ceramic vessels, with the dough being made from ground cereals and fermented milk (rather than water; the suggestion of fermented milk is based upon the presumption that early farming societies in Ireland were lactose intolerant and unlikely to consume raw milk; Witas et al. 2015). Detailed analysis of cereals at a microstructural level (for example, Valamoti et al. 2008) has not yet been undertaken in Ireland. The nature and role of cereal-based preparations is somewhat unclear, therefore.

As well as pot-based preparations and brewing, cereals could have been processed to produce baked products. The dominant cereal in Neolithic Ireland – emmer wheat – has been recorded

elsewhere as a primary ingredient in bread (Samuel 1996). Bread fragments have been found at several early farming sites – for example recently at Çatalhöyük East in Turkey (González Carretero et al. 2017) – but have not yet been recorded from Neolithic Ireland. Possible bread fragments had been found at an Early Neolithic site in Yarnton, Oxfordshire (Hey et al. 2003, 84). A recent reappraisal of this material suggests it could instead represent a malt cake, however, perhaps reflecting brewing (Campbell et al. 2012). The rarity of querns at many Neolithic sites in Ireland, particularly EN II settlements, has been outlined above. Given the rarity of querns and the absence of bread fragments, it is tempting to assume that cereals were not being ground to produce flour for baked products or malt for brewing.

An alternative approach to assessing the use of grinding stones in food preparation has been explored recently, however, with intriguing results. McLaughlin (2007; 2008) undertook dental microwear analysis to investigate human diet from microscopic tooth-wear patterns, focusing on individuals from Mesolithic and Neolithic Denmark, Orkney, southern Britain, Brittany and Ireland. Using electron microscopy, Mesolithic specimens from Southern Britain were found to have many fine scratches on the parts of their molar teeth used for chewing food, probably caused by environmental dust (Figure 7). By contrast, almost all Neolithic individuals from all regions had larger scratches (Figure 7). The width of the scratches depends on the size of the wear-causing agent, and so the large Neolithic scratches were interpreted as being caused by hard objects in food, possibly quern grit. An individual from a henge (Ballynahatty, Co. Down; MN II) is typical of this pattern, although three from a tomb (Millin Bay, Co. Down; MN I–II) have smaller scratches than is typical for Neolithic sites. These date to a time when there is minimal evidence for cereal remains in the archaeobotanical record. In Orkney and southern Britain, where greater number of samples were available for study, all the teeth have large scratches and within-population variability is

low. Given that microwear turnover rates are high, in Neolithic Britain it seems that a similar foodstuff was being eaten regularly by many people, and this foodstuff may have been ground cereals. Although the Irish material is from a smaller dataset, it seems there is more variability and the signal of cereal processing is not as clear as throughout Britain.

If quern-processing really was prevalent, one might reasonably expect more evidence for querns, given their robustness and likelihood of surviving in the archaeological record. While quern-stones may have been broken up, perhaps making them slightly less recognisable – and in Ireland a tradition of breaking objects before deposition is apparent during the prehistoric period (Cleary 2018) – we argue that more querns should still be recorded. It is possible that outdoor natural hollows in large stone surfaces were used instead, providing ready-made grinding stations – the difficulty of identifying such facilities means that clear evidence is lacking, unfortunately. While the evidence for ground-cereal consumption seems stronger in Britain, based on tooth microwear analysis, the picture from Ireland is not as clear. Perhaps the prevalence of substantial houses in EN II Ireland reflects the notion of hearth, home and permanence, where cereal foods were predominantly prepared in ceramic vessels, with families and communities gathering for warm, nourishing food in the realm of ‘endo-cuisine’ (Lévi-Strauss 1966, 589). It is possible that bread, for example, became more popular from the Bronze Age in Ireland, reflecting a shift from the home to different strategies of landscape management and engagement, requiring participants to bring their ‘packed lunch’ with them on their travels. While recognising that this is a speculative interpretation, the emerging trends explored above do merit further investigation.

Towards foodways

Significant progress has been made in understanding the ingredients of meals in Neolithic Ireland, and how food choices changed over time and space. Further work is required, however, to understand the foodways of Ireland's first farmers. Many scholars have demonstrated how food is not only good to eat, but also good to think (for example, Lévi-Strauss 1964; Douglas 1966; Goody 1982; Dietler 1996; Twiss 2012; Hastorf 2016), encouraging exploration of materialisation and social experience. Investigations of foodways can be wide-ranging, including the 'meaning' of meals, their rhythm, and social participation or commensality. In recent years, scholars of the Irish Neolithic have developed valuable insights into food procurement and preparation activities, such as the placement of dairy and sometimes meats into pots (Smyth and Evershed 2015), the potential use of querns for grinding foods (this paper) and the intensity of early land management practices (McClatchie et al. 2014). The evidence from Ireland is often rather limited, however, which may explain why there has been relatively little consideration of broader concepts of foodways, for example how ethnicity, gender, age, status, social relations and economic circumstances were expressed through food, as well as the potential agency of food.

The arrival of new foods into Neolithic Ireland – perhaps accompanied by changes in how wild foods were processed and consumed – could have played a key role in the expression and reinforcing of identities, as well as social and political relations. New food traditions were created and learned, and food as an active agent may have played a role in influencing behaviours. Rectangular houses provided new arenas for social engagement and commensality during the earlier Neolithic, although the presence of interior hearths at many of these houses (Smyth 2014, 52) may point towards cooking being regarded a private activity (Wright 2000). As well as considering what was eaten, exploration of foodways can highlight food avoidance. Isotopic evidence highlights a shift away from marine proteins

during the earlier Neolithic, when compared with the preceding Mesolithic period (Schulting 2013), and the absence of einkorn wheat in Ireland provides a sharp contrast with other areas of northern Europe (McClatchie et al. 2014). It is possible that the decreased marine signal and the absence of einkorn may reflect societal classification of foods – perhaps foods were imbued with certain meaning, which led to the rejection of some products in specific contexts. It is even possible that the dearth of cereals in the later Neolithic reflected not an environmental or economic failure of farming (Stevens and Fuller 2012), but rather a socially constructed avoidance of certain foods.

Intra-societal diversity may have existed, however, and attempts to define generalised foodways for Neolithic Ireland – a period that extended over one and a half millennia – may be unwise. Twiss (2012, 378) has noted how collaboration between multiple specialists is “absolutely key to understanding the true breadth and diversity of past foodways”. By bringing together a variety of datasets, this current paper has developed new insights intended to improve understandings of foodways. To move forward, further scientific analyses are required to broaden the dataset, accompanied by more detailed consideration of how such data can be drawn upon to develop our understanding of social identities and relations.

Acknowledgements

We would like to express our thanks to our project partners, who provided invaluable advice and assistance: Jane Bunting (University of Hull); Finbar McCormick (QUB); Finola O’Carroll (CRDS); Alison Sheridan (National Museums Scotland); Jessica Smyth (UCD); Rónán Swan (TII); and Graeme Warren (UCD). The following archaeologists, archaeobotanists and organisations are thanked for discussions, and for providing access to Neolithic data and plant remains: ACS; ADS; Aegis Archaeology; AML Archaeology;

Arthur ApSimon; Centre for Archaeological Fieldwork, QUB; Robert Chapple; James Conolly, Trent University; CRDS; UCC Department of Archaeology; Catherine Dunne; Eachtra Archaeological Projects; Allan Hall, University of York; Rubicon Heritage; IAC; Judith Carroll Network Archaeology; Kilkenny Archaeology; Susan Lyons; Margaret Gowen; NAC; National Monuments Service; National Museum of Ireland; National Roads Authority; UCD School of Archaeology; Stafford McLoughlin Archaeology; Stephen Shennan, UCL; TVAS Ireland; Ulster Museum; Valerie J. Keeley. We would also like to thank Mark Gardiner and Eileen Murphy (QUB) for permission to access unpublished quern data from Ballygalley. We are grateful to the two anonymous reviewers for helpful and constructive suggestions.

Funding details

This work was supported by the Heritage Council, Ireland under the INSTAR programme 2008–2010 for the project ‘Cultivating Societies: Assessing the Evidence for Agriculture in Neolithic Ireland’ (Reference 16682 to Whitehouse, Schulting, Bogaard and McClatchie).

Declaration of interest statement

No financial interest or benefit has arisen from the direct applications of our research.

References

Bayliss, A. and M. O'Sullivan. 2013. “Interpreting chronologies for the Mound of the Hostages, Tara and its contemporary contexts in Neolithic and Bronze Age Ireland”. In *Tara – From the Past to the Future. Towards a New Research Agenda*, edited by M. O'Sullivan, C. Scarre and M. Doyle, 26–104. Dublin: Wordwell.

Bogaard, A., R. A. Fraser, T. H. E. Heaton, M. Wallace, P. Vaiglova, M. Charles, G. Jones, R. P. Evershed, A. K. Styring, N. H. Andersen, R.-M. Aerbogast, L. Bartosiewicz, A. Gardeisen, M. Kanstrup, U. Maier, E. Marinova, L. Ninov, M. Schäfer and E. Stephan. 2013. Crop manuring and intensive land management by Europe's first farmers. *Proceedings of the National Academy of Sciences* 110 (31), 12589–12594.

Bonafini, M., M. Pellegrini, P. Ditchfield and A. M. Pollard. 2013. Investigation of the ‘canopy effect’ in the isotope ecology of temperate woodlands. *Journal of Archaeological Science* 40(11), 3926–3935.

Bronk Ramsey, C. 2008. Deposition models for chronological records. *Quaternary Science Reviews* 27, 42–60.

Campbell, G., S. Mays, J. Last, F. Worley, and R. Pelling. 2012. “Chapter 7: Diet”. In *Stonehenge, Wiltshire – Stonehenge World Heritage Site Synthesis: Prehistoric Landscape, Environment and Economy*, edited by M. Canti, G. Campbell, and S. Greaney, 107–118. Eastney: English Heritage.

Cleary, K. 2018. “Broken bones and broken stones: exploring fragmentation in Middle and Late Bronze Age settlement contexts in Ireland”. *European Journal of Archaeology* 21 (3), 336–360.

Colledge, S. and J. Conolly eds. 2007. *The origins and spread of domestic plants in southwest Asia and Europe*. Walnut Creek: Left Coast Press.

Colledge, S. and J. Conolly. 2014. Wild plant use in European Neolithic subsistence economies: a formal assessment of preservation bias in archaeobotanical assemblages and the implications for understanding changes in plant diet breadth. *Quaternary Science Reviews* 101, 191–206.

Colledge, S., J. Conolly, K. Dobney, K. Manning and S. Shennan. 2013. *The origins and spread of domestic animals in southwest Asia and Europe*. London: Institute of Archaeology, University College London.

Colledge, S., J. Conolly, and S. Shennan. 2005. The evolution of Neolithic farming from SW Asian origins to NW European limits. *European Journal Archaeology* 8, 137–156

Connolly, A. 1994. Saddle querns in Ireland. *Ulster Journal of Archaeology* 57, 26–36.

Cooney, G. 1981. A saddle quern from Baltinglass Hill, Co. Wicklow. *Journal of the Royal Society of Antiquaries of Ireland* 111, 102–106.

Cooney, G. 2000. *Landscapes of Neolithic Ireland*. London: Routledge.

Cooney, G., A. Bayliss, F. Healy, A. Whittle, E. Danaher, L. Cagney, J. Mallory, J. Smyth, T. Kador, and M. O’Sullivan, M. 2011. “Ireland”. In *Gathering Time: Dating the Early Neolithic Enclosures of Southern Britain and Ireland, vol. 1*, edited by A. Whittle, F. Healy, and A. Bayliss, 562–681. Oxford: Oxbow Books.

Danaher, E. and L. Cagney. 2004. *Report on the archaeological excavation of a multi-phased site at Ballinaspig More 5, Ballincollig, Co. Cork*. Unpublished excavation report. ACS Ltd.

Danaher, E. and L. Cagney. 2005. *Report on an archaeological excavation of an Early Neolithic causewayed enclosure at Area 2C, Magheraboy, Sligo*. Unpublished excavation report. CRDS Ltd.

Dietler, M. 1996. “Feasts and commensal politics in the political economy: food, power and status in prehistoric Europe”. In *Food and the status quest*, edited by P. Wiessner and W. Schiefenhovel, 87 – 125. Oxford: Berghahn.

Ditchfield, P. 2014. “Stable isotope analysis”. In *Poulnabrone, Co. Clare. Excavation of an Early Neolithic Portal Tomb*, edited by A. Lynch, 86–92. Dublin: Department of Arts, Heritage and the Gaeltacht, Archaeological Monograph Series.

Douglas, M. 1966. *Purity and danger*. London: Routledge & Keegan Paul.

Eogan, G. and K. Cleary, ed. 2017. *Excavations at Knowth 6: The Archaeology of the Great Passage Tomb at Knowth*. Dublin: Royal Irish Academy.

González Carretero, L., M. Wollstonecroft and D. Q Fuller. 2017. A methodological approach to the study of archaeological cereal meals: a case study at Çatalhöyük East (Turkey). *Vegetation History and Archaeobotany* 26 (4), 415–432.

Goody, J. 1982. *Cooking, cuisine and class: a study in comparative sociology*. Cambridge: Cambridge University Press.

Guiry, E. J., F. Beglane, P. Szpak, R. J. Schulting, F. McCormick and M. P. Richards. 2018. Anthropogenic changes to the Holocene nitrogen cycle in Ireland. *Science Advances* 13(6), e9383.

Hey, G., J. Mulville, and M. Robinson. 2003. “Diet and culture in southern Britain: the evidence from Yarnton”. In *Food, culture and identity in the Neolithic and Early Bronze Age*, edited by M. Parker Pearson, 79–88. British Archaeological Reports, International Series 1117. Oxford: Archaeopress.

Hammann, S. and L. J. E. Cramp. 2018. Towards the detection of dietary cereal processing through absorbed lipid biomarkers in archaeological pottery. *Journal of Archaeological Science* 93, 74–81.

Hastorf, C. A. 2016. *The social archaeology of food: thinking about eating from prehistory to the present*. Cambridge: Cambridge University Press.

Jones, G. and P. Rowley-Conwy. 2007. On the importance of cereal cultivation in the British Neolithic. In *The Origins and Spread of Domestic Plants in Southwest Asia and Europe*, edited by S. Colledge and J. Conolly, 391–419. Walnut Creek: Left Coast Press.

Kador, T., L. M. Cassidy, J. Geber, R. Hensey, P. Meehan and S. Moore. 2018. Rites of passage: mortuary practice, population dynamics, and chronology at the Carrowkeel passage

tomb complex, Co. Sligo, Ireland. *Proceedings of the Prehistoric Society* 84, 225–255.

Lévi-Strauss, C. 1964. *Totemism*. London: Merlin Press.

Lévi-Strauss, C. 1966. “The culinary trainagle”. *The Partisan Review* 33, 586–96.

McClatchie, M. 2011. “Analysis of non-wood plant macro-remains”. In *Archaeological excavations at Tullahedy, County Tipperary: Neolithic settlement in north Munster*, edited by R.M. Cleary and H. Kelleher, 162–185. Cork: Collins.

McClatchie, M., A. Bogaard, S. Colledge, N. J. Whitehouse, R. J. Schulting, P. Barratt and T. R. McLaughlin. 2014. Neolithic farming in north-western Europe: Archaeobotanical evidence from Ireland. *Journal of Archaeological Science* 51, 206–215.

McClatchie, M., A. Bogaard, S. Colledge, N. J. Whitehouse, R. J. Schulting, P. Barratt and T. R. McLaughlin. 2016. Farming and foraging in Neolithic Ireland: An archaeobotanical perspective. *Antiquity* 90 (350), 302–318.

McCormick, F. 1986. Faunal remains from prehistoric Irish burials, *Journal of Irish Archaeology* 3, 37–48.

McCormick, F. 2007. “Mammal bone studies from prehistoric Irish sites”. In *Environmental archaeology in Ireland*, edited by E. M. Murphy and N. J. Whitehouse, 77–101. Oxford: Oxbow.

McCormick, F. 2009. "Appendix 9: Animal bone report". In *Report on archaeological excavation of Site 5, Kilshane, County Dublin*, edited by D. Moore, 190–218. Unpublished excavation report. ACS Ltd.

McLaughlin, T.R. 2007. Diet in Mesolithic Europe: New evidence from dental microwear. *Internet Archaeology* 22. <https://doi.org/10.11141/ia.22.1>

McLaughlin, T. R. 2008. *Investigating food and diet in Mesolithic and Neolithic Europe: an exploratory approach using dental microwear analysis*. Unpublished PhD dissertation, Queen's University Belfast.

McLaughlin, T. R., N. J. Whitehouse, R. J. Schulting, M. McClatchie, P. Barratt and A. Bogaard. 2016. The Changing Face of Neolithic and Bronze Age Ireland: A Big Data Approach to the Settlement and Burial Records. *Journal of World Prehistory* 29 (2), 117–153.

Monk, M. A. 2000. "Seeds and soils of discontent: an environmental archaeological contribution to the nature of the Early Neolithic". In *New Agendas in Irish Prehistory: Papers in Commemoration of Liz Anderson*, edited by A. Desmond, G. Johnson, M. McCarthy, J. Sheehan, and E. Shee Twohig, 67-87. Bray: Wordwell.

Moore, D. G. 2004. "The coarse stone and metal assemblage". In *Excavations at Croft Manor, Ballygalley, Co. Antrim, 1989-1994*, edited by D. G. Moore and D. Simpson. Unpublished draft report to NIEA, Queen's University Belfast.

Moore, D. 2009. *Report on archaeological excavation of Site 5, Kilshane, County Dublin*.
Unpublished excavation report. ACS Ltd.

O'Connell, M., B. Ghilardi and L. Morrison. 2014. A 7000-year record of environmental change, including early farming impact, based on lake-sediment geochemistry and pollen data from County Sligo, western Ireland. *Quaternary Research* 81(1), 35–49.

Pryor, F. 1998. *Etton: Excavations at a Neolithic Causewayed Enclosure near Maxey, Cambridgeshire, 1982-7*. London: English Heritage.

Samuel, D. 1996. Investigation of ancient Egyptian baking and brewing methods by correlative microscopy. *Science* 273, 488–490.

Schulting, R. 2013. “On the northwestern fringes: earlier Neolithic subsistence in Britain and Ireland as seen through faunal remains and stable isotopes”. In *The origins and spread of domestic animals in southwest Asia and Europe*, edited by S. Colledge, J. Conolly, K. Dobney, K. Manning, and S. Shennan, 313–338. Walnut Creek: Left Coast Press.

Schulting, R.J. 2014. “The dating of Poul nabrone, Co. Clare”. In *Poul nabrone: An Early Neolithic Portal Tomb in Ireland*, edited by A. Lynch, 93–113. Dublin: Department of Arts, Heritage and the Gaeltacht, Archaeological Monograph Series no. 9.

Schulting, R.J. and D. Borić. 2017. “A tale of two processes of Neolithisation: southeast Europe and Britain/Ireland”. In *Neolithic Europe: essays in honour of Professor Alasdair*

Whittle, edited by P. Bickle, V. Cummings, D. Hofmann and J. Pollard, 82–104. Oxford: Oxbow.

Schulting, R. J., M. McClatchie, A. Sheridan, R. McLaughlin, P. Barratt, and N. J. Whitehouse. 2017. Radiocarbon Dating of a Multi-phase Passage Tomb on Baltinglass Hill, Co. Wicklow, Ireland. *Proceedings of the Prehistoric Society* 83, 1-19.

Schulting, R. J., E. Murphy, C. Jones and G. Warren. 2012. New dates from the north and a proposed chronology for Irish court tombs. *Proceedings of the Royal Irish Academy* 112C, 1–60.

Sheridan, A. 2010. “The Neolithization of Britain and Ireland: the ‘big picture’”. In *Landscapes in transition*, edited by B. Finlayson and G. Warren, 89–105. Oxford: Oxbow.

Smyth, J. 2014. *Settlement in the Irish Neolithic: new discoveries at the edge of Europe*. Oxford: Oxbow.

Smyth, J. and R. P. Evershed. 2015. The molecules of meals: new insight into Neolithic fodways. *Proceedings of the Royal Irish Academy* 115C, 27–46.

Stevens, C.J. and D. Q Fuller. 2012. Did Neolithic farming fail? The case for a Bronze Age agricultural revolution in the British Isles. *Antiquity* 86, 707–722.

Twiss, K. 2012. The archaeology of food and social diversity. *Journal of Archaeological Research* 20, 357–395.

Valamoti, S. M., D. Samuel, M. Bayram, and E. Marinova. 2008. Prehistoric cereal foods from Greece and Bulgaria: investigation of starch microstructure in experimental and archaeological charred remains. *Vegetation History and Archaeobotany* 17 (S1), 265–276.

Whitehouse, N. J., M J. Bunting, M. McClatchie, P. Barratt, R. McLaughlin, R. Schulting and A. Bogaard. 2018. Prehistoric land-cover and land-use at 6000 BP. *Past Global Changes* 26 (1), 24–25.

Whitehouse, N. J., R. J. Schulting, M. McClatchie, P. Barratt, T. R. McLaughlin, A. Bogaard, S. Colledge, R. Marchant, J. Gaffrey, P. Reimer, and M J. Bunting. 2014. Neolithic agriculture on the European western frontier: the boom and bust of early farming in Ireland. *Journal of Archaeological Science* 51, 181–205.

Witas HW, T. Płoszaj, K. Jędrychowska-Dańska, P. J. Witas, A. Masłowska, B. Jerszyńska, T. Kozłowski and G. Osipowicz 2015. Hunting for the LCT-13910*T allele between the Middle Neolithic and the Middle Ages suggests its absence in dairying LBK people entering the Kuyavia region in the 8th millennium BP. *PLOS ONE* 10,1–24.

Wright, K. I. 1994. Ground-stone tools and hunter-gatherer subsistence in Southwest Asia: implications for the transition to farming. *American Antiquity* 59, 238–263.

Wright, K. I. 2000. The social origins of cooking and dining in early villages of Western Asia. *Proceedings of the Prehistoric Society* 66, 89–121.

Zohary, D., M. Hopf, and E. Weiss. 2012. *Domestication of plants in the Old World*. Oxford: Oxford University Press.

Figure and Table captions

Table 1: Chronology of Neolithic sites in Ireland

Table 2: Categories of examined sites

Figure 1: Map of sites where archaeobotanical and zooarchaeological remains recorded

Figure 2: Relative occurrence of plant categories at EN II, MN I and MN II/LN sites (sites n=49)

Figure 3: Relative occurrence of animal remains (NISP calculations) at various sites. NISP quantities are higher than Schulting 2013 because burnt fragments have been included in the current study where identified to species. Kilshane Co. Meath and Poul nabrone, Co. Clare are not included because data were not available. Ashleypark, Co. Tipperary is not included because plant remains were absent.

Figure 4: Relative occurrence of animal categories at EN II, MN I and MN II/LN sites (sites n=49)

Figure 5: Human bone/tooth collagen and faunal bone collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ data from Neolithic Ireland (human data from Bayliss and O'Sullivan 2013; Ditchfield 2014; Kador et al. 2018; Schulting et al. 2012; 2017; Neolithic faunal (cattle, sheep and pig) data from Guiry et al. 2018). Note that one outlying $\delta^{13}\text{C}$ value of -23.8‰ (2.9 standard deviations from the mean) from Carrowkeel has been omitted from the inland dataset.

Figure 6. Median AMS ^{14}C dates (± 60 yrs) and $\delta^{15}\text{N}$ values for Neolithic humans with and without the inclusion of Poul nabrone (data from Bayliss and O'Sullivan 2013; Kador et al. 2012; Schulting 2014; Schulting et al. 2012; 2017).

Figure 7: Top: Tooth from Mesolithic individual (southern England) displaying many fine scratches caused by environmental dust; Bottom: Tooth from Neolithic individual (southern England) with larger scratches, potentially caused by grit from grinding stones

Tables

Period	Sub-period	Date range
Early Neolithic (EN)	I	4000-3750 cal BC
	II	3750-3600 cal BC
Middle Neolithic (MN)	I	3600-3400 cal BC
	II	3400-3000 cal BC
Late Neolithic (LN)		3000-2500 cal BC

Table 1: Chronology of Neolithic sites in Ireland

Period	No. of sites	Site category
EN II	28	17 rectangular structures or 'houses' (single and multiple), 3 pit complexes, 3 non-rectangular structures, 1 causewayed enclosure (2 sites), 1 barrow, 2 burnt mounds
MN I	10	7 pit/post-hole complexes, 2 structures, 1 passage tomb
MN II to LN	11	5 pit/post-hole complexes, 4 structures, 2

		passage tombs
NEO	3	1 cremation pit complex and settlement, 1 structure, 1 palisade

Table 2: Categories of examined sites