



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Food and power in Early Medieval England

A lack of (isotopic) enrichment

Citation for published version:

Leggett, S & Lambert, T 2022, 'Food and power in Early Medieval England: A lack of (isotopic) enrichment', *Anglo-Saxon England*. <https://doi.org/10.1017/S0263675122000072>

Digital Object Identifier (DOI):

[10.1017/S0263675122000072](https://doi.org/10.1017/S0263675122000072)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Anglo-Saxon England

Publisher Rights Statement:

This article has been published in a revised form in *Anglo-Saxon England* <https://doi.org/10.1017/S0263675122000072>. This version is published under a Creative Commons CC-BY-NC-ND. No commercial re-distribution or re-use allowed. Derivative works cannot be distributed. © Cambridge University Press.

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



Food and Power in Early Medieval England: a lack of (isotopic) enrichment

SAM LEGGETT AND TOM LAMBERT

ABSTRACT

This work tackles long held assumptions in both archaeology and history surrounding elite diets in early medieval England i.e., that higher status individuals had a more meat-heavy diet and that this was especially true for males. We utilise the largest isotopic dataset on early medieval diets to date to show that not only were high protein diets extremely rare in England before Scandinavian settlement, but that dietary differences cannot be linked to gender or social status from the funerary record. Comparisons with the calculations made in our companion article and the bioarchaeological evidence demonstrate further that the lists of food demanded by eighth-century kings were not the basis for regular elite diet, and that these texts probably represent the supplies for infrequent feasts.

INTRODUCTION

There are long held assumptions in both archaeology and history surrounding elite diets in early medieval England, namely that higher status individuals had a more meat-heavy and therefore protein-rich diet than the lower classes, and that this was especially true for males over females.¹ So closely held are these assumptions that it is commonplace for bioarchaeological studies to actively seek out social differences in diet, comparing variables like numbers and kinds of grave goods with dietary signatures from skeletal remains. These studies have never found biologically meaningful correlations at a cemetery or regional level²

¹ Debby Banham, *Food and Drink in Anglo-Saxon England* (Stroud: Tempus, 2004), 53–70; Ann Hagen, *Anglo-Saxon Food & Drink* (Ely: Anglo-Saxon Books, 2010), 444, 460; Alban Gautier, *Le Festin dans l'Angleterre anglo-saxonne (Ve-XIe siècle)*, Nouvelle édition [en ligne] (Rennes: Presses universitaires de Rennes, 2006), 225–50, <https://doi.org/10.14375/NP.9782753502345>.

² Yet some studies claim to find differences between the sexes or individuals with different types/quantities of grave goods, however on closer inspection these differences might be statistically significant but are either within machine/analytical error (and therefore meaningless) or less than one trophic level shift (3-5‰) and therefore cannot be interpreted as a meaningful dietary difference especially when sample sizes are so small e.g. Karen L. Privat, Tamsin C. O'Connell, and Michael P. Richards, 'Stable Isotope Analysis of Human and Faunal Remains from the Anglo-Saxon Cemetery at Berinsfield, Oxfordshire: Dietary and Social Implications', *Journal of Archaeological Science* 29, no. 7 (July 2002): 779–90, <https://doi.org/10.1006/jasc.2001.0785>.

, yet the assumptions remain pervasive.³ To the extent that they are underpinned by evidence, it is not archaeological but textual.

This textual evidence takes the form of a series of lists of foodstuffs written between the late seventh and tenth centuries. Most of these have traditionally been interpreted as part of a system of ‘food rents’ or ‘food renders’ (also sometimes known by the Old English term *feorm*), and understood to detail the payments in kind that peasants owed first to kings and later also to non-royal landlords. Since the nineteenth century it has been assumed that these renders were collected regularly by royal households and comprised most of their meals, and that they contributed substantially to the diets of other members of the elite who had been endowed with the right to receive local royal revenues. Ann Hagen summarises the arrangement as follows:

The holder of large estates could expect to receive a quantity of food, including prestigious items, without working on its production himself. The only food-getting activities the lord was likely to engage in were recreational pursuits... Food was an important component, if not the most important, of the king’s revenue. All lands in the realm unless specifically exempted had to contribute food to the king. The unit was the farm of one night, that is the food and drink necessary to support the king and his court for one day... The king, or landowner, went round to his estates in turn with his retinue eating up the provisions gathered for him. He would stay in the main dwelling to which corn, provisions, cattle, and dairy produce were sent from the collecting centres...⁴

As we argue in the companion piece to this article, these assumptions must be questioned. We contend that our food lists and documentary allusions to *feorm* do not refer to renders of general-purpose food supplies used to sustain elite households. The quantities and proportions of different foodstuffs in these texts, and often their contexts, suggest that they are lists of supplies for large and symbolically significant communal feasts.⁵ This conclusion

³ Rocio Vidal-Ronchas et al., ‘Diet, Sex, and Social Status in the Late Avar Period: Stable Isotope Investigations at Nuštar Cemetery, Croatia’, *Archaeological and Anthropological Sciences* 11, no. 5 (1 May 2019): 1727–37, <https://doi.org/10.1007/s12520-018-0628-4>; Emma L. Hannah et al., ‘Anglo-Saxon Diet in the Conversion Period: A Comparative Isotopic Study Using Carbon and Nitrogen’, *Journal of Archaeological Science: Reports* 19 (June 2018): 24–34, <https://doi.org/10.1016/j.jasrep.2018.02.012>; Tamsin C. O’Connell and Bradley D. Hull, ‘Diet: Recent Evidence from Analytical Chemical Techniques’, in *The Oxford Handbook of Anglo-Saxon Archaeology*, Oxford Handbooks (Oxford: Oxford University Press, 2011), 667–87, <https://doi.org/10.1093/oxfordhb/9780199212149.013.0034>; Rosalind Purcell, ‘Social Differentiation through Diet: An Isotopic Study of Anglo-Saxon Lakenheath’ (Cambridge, UK, University of Cambridge, 2012); Bradley D. Hull, ‘Social Differentiation and Diet in Early Anglo-Saxon England: Stable Isotope Analysis of Archaeological Human and Animal Remains’ (Oxford, University of Oxford, 2007); Privat, O’Connell, and Richards, ‘Stable Isotope Analysis of Human and Faunal Remains from the Anglo-Saxon Cemetery at Berinsfield, Oxfordshire’.

⁴ Hagen, *Anglo-Saxon Food & Drink*, 304–7.

⁵ Hagen, 306; Tom Lambert and Sam Leggett, ‘Food and Power in Early Medieval England: Rethinking Feorm’, *Anglo-Saxon England* (this issue).

is reinforced in this article, where we demonstrate that these food lists cannot be representative of elite diets because their exceptionally high proportion of animal products is inconsistent with the bioarchaeological evidence, primarily isotopic data. It instead shows that diets were more similar (isotopically) across social groups than previously thought. Most people in pre-Viking Age England ate only low to moderate amounts of animal protein, and there is nothing to suggest that those who consumed more were of higher status. Such dietary variations should be understood to result from differences in environment and agriculture between regions and larger scale chronological changes to foodways.

Assumptions around wealth and social status, and the number and kinds of grave goods are readily made in archaeology; and certain styles of female dress accessories are often taken to be ethnic signifiers.⁶ Chris Scull highlights that one of the clearest forms of archaeological evidence for social structure in the fifth to seventh centuries is mortuary ritual, and that the graves of early medieval individuals clearly show socioeconomic hierarchy and inequality.⁷ There are of course complexities in drawing social inferences from funerary archaeology, the largest of which is ‘the dead don’t bury themselves’ followed closely by the incompleteness of the archaeological record; however, funerary deposits were clearly socially governed and are a useful tool in investigating how living communities operated, more so than settlement archaeology for this period.⁸ The early documentary evidence (principally law codes from seventh-century Kent and Wessex and narrative works from eighth-century Northumbria) suggests a ranked society with slaves at the bottom, a free peasant majority, and an increasingly entrenched noble class associated with service to the king.⁹ This picture is broadly consistent with that of funerary archaeology until the late sixth and seventh centuries, when furnished burial declines and clear status identifiers are lost.¹⁰

⁶ Helen Geake, *The Use of Grave-Goods in Conversion-Period England, c.600-c.850*, B.A.R. British Series 261 (Oxford: British Archaeological Reports, 1997); Elizabeth O’Brien, *Post-Roman Britain to Anglo-Saxon England: Burial Practices Reviewed*, BAR British Series 289 (Oxford: British Archaeological Reports, 1999); Gale R. Owen-Crocker, *Dress in Anglo-Saxon England*, 2nd ed. (Woodbridge: Boydell Press, 2010); Penelope Walton Rogers, ‘Cloth, Clothing and Anglo-Saxon Women’, in *A Stitch in Time: Essays in Honour of Lise Bender Jørgensen*, Gothenburg Archaeological Studies 4 (Gothenburg: Gothenburg University Department of Historical Studies, 2014), 253–80.

⁷ Christopher Scull, ‘Social Transactions, Gift Exchange, and Power in the Archaeology of the Fifth to Seventh Centuries’, in *The Oxford Handbook of Anglo-Saxon Archaeology*, Oxford Handbooks (Oxford: Oxford University Press, 2011), 848–64.

⁸ Scull; Michael Parker Pearson, *The Archaeology of Death and Burial*, Texas A & M University Anthropology Series, no 3 (College Station: Texas A&M University Press, 1999).

⁹ Tom Lambert, *Law and Order in Anglo-Saxon England*, *Law and Order in Anglo-Saxon England* (Oxford: Oxford University Press, 2017), 50–51; Thomas M. Charles-Edwards, ‘Social Structure’, in *A Companion to the Early Middle Ages*, ed. Pauline Stafford (Oxford, UK: Wiley-Blackwell, 2009), 107–25, <https://doi.org/10.1002/9781444311020.ch8>.

¹⁰ Emma Brownlee, ‘Connectivity and Funerary Change in Early Medieval Europe’, *Antiquity* 95, no. 379 (2021): 142–59, <https://doi.org/10.15184/aqy.2020.153>; Emma Brownlee, ‘Grave Goods in Early Medieval Europe: Regional Variability and Decline’, *Internet Archaeology*, no. 56 (28 July 2021), <https://doi.org/10.11141/ia.56.11>; Jo Buckberry, ‘On Sacred Ground: Social Identity and Churchyard Burial in Lincolnshire and Yorkshire, C. 700-1100 AD’, in *Anglo-Saxon Studies in Archaeology and History 14: Early Medieval Mortuary Practices.*, Anglo-Saxon Studies in Archaeology and History 14 (Oxford: Oxbow Books, 2007), 46, <http://hdl.handle.net/10454/988>; Elizabeth Craig-Atkins, ‘Seeking “Norman Burials”: Evidence for Continuity and Change in Funerary Practice Following the Norman Conquest’, in *The Archaeology of the*

In the post-Roman period furnished burial was the norm from the fifth to seventh centuries, not just in England, but generally across much of Western Europe.¹¹ Ignoring here fifth-century cremation burials due to the challenges they pose for osteology and isotopic analyses,¹² generally, both furnished and unfurnished burials were common in England up to the late seventh and early eighth centuries. Inhumations of this period are highly varied in practice with numbers and kinds of grave goods, orientation, grave furniture, body position and other variables all part of a mutable and dynamic process of death.¹³ Grave goods, when present, are often highly gendered, and suggest levels of social stratification, which fluctuate in meaning through time.¹⁴ However, this seems to peter out in the seventh and eighth centuries and in England, at least, this coincides with the shift towards churchyard burials which are more tightly regulated, and most importantly, unfurnished and difficult to date.¹⁵ This means that beyond the mid-to-late-seventh and early eighth centuries determining social status through the funerary record is exceedingly difficult. Therefore, we refrain here from examining closely diet or social status beyond the use of furnished burial aside from broader chronological comparisons. However, dating issues with some sites mean that some later unfurnished individuals are likely to be present in the sample here and are discussed in more detail in analyses below.

As mentioned above, Banham, Franzten, Gautier and Hagen's work (amongst others) on early medieval agriculture and food has suggested that types and quality of food and drink varied with social status and gender roles; most notably that women and younger children were more likely to be hardest hit by food shortages, and there seems to be social precedence for being served at feasts and special occasions, but the assumption of a meat- and alcohol-heavy

Eleventh Century: Continuities and Transformations, Society for Medieval Archaeology Monograph 38 (Abingdon, UK: Routledge, 2017), 139–58; Geake, *The Use of Grave-Goods in Conversion-Period England, c. 600-c. 850*; Sam Lucy, *The Anglo-Saxon Way of Death: Burial Rites in Early England* (Stroud: Sutton, 2000).

¹¹ Lucy, *The Anglo-Saxon Way of Death*; Brownlee, 'Grave Goods in Early Medieval Europe'.

¹² Gareth J. Perry, 'Ceramic Hinterlands: Establishing the Catchment Areas of Early Anglo-Saxon Cremation Cemeteries', *World Archaeology* 52, no. 1 (1 January 2020): 163–82, <https://doi.org/10.1080/00438243.2019.1741438>; Christophe Snoeck et al., 'Calcined Bone Provides a Reliable Substrate for Strontium Isotope Ratios as Shown by an Enrichment Experiment: Strontium Isotope Ratios in Calcined Bone', *Rapid Communications in Mass Spectrometry* 29, no. 1 (15 January 2015): 107–14, <https://doi.org/10.1002/rcm.7078>; Catherine Hills, *The Anglo-Saxon Cemetery at Spong Hill, North Elmham, Part I: Catalogue of Cremations* (East Anglian Archaeology, 1977), <http://eaareports.org.uk/publication/report6/>; Jacqueline McKinley, *The Anglo-Saxon Cemetery at Spong Hill, North Elmham, Part VIII: The Cremations* (East Anglian Archaeology, 1994), <http://eaareports.org.uk/publication/report69/>.

¹³ Lucy, *The Anglo-Saxon Way of Death*; Brownlee, 'Grave Goods in Early Medieval Europe'; Emma Claire Brownlee, 'The Dead and Their Possessions: The Declining Agency of the Cadaver in Early Medieval Europe', *European Journal of Archaeology*, 6 February 2020, 1–22, <https://doi.org/10.1017/eea.2020.3>.

¹⁴ Lucy, *The Anglo-Saxon Way of Death*; Alexandra Bayliss et al., *Anglo-Saxon Graves and Grave Goods of the 6th and 7th Centuries AD: A Chronological Framework*, ed. John Hines and Alex Bayliss, The Society for Medieval Archaeology Monograph 33 (London: Society for Medieval Archaeology, 2013); Brownlee, 'Grave Goods in Early Medieval Europe'; Nick Stoodley, *The Spindle and the Spear: A Critical Enquiry into the Construction and Meaning of Gender in the Early Anglo-Saxon Burial Rite*, B.A.R. British Series 288 (Oxford: British Archaeological Reports, 1999); Sam Lucy, 'Gender and Gender Roles', in *The Oxford Handbook of Anglo-Saxon Archaeology*, ed. David A. Hinton, Sally Crawford, and Helena Hamerow (Oxford University Press, 2011), 688–703, <https://doi.org/10.1093/oxfordhb/9780199212149.013.0035>.

¹⁵ Bayliss et al., *Anglo-Saxon Graves and Grave Goods*; Brownlee, 'Grave Goods in Early Medieval Europe'.

elite diet is still pervasive.¹⁶ As Alban Gautier puts it ‘...there were those who had access to the “permanent feast” and those who did not... So, the poor did not eat like the rich, the weak did not drink like the powerful.’¹⁷

Hence here we analyse the data both in terms of sex and funerary treatment to attempt to tease these variables apart and test these assumptions. We largely remove children from the equation due to issues over the osteological paradox and isotopic complications introduced by studying deceased juveniles.¹⁸

Previous isotopic studies of diet for the period have primarily been site or region specific.¹⁹ Whilst some studies actively hunt for variation in the isotopic evidence and find social differentiation in diet²⁰, larger multi-site studies have noted a distinct lack of social

¹⁶ Banham, *Food and Drink in Anglo-Saxon England*, 71–76; Allen J. Frantzen, *Food, Eating and Identity in Early Medieval England*, Anglo-Saxon Studies 22 (Woodbridge: Boydell Press, 2014), 34–80; Hagen, *Anglo-Saxon Food & Drink*, 451–62; Zoe Knapp, ‘The Zooarchaeology of the Anglo-Saxon Christian Conversion: Lyminge, a Case Study’ (PhD, Reading, University of Reading, 2018); Christina Lee, ‘Earth’s Treasures: Food and Drink’, in *The Material Culture of Daily Living in the Anglo-Saxon World*, Exeter Studies in Medieval Europe (Liverpool: Liverpool University Press, 2013), 142–56; Gautier, *Le Festin dans l’Angleterre anglo-saxonne (Ve-XIe siècle)*.

¹⁷ ‘...il y avait ceux qui avaient accès au « festin permanent » et ceux qui n’y avaient pas accès... Ainsi, les pauvres ne mangeaient pas comme les riches, les faibles ne buvaient pas comme les puissants.’ Gautier, *Le Festin dans l’Angleterre anglo-saxonne (Ve-XIe siècle)*, 227. The translation is our own.

¹⁸ The osteological paradox is the interpretational issue that arises from studying deceased populations - we cannot study alive ‘healthy’ individuals from any given time period, only those who are dead and therefore were not healthy at least at the end of their life. With juveniles this is particularly true as they did not survive into adulthood and therefore do not constitute a ‘normal’ healthy child of their age group. Bodily stress caused by illness often wreaks havoc on collagen isotope values, nitrogen in particular see: Hannah Haydock et al., ‘Weaning at Anglo-Saxon Raunds: Implications for Changing Breastfeeding Practice in Britain over Two Millennia: Weaning at Anglo-Saxon Raunds’, *American Journal of Physical Anthropology* 151, no. 4 (August 2013): 604–12, <https://doi.org/10.1002/ajpa.22316>; Julia Beaumont et al., ‘Comparing Apples and Oranges: Why Infant Bone Collagen May Not Reflect Dietary Intake in the Same Way as Dentine Collagen’, *American Journal of Physical Anthropology* 167, no. 3 (November 2018): 524–40, <https://doi.org/10.1002/ajpa.23682>; Sharon N. DeWitte and Christopher M. Stojanowski, ‘The Osteological Paradox 20 Years Later: Past Perspectives, Future Directions’, *Journal of Archaeological Research* 23, no. 4 (1 December 2015): 397–450, <https://doi.org/10.1007/s10814-015-9084-1>; Ellen Kendall, Andrew Millard, and Julia Beaumont, ‘The “Weanling’s Dilemma” Revisited: Evolving Bodies of Evidence and the Problem of Infant Paleodietary Interpretation’, *American Journal of Physical Anthropology*, 18 January 2021, [ajpa.24207](https://doi.org/10.1002/ajpa.24207), <https://doi.org/10.1002/ajpa.24207>; Benjamin T. Fuller et al., ‘Nitrogen Balance and $\Delta^{15}\text{N}$: Why You’re Not What You Eat during Nutritional Stress’, *Rapid Communications in Mass Spectrometry* 19, no. 18 (30 September 2005): 2497–2506, <https://doi.org/10.1002/rcm.2090>.

¹⁹ For example - Fiona E. Moore, ‘Diet and Subsistence in the Anglo-Saxon Trent Valley: A Stable Isotope Investigation of Broughton Lodge Anglo-Saxon Cemetery, Nottinghamshire’ (Masters, Nottingham, UK, University of Nottingham, 2017), http://eprints.nottingham.ac.uk/47841/1/MOORE%2C%20Fiona%20Elizabeth%204285593_MRes%20thesis%20Sept%202017_Diet%20and%20Subsistence%20in%20the%20Anglo-Saxon%20Trent%20Valley.pdf; Janet Montgomery et al., ‘Continuity or Colonization in Anglo-Saxon England? Isotope Evidence for Mobility, Subsistence Practice, and Status at West Heslerton’, *American Journal of Physical Anthropology* 126, no. 2 (February 2005): 123–38, <https://doi.org/10.1002/ajpa.20111>; Sam Lucy et al., ‘The Burial of A Princess? The Later Seventh-Century Cemetery At Westfield Farm, Ely’, *The Antiquaries Journal* 89 (September 2009): 81, <https://doi.org/10.1017/S0003581509990102>; Haydock et al., ‘Weaning at Anglo-Saxon Raunds’.

²⁰ Privat, O’Connell, and Richards, ‘Stable Isotope Analysis of Human and Faunal Remains from the Anglo-Saxon Cemetery at Berinsfield, Oxfordshire’; Purcell, ‘Social Differentiation through Diet: An Isotopic Study of Anglo-Saxon Lakenheath’; Duncan Sayer, *Early Anglo-Saxon Cemeteries: Kinship, Community and Identity*, Social Archaeology and Material Worlds (Manchester: Manchester University Press, 2020), 209–14.

differentiation in diet from the fifth to the eighth centuries.²¹ Certainly there is a high degree of regional variation in diets and isotopic baselines²², and we should not assume isotopic homogeneity across “England” during a highly dynamic period. However, nor should we actively hunt for variation which may be biologically or socially meaningless as it is a ‘statistical sin’.²³ This study will redress that balance by using an Exploratory Data Analysis approach, and analysing the data at various scales, constraining assumptions within the historical evidence analysed above.²⁴

What is even more elusive are isotopic studies on definitively “royal” or “noble” individuals from this period. Whilst “princely” graves like those at Sutton Hoo, Prittlewell and Benty Grange are likely candidates for such individuals, no skeletal remains survive to analyse.²⁵ The phenomena of bed burials may be marking out high status women in a special and short-lived way in the seventh century, and whilst these burials are rarely richly furnished in the number of grave goods, their burial on a bed often with select, highly valuable items (like the gold and garnet cross with Grave 1 at Trumpington Meadows) may denote their royal and Christian connections.²⁶ More skeletons survive from bed burials than they do from “princely” graves (seven of the fourteen confirmed bed burials have some bone surviving),

²¹ Hull, ‘Social Differentiation and Diet in Early Anglo-Saxon England’; Sarah Mallet, ‘Diets in England: Change, Continuity and Regionality between the Iron Age and Domesday Book (700 B.C -1086 A.D.)’ (<http://purl.org/dc/dcmitype/Text>, University of Oxford, 2016), <https://ora.ox.ac.uk/objects/uuid:faa5c291-bebc-4c86-ba30-c320b2893e25>; Hannah et al., ‘Anglo-Saxon Diet in the Conversion Period’.

²² Mallet, ‘Diets in England’; Samantha Alicen Leggett, ‘“Tell Me What You Eat, and I Will Tell You Who You Are”: A Multi-Tissue and Multi-Scalar Isotopic Study of Diet and Mobility in Early Medieval England and Its European Neighbours’ (PhD, Cambridge, University of Cambridge, 2020), <https://doi.org/10.17863/CAM.63545>; Kathryn Boulden, ‘A Bioarchaeological Reassessment of Land-Use Practices from the Neolithic to the Roman Period in Central Southern Britain Using Stable Isotope Analysis and Machine Learning Methods.’ (PhD, Cambridge, 2016, 2016).

²³ John W. Tukey, *Exploratory Data Analysis*, Addison-Wesley Series in Behavioural Science : Quantitative Methods (Reading, Mass.: Addison-Wesley, 1977).

²⁴ Tukey.

²⁵ M. O. H. Carver, *Sutton Hoo : Burial Ground of Kings?* (London: British Museum, 1998); S. M. Hirst et al., *The Prittlewell Prince: The Discovery of a Rich Anglo-Saxon Burial in Essex* (London, UK: Museum of London, 2004); Museums Sheffield, ‘EMuseum - Collections Search - Benty Grange Helmet Accession Number J93.1189’, 2012, <http://collections.museums-sheffield.org.uk/view/objects/asitem/search@/0?t:state:flow=f0db17a3-b3b1-465d-9efd-5027ef3b8c89>; ‘Benty Grange Hlaew, Monyash - 1013767 | Historic England’, accessed 25 March 2021, <https://historicengland.org.uk/listing/the-list/list-entry/1013767>.

²⁶ G Speake and English Heritage, *A Saxon Bed Burial on Swallowcliffe Down*, n.d.; Nick Stoodley and Jörn Schuster, ‘Collingbourne Ducis, Wiltshire: an Early Saxon Cemetery with bed burial’, in *Glaube, Kult und Herrschaft: Phänomene des Religiösen im 1. Jahrtausend n. Chr. in Mittel- und Nordeuropa ; Akten des 59. Internationalen Sachsensymposiums und der Grundprobleme der frühgeschichtlichen Entwicklung im Mitteldonauraum*, ed. Uta von Freeden et al., Kolloquien zur Vor- und Frühgeschichte, Bd. 12 (Bonn: R. Habelt, 2009); Jacqui Watson, ‘Smythes Corner (Shrublands Quarry), Coddanham, Suffolk The Examination and Reconstruction of an Anglo-Saxon Bed Burial’, Research Department Report Series (Portsmouth, UK: English Heritage, 2006); Christopher Evans, Sam Lucy, and Ricky Patten, ‘Chapter 5 - Anglo-Saxon Burials and Settlement’, in *Riversides: Neolithic Barrows, a Beaker Grave, Iron Age and Anglo-Saxon Burials and Settlement at Trumpington, Cambridge*, ed. Christopher Evans, Sam Lucy, and Ricky Patten, CAU Landscape Archives: New Archaeologies of the Cambridge Region 2 (Cambridge, UK: McDonald Institute for Archaeological Research, 2018); Sam Lucy, ‘The Trumpington Cross in Context’, *Anglo-Saxon England* 45 (December 2016): 7–37, <https://doi.org/10.1017/S0263675100080200>.

and four of them have been analysed isotopically, with their data included here.²⁷ They do not stand out in our dietary analyses, but more work on these fascinating graves is forthcoming. There has also been recent radiocarbon dating and ancient DNA work (and presumably accompanying isotopic analyses) on the funerary chests in Winchester Cathedral, believed to be the remains of late-Saxon and Anglo-Norman royalty including – Cynegils of Wessex, Bishop Wini, Cynewulf of Wessex, Egbert of Wessex, Æthelwulf of Wessex, Eadred of Wessex, Emma of Normandy, Edmund Ironside, Cnut the Great, Bishop Ælfwyn and William (II) Rufus, and additional unexpected individuals thought to be other members of the royal family of Wessex.²⁸ Sadly these results are yet to be fully published, but could give definite answers about what English rulers were eating and drinking, and if their diet changed much between the seventh and twelfth centuries.

This article will first tackle dietary evidence and social status from across early medieval England as a whole and then look specifically at cemeteries from Wessex to minimise the impact of regional variation on the data.

BACKGROUND

'Food renders' and elite consumption

We point readers to the companion article to this one for a more in-depth discussion on our assessment of the food list texts and their context²⁹; however, it is useful here to discuss the calculations and assumptions carried through into the analysis of the isotopic data below. This is clause 70.1 of the laws of King Ine of Wessex (r. 688 –726):

From ten hides as *fostre*: ten *fata* of honey, 300 loaves, twelve *ambra* of Welsh ale, thirty of clear ale, two full-grown cattle or ten wethers, ten geese, twenty hens, ten cheeses, an *amber* full of butter, five salmon, twenty *pundwæge* of fodder and 100 eels.³⁰

We estimated the volume, weight, and calorie content of each of the food stuffs listed here, and in the handful of broadly comparable lists, using a range of historical and zooarchaeological evidence in conjunction with information on modern livestock and the nutritional composition of foods. Our calculations suggest that the foods listed by Ine were disproportionately skewed towards animal products. A “loaf” in this context is likely to mean

²⁷ Leggett et al., ‘Multi-Tissue and Multi-Isotope ($\Delta 13C$, $\Delta 15N$, $\Delta 18O$ and $87/86Sr$) Data for Early Medieval Human and Animal Palaeoecology’; Evans, Lucy, and Patten, ‘Chapter 5 - Anglo-Saxon Burials and Settlement’.

²⁸ ‘Kings and Scribes: The Birth of a Nation’, Winchester Cathedral, accessed 25 March 2021, <https://www.winchester-cathedral.org.uk/conservation-action/kings-and-scribes-the-birth-of-a-nation/>; ‘Mortuary Chests Unlocked’, Winchester Cathedral, 16 May 2019, <https://www.winchester-cathedral.org.uk/mortuary-chests-unlocked/>; ‘The Riddle of Winchester Cathedral’s Skeletons’, *BBC News*, 18 May 2019, sec. Hampshire & Isle of Wight, <https://www.bbc.com/news/uk-england-hampshire-48300450>.

²⁹ Lambert and Leggett, ‘Food and Power in Early Medieval England: Rethinking *Feorm*’.

³⁰ ‘Æt x hidum to fostre x fata hunies, ccc hlafa, xii ambra wilisc ealað, xxx hluttres, tu eald hriðeru oððe x weðeras, x gees, xx henna, x cesas, amber fulne buteran, v leaxas, xx pundwæga foðres 7 hundteontig æla.’ Text: Jurasinski and Oliver, *Laws of Alfred*, pp. 430–1; Liebermann, *Gesetze I*, 118–19. The translation is our own.

a small round bun, an individual portion at most and highly unlikely to weigh more than the 300g we have assumed. For each such loaf, Ine's list includes 1.2kg of meat, fish, and cheese, as well as approximately 2.1 litres of ale. A remarkable 55% of the list's total calories derive from animal products, and if (as is likely) each loaf represents a single imagined diner, an individual meal was 4140kcal. None of these figures can be relied on precisely, of course, but the estimates underlying them have robust bases for the bread and livestock, where it matters most. The impression they provide of the scale and proportions of the foods demanded can be trusted.³¹ Moreover, as we show, the scale and proportions of Ine's list is broadly consistent with those of the food lists contained in a range of other texts, dating from the late eighth to the late tenth centuries, from Gloucestershire, Kent, and Hertfordshire, which hail from royal and ecclesiastical contexts.³² These similarities have long been noted and have sometimes been assumed to reflect a degree of institutional continuity, with ecclesiastical food renders representing privatised versions of the king's "farm of one night".³³ Our contention is that this is a misunderstanding and that these food lists have similar proportions because they are all lists of provisions for a specific sort of meal, a lavish feast typically involving several hundred guests. These were not the lists of general-purpose food supplies that the literature has widely assumed them to be. Rather, they constituted feasting food for special occasions with implications for community building and politics. This is not to downplay the key economic role of food and animals, especially cattle, in early medieval England – far from it. However, as we demonstrate below, the easy assumption that these texts provide evidence for what day-to-day meals looked like for elite households must be rejected, as the direct evidence from skeletons shows.

Stable isotope background

Light stable isotope analysis has become a regularly used technique in archaeological science to help answer questions surrounding diet and mobility in the past. Carbon and nitrogen stable isotope analysis for dietary reconstruction in archaeological contexts is a well-established methodology which is based on the principle that different foods differ in their isotopic compositions and that these can be quantified in the foods themselves and in the tissues of consumers. The core premise is "you are what you eat (and drink)" plus or minus a few permille (‰).³⁴ The foods and beverages you consume are incorporated into your bodily

³¹ Lambert and Leggett, 'Food and Power in Early Medieval England: Rethinking *Feorm*'.

³² Lambert and Leggett, 'Food and Power in Early Medieval England: Rethinking *Feorm*'.

³³ Chris Wickham, *Framing the Early Middle Ages: Europe and the Mediterranean, 400–800* (Oxford: Oxford University Press, 2005), 321, <https://doi.org/10.1093/acprof:oso/9780199264490.001.0001>.

³⁴ Stable isotope measurements are reported as a ratio of the heavy to the light isotope in relation to internationally defined standards in units permille (‰) - VPDB ($\delta^{13}\text{C}$) and AIR ($\delta^{15}\text{N}$). Where $\delta^{15}\text{N}_{\text{AIR}} = [(\frac{^{15}\text{N}_{\text{sample}}}{^{15}\text{N}_{\text{AIR}}}) - 1]$, and $\delta^{13}\text{C}_{\text{VPDB}} = [(\frac{^{13}\text{C}_{\text{sample}}}{^{13}\text{C}_{\text{VPDB}}}) - 1]$. Terry Brown and Keri Brown, *Biomolecular Archaeology: An Introduction* (Chichester: Wiley-Blackwell, 2011); Tyler B. Coplen, 'Guidelines and Recommended Terms for Expression of Stable-Isotope-Ratio and Gas-Ratio Measurement Results', *Rapid Communications in Mass Spectrometry* 25, no. 17 (2011): 2538–60, <https://doi.org/10.1002/rcm.5129>; Jochen Hoefs, *Stable Isotope Geochemistry*, 6th ed. (Berlin: Springer, 2009); T. Douglas Price and James H. Burton, *An Introduction to Archaeological Chemistry* (New York: Springer, 2012).

tissues and thus a chemical signature of diet for the period that tissue was formed is preserved. Different tissues remodel at different rates, giving archaeologists different windows into diet across an individual's life if samples are chosen wisely. Bones preserve a much longer isotopic average of the food consumed for an individual, with long bones such as femurs estimated to have a turnover rate of several decades, whilst ribs represent approximately up to one decade before death. Dentine from tooth roots has tighter constraints, with dentine not remodelling once formed, so for third molars (wisdom teeth) for instance the roots start forming at approximately twelve to sixteen years old and finish between eighteen to twenty-five years, and so represent consumption during adolescence and early adulthood, whereas a permanent (adult) first molar crown begins forming at birth, with roots capturing dietary signatures from two-and-a-half to ten years old.³⁵

Isotopic composition in the biosphere is highly variable and is affected by a variety of different processes depending on the element in question.³⁶ Isotope fractionation is the term that describes these processes which cause the relative abundance of difference in isotopes between substances, or the partitioning of the heavier and lighter isotopes.³⁷ The ratios of $^{13}\text{C}/^{12}\text{C}$ and $^{15}\text{N}/^{14}\text{N}$ in the environment and the food chain are therefore changeable and depend on many different variables. These natural variations in isotope ratios in the ecosystem form the basis of isotope analysis in archaeology and ecology, as measurable differences can be associated with human/animal behaviours.

Plants are the base of most terrestrial food chains and the isotopic variation in them will be passed onto consumers, be they herbivores or humans.³⁸ Carbon in plant tissues is a product of photosynthesis where atmospheric carbon dioxide is turned into oxygen (expelled) and glucose (stored for the plant to use), and isotopic fractionation occurs during this process.³⁹ There are three photosynthetic pathways – C_3 , C_4 and CAM – each fixes carbon in a different way which results in ^{13}C value differences between plant types.⁴⁰ As this study focuses on early medieval England, only C_3 (most cereals and vegetables) and C_4 plants are of interest here (CAM plants being desert species such as cacti and succulents). Millet, sago and amaranth are the only known C_4 plants to be consumed in Continental Europe in the early

³⁵ Rickne C. Scheid, *Woelfel's Dental Anatomy: Its Relevance to Dentistry*, 7th ed. (Baltimore: Lippincott Williams & Wilkins, 2007), 327–29.

³⁶ Hoefs, *Stable Isotope Geochemistry*, 334–82.

³⁷ Manish Tiwari, Ashutosh K. Singh, and Devesh K. Sinha, 'Chapter 3 - Stable Isotopes: Tools for Understanding Past Climatic Conditions and Their Applications in Chemostratigraphy', in *Chemostratigraphy*, ed. Mu. Ramkumar (Oxford: Elsevier, 2015), 65–92, <https://doi.org/10.1016/B978-0-12-419968-2.00003-0>.

³⁸ G D Farquhar, J R Ehleringer, and K T Hubick, 'Carbon Isotope Discrimination and Photosynthesis', *Annual Review of Plant Physiology and Plant Molecular Biology* 40, no. 1 (1989): 503–37, <https://doi.org/10.1146/annurev.pp.40.060189.002443>; Marion H. O'Leary, 'Carbon Isotopes in Photosynthesis', *BioScience* 38, no. 5 (May 1988): 328–36, <https://doi.org/10.2307/1310735>; L. L. Tieszen et al., 'Fractionation and Turnover of Stable Carbon Isotopes in Animal Tissues: Implications for $\Delta^{13}\text{C}$ Analysis of Diet', *Oecologia* 57, no. 1 (1 March 1983): 32–37, <https://doi.org/10.1007/BF00379558>.

³⁹ Farquhar, Ehleringer, and Hubick, 'Carbon Isotope Discrimination and Photosynthesis'; O'Leary, 'Carbon Isotopes in Photosynthesis'.

⁴⁰ Farquhar, Ehleringer, and Hubick, 'Carbon Isotope Discrimination and Photosynthesis'; O'Leary, 'Carbon Isotopes in Photosynthesis'; Hoefs, *Stable Isotope Geochemistry*, 52.

Middle Ages, but were not known in Britain until the later Middle Ages.⁴¹ C₃ plants have a possible $\delta^{13}\text{C}$ range of between -38 to -22‰, and C₄ plants between -9 and -21‰, when analysed as a whole plant, with some variation between species and plant tissues.⁴² Therefore when we find relatively elevated $\delta^{13}\text{C}_{\text{coll}}$ values in early medieval England, a possible interpretation could be that these individuals were migrants from regions where C₄ plants were consumed (e.g. Croatia or Italy).⁴³ However, a more plausible explanation in this context, as we explain below, is marine resource consumption.

Diversity in aquatic plants and extended food webs in both freshwater and marine ecosystems means that isotopic signatures of plants and animals in these environments are highly variable with large intra- and inter-species variations observed, particularly in freshwater fish.⁴⁴ Carbon isotopic signatures in these ecosystems are particularly complex. This complexity is

⁴¹ Kurt W. Alt et al., ‘Lombards on the Move – An Integrative Study of the Migration Period Cemetery at Szólád, Hungary’, ed. Luca Bondioli, *PLoS ONE* 9, no. 11 (4 November 2014): e110793, <https://doi.org/10.1371/journal.pone.0110793>; Giovanna Ganzarolli et al., ‘Direct Evidence from Lipid Residue Analysis for the Routine Consumption of Millet in Early Medieval Italy’, *Journal of Archaeological Science* 96 (1 August 2018): 124–30, <https://doi.org/10.1016/j.jas.2018.06.007>; Hagen, *Anglo-Saxon Food & Drink*, 23, 33, 38–39; Susanne E. Hakenbeck et al., ‘Practising Pastoralism in an Agricultural Environment: An Isotopic Analysis of the Impact of the Hunnic Incursions on Pannonian Populations’, ed. David Caramelli, *PLOS ONE* 12, no. 3 (22 March 2017): e0173079, <https://doi.org/10.1371/journal.pone.0173079>.

⁴² Hoefs, *Stable Isotope Geochemistry*, 52; O’Leary, ‘Carbon Isotopes in Photosynthesis’; Larry L. Tieszen, ‘Natural Variations in the Carbon Isotope Values of Plants: Implications for Archaeology, Ecology, and Paleocology’, *Journal of Archaeological Science* 18, no. 3 (1 May 1991): 227–48, [https://doi.org/10.1016/0305-4403\(91\)90063-U](https://doi.org/10.1016/0305-4403(91)90063-U); Nikolaas J. van der Merwe, ‘Carbon Isotopes, Photosynthesis, and Archaeology: Different Pathways of Photosynthesis Cause Characteristic Changes in Carbon Isotope Ratios That Make Possible the Study of Prehistoric Human Diets’, *American Scientist* 70, no. 6 (1982): 596–606. Photosynthesis and thus stable isotope ratios in plants (of both carbon and nitrogen) are inextricably linked with the plant’s growing environment – water availability, light, altitude, heat, the canopy effect, salinity and plant physiology can all impact on plant stable isotope ratios. Farquhar, Ehleringer, and Hubick, ‘Carbon Isotope Discrimination and Photosynthesis’; Emma Lightfoot et al., ‘Intraspecific Carbon and Nitrogen Isotopic Variability in Foxtail Millet (*Setaria Italica*)’, *Rapid Communications in Mass Spectrometry* 30, no. 13 (2016): 1475–87, <https://doi.org/10.1002/rcm.7583>; Emma Lightfoot et al., ‘Carbon and Nitrogen Isotopic Variability in Foxtail Millet (*Setaria Italica*) with Watering Regime’, *Rapid Communications in Mass Spectrometry* 34, no. 6 (2020): e8615, <https://doi.org/10.1002/rcm.8615>; O’Leary, ‘Carbon Isotopes in Photosynthesis’; Tieszen, ‘Natural Variations in the Carbon Isotope Values of Plants’; van der Merwe, ‘Carbon Isotopes, Photosynthesis, and Archaeology’.

⁴³ e.g. Carlos Eduardo G. Amorim et al., ‘Understanding 6th-Century Barbarian Social Organization and Migration through Paleogenomics.’ *Nature Communications* 9, no. 1 (2018): 1–11, <https://doi.org/10.1038/s41467-018-06024-4>; Vidal-Ronchas et al., ‘Diet, Sex, and Social Status in the Late Avar Period: Stable Isotope Investigations at Nuštar Cemetery, Croatia’.

⁴⁴ Anton Eryvnyck, Mathieu Boudin, and Wim Van Neer, ‘Assessing the Radiocarbon Freshwater Reservoir Effect for a Northwest-European River System (the Schelde Basin, Belgium)’, *Radiocarbon* 60, no. 2 (April 2018): 395–417, <https://doi.org/10.1017/RDC.2017.148>; Eric Guiry, ‘Complexities of Stable Carbon and Nitrogen Isotope Biogeochemistry in Ancient Freshwater Ecosystems: Implications for the Study of Past Subsistence and Environmental Change’, *Frontiers in Ecology and Evolution* 7 (2019), <https://doi.org/10.3389/fevo.2019.00313>; Robert E.M. Hedges and Linda M. Reynard, ‘Nitrogen Isotopes and the Trophic Level of Humans in Archaeology’, *Journal of Archaeological Science* 34, no. 8 (August 2007): 1240–51, <https://doi.org/10.1016/j.jas.2006.10.015>; Hoefs, *Stable Isotope Geochemistry*, 153.

highlighted by the high degree of overlap between freshwater fish bone collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values and those of terrestrial and marine species.⁴⁵

Marine $\delta^{13}\text{C}$ values are higher in comparison with terrestrial environments due to their long and complex food chains and carbon reservoir effect. This means they are easily isotopically distinguished in the tissues of producers and consumers.⁴⁶ However, there is an interpretational problem due to the overlap between $\delta^{13}\text{C}$ values of C_4 consumers, marine consumers, and consumers of mixed plant or terrestrial/marine diets.⁴⁷ Therefore isotopically separating these consumption patterns is extremely difficult without good baseline evidence or other contextual dietary information (archaeological or historical) to constrain interpretations.

Many of the causes of $\delta^{15}\text{N}$ variation in nature are the same as $\delta^{13}\text{C}$ described above – water availability, heat, the canopy effect etc. Differences in ecosystems are as apparent in $\delta^{15}\text{N}$ values as they are in $\delta^{13}\text{C}$, aiding in the distinction between terrestrial and marine resource consumption. In animal tissues $\delta^{15}\text{N}$ increases stepwise up the food chain so that carnivores have higher values than omnivores and omnivores higher than herbivores, with each step called a ‘trophic level’, with $\delta^{15}\text{N}$ assumed to increase between 3-5‰ between each level.⁴⁸

Terrestrial plants assimilate nitrogen from decaying organic matter and the atmosphere via two pathways – direct nitrogen (N_2) fixation, and assimilation with help from soil microbes or

⁴⁵ J. Iwan Jones and Susan Waldron, ‘Combined Stable Isotope and Gut Contents Analysis of Food Webs in Plant-Dominated, Shallow Lakes’, *Freshwater Biology* 48, no. 8 (2003): 1396–1407, <https://doi.org/10.1046/j.1365-2427.2003.01095.x>; Olaf Nehlich et al., ‘Sulphur Isotope Evidence for Freshwater Fish Consumption: A Case Study from the Danube Gorges, SE Europe’, *Journal of Archaeological Science* 37, no. 5 (May 2010): 1131–39, <https://doi.org/10.1016/j.jas.2009.12.013>; Guiry, ‘Complexities of Stable Carbon and Nitrogen Isotope Biogeochemistry in Ancient Freshwater Ecosystems’.

⁴⁶ B. S. Chisholm, D. E. Nelson, and H. P. Schwarcz, ‘Stable-Carbon Isotope Ratios as a Measure of Marine Versus Terrestrial Protein in Ancient Diets’, *Science* 216, no. 4550 (4 June 1982): 1131–32, <https://doi.org/10.1126/science.216.4550.1131>; Gundula Müldner, ‘Marine Fish Consumption in Medieval Britain: The Isotope Perspective from Human Skeletal Remains’, in *Cod and Herring: The Archaeology and History of Medieval Sea Fishing*, ed. James H. Barrett and David C. Orton (Oxford: Oxbow Books, 2016), 239–49; Margaret J Schoeninger and Michael J DeNiro, ‘Nitrogen and Carbon Isotopic Composition of Bone Collagen from Marine and Terrestrial Animals’, *Geochimica et Cosmochimica Acta* 48, no. 4 (1 April 1984): 625–39, [https://doi.org/10.1016/0016-7037\(84\)90091-7](https://doi.org/10.1016/0016-7037(84)90091-7); Henrik Tauber, ‘ ^{13}C Evidence for Dietary Habits of Prehistoric Man in Denmark’, *Nature* 292, no. 5821 (July 1981): 332–33, <https://doi.org/10.1038/292332a0>.

⁴⁷ Chisholm, Nelson, and Schwarcz, ‘Stable-Carbon Isotope Ratios as a Measure of Marine Versus Terrestrial Protein in Ancient Diets’; Matthew C. Lewis and Judith C. Sealy, ‘Coastal Complexity: Ancient Human Diets Inferred from Bayesian Stable Isotope Mixing Models and a Primate Analogue’, *PLOS ONE* 13, no. 12 (20 December 2018): e0209411, <https://doi.org/10.1371/journal.pone.0209411>; van der Merwe, ‘Carbon Isotopes, Photosynthesis, and Archaeology’.

⁴⁸ Stanley H. Ambrose, ‘Stable Carbon and Nitrogen Isotope Analysis of Human and Animal Diet in Africa’, *Journal of Human Evolution* 15, no. 8 (December 1986): 707–31, [https://doi.org/10.1016/S0047-2484\(86\)80006-9](https://doi.org/10.1016/S0047-2484(86)80006-9); Stanley H. Ambrose, ‘Effects of Diet, Climate and Physiology on Nitrogen Isotope Abundances in Terrestrial Foodwebs’, *Journal of Archaeological Science* 18, no. 3 (1 May 1991): 293–317, [https://doi.org/10.1016/0305-4403\(91\)90067-Y](https://doi.org/10.1016/0305-4403(91)90067-Y); Hedges, ‘On Bone Collagen?’; Hedges and Reynard, ‘Nitrogen Isotopes and the Trophic Level of Humans in Archaeology’.

commensal microbes living in the plant's roots (e.g. legumes).⁴⁹ The differences in these pathways causes fractionation giving direct nitrogen fixers $\delta^{15}\text{N}$ values similar to atmospheric values (0‰).⁵⁰ Whereas nitrogen assimilators (non-fixers), the majority of terrestrial plants, have $\delta^{15}\text{N}$ values ranging from 2-10‰ due to variation in soil isotopic values which can be altered through processes such as manuring or water logging.⁵¹

In marine ecosystems nitrogen is fixed by both algae and phytoplankton and can also enter food chains from decomposing organic matter in the oceans.⁵² The main cause of denitrification in marine systems is from water evaporation, which favours the lighter isotope, leaving these ecosystems isotopically enriched in ^{15}N . This evapo-concentration combined with the longer marine food chains described above, leads to marine organisms having higher $\delta^{15}\text{N}$ values compared to their terrestrial counterparts.⁵³ Long aquatic food chains are also the main driving factor for freshwater ^{15}N enrichment, as mentioned above with carbon in these ecosystems.⁵⁴

Another important factor to consider with nitrogen, especially in humans, is nitrogen balance. It is the equilibrium in our bodies between protein intake (from diet) and loss (through metabolism and excretion). If this equilibrium is thrown out then the body might start to self-metabolise, breaking down its own tissues for fuel. This balance between energy intake and expenditure can be disturbed by illness or nutritional stress causing isotopic changes in bodily tissues. Research also suggests that in otherwise healthy individuals, lactation, pregnancy and growth during puberty where the energy demands of the body exceed dietary input, likely cause isotopic changes similar to periods of illness.⁵⁵ The impact of stress on δ

⁴⁹ Hoefs, *Stable Isotope Geochemistry*, 54–55.

⁵⁰ Hoefs, 54–55; David Robinson, 'Δ15N as an Integrator of the Nitrogen Cycle', *Trends in Ecology & Evolution* 16, no. 3 (March 2001): 153–62, [https://doi.org/10.1016/S0169-5347\(00\)02098-X](https://doi.org/10.1016/S0169-5347(00)02098-X).

⁵¹ A. Bogaard et al., 'The Impact of Manuring on Nitrogen Isotope Ratios in Cereals: Archaeological Implications for Reconstruction of Diet and Crop Management Practices', *Journal of Archaeological Science* 34, no. 3 (1 March 2007): 335–43, <https://doi.org/10.1016/j.jas.2006.04.009>; Hoefs, *Stable Isotope Geochemistry*, 55; Lightfoot et al., 'Intraspecific Carbon and Nitrogen Isotopic Variability in Foxtail Millet (*Setaria Italica*)'; Lightfoot et al., 'Carbon and Nitrogen Isotopic Variability in Foxtail Millet (*Setaria Italica*) with Watering Regime'; Schoeninger and DeNiro, 'Nitrogen and Carbon Isotopic Composition of Bone Collagen from Marine and Terrestrial Animals'.

⁵² Nicolas Gruber, 'The Dynamics of the Marine Nitrogen Cycle and Its Influence on Atmospheric CO₂ Variations', in *The Ocean Carbon Cycle and Climate*, ed. Mick Follows and Temel Oguz, NATO Science Series 40 (Dordrecht: Springer Netherlands, 2004), 97–148, https://doi.org/10.1007/978-1-4020-2087-2_4; Nicolas Gruber, 'The Marine Nitrogen Cycle: Overview and Challenges', in *Nitrogen in the Marine Environment*, ed. Douglas C Capone et al., 2nd Edition (London: Academic Press, 2008), 1–50.

⁵³ M. P. Richards and R. E. M. Hedges, 'Stable Isotope Evidence for Similarities in the Types of Marine Foods Used by Late Mesolithic Humans at Sites Along the Atlantic Coast of Europe', *Journal of Archaeological Science* 26, no. 6 (1 June 1999): 717–22, <https://doi.org/10.1006/jasc.1998.0387>; Schoeninger and DeNiro, 'Nitrogen and Carbon Isotopic Composition of Bone Collagen from Marine and Terrestrial Animals'.

⁵⁴ Guiry, 'Complexities of Stable Carbon and Nitrogen Isotope Biogeochemistry in Ancient Freshwater Ecosystems'; Hoefs, *Stable Isotope Geochemistry*, 154; Jones and Waldron, 'Combined Stable Isotope and Gut Contents Analysis of Food Webs in Plant-Dominated, Shallow Lakes'; Privat, O'Connell, and Hedges, 'The Distinction between Freshwater- and Terrestrial-Based Diets'.

⁵⁵ Casey T. Clark et al., 'Heavy with Child? Pregnancy Status and Stable Isotope Ratios as Determined from Biopsies of Humpback Whales', *Conservation Physiology* 4, no. 1 (1 January 2016),

^{15}N values is exemplified by work on Irish famine populations where a “stress bubble” can be seen in incremental dentine slices of people who survived the famine.⁵⁶ Nutritional stress and breastfeeding are therefore also isotopically visible in tissues of mothers and infants, making early life health events traceable using this methodology.⁵⁷

When there is not sufficient protein in someone’s diet (either through starvation or by choice e.g. veganism) the body routes carbon from whole diet (carbohydrates, lipids and any residual protein from plants) into collagen which is usually skewed towards protein intake. So, whilst no “stress bubble” is seen in $\delta^{13}\text{C}$ values, $\delta^{15}\text{N}$ values will appear low, and this re-routing can impact interpretations of isotopic values. Conversely, the more protein there is in the diet, the more carbon will be sourced from that portion of the diet.⁵⁸ Therefore modern veganism is isotopically identifiable in $\delta^{15}\text{N}$ values and looks like other herbivorous mammals. Controlled

<https://doi.org/10.1093/conphys/cow050>; Fuller et al., ‘Nitrogen Balance and $\Delta^{15}\text{N}$ ’; Haydock et al., ‘Weaning at Anglo-Saxon Raunds’; E. K. Nitsch, L. T. Humphrey, and R. E. M. Hedges, ‘The Effect of Parity Status on $\Delta^{15}\text{N}$: Looking for the “Pregnancy Effect” in 18th and 19th Century London’, *Journal of Archaeological Science* 37, no. 12 (1 December 2010): 3191–99, <https://doi.org/10.1016/j.jas.2010.07.019>; Laurie J. Reitsema, ‘Beyond Diet Reconstruction: Stable Isotope Applications to Human Physiology, Health, and Nutrition’, *American Journal of Human Biology* 25, no. 4 (2013): 445–56, <https://doi.org/10.1002/ajhb.22398>; Julia Beaumont and Janet Montgomery, ‘The Great Irish Famine: Identifying Starvation in the Tissues of Victims Using Stable Isotope Analysis of Bone and Incremental Dentine Collagen’, *PLOS ONE* 11, no. 8 (10 August 2016): e0160065, <https://doi.org/10.1371/journal.pone.0160065>.

⁵⁶ A “stress bubble” on an incremental dentine chart occurs when the ^{15}N values go up and the ^{13}C values more or less remain constant around the nutritional stress event thus creating co-occurring anomalies and a “bubble” on the chart is formed. Isotopic analysis of incremental dentine, a technique not used here, uses fine slices along a cross-section of the tooth root to look at diet through the period of that tissue’s formation. Beaumont et al., ‘Comparing Apples and Oranges’; Julia Beaumont et al., ‘Infant Mortality and Isotopic Complexity: New Approaches to Stress, Maternal Health, and Weaning’, *American Journal of Physical Anthropology* 157, no. 3 (2015): 441–57, <https://doi.org/10.1002/ajpa.22736>; Beaumont and Montgomery, ‘The Great Irish Famine’; J. Beaumont et al., ‘Childhood Diet: A Closer Examination of the Evidence from Dental Tissues Using Stable Isotope Analysis of Incremental Human Dentine’, *Archaeometry* 55, no. 2 (2013): 277–95; Elizabeth Craig-Atkins, Jacqueline Towers, and Julia Beaumont, ‘The Role of Infant Life Histories in the Construction of Identities in Death: An Incremental Isotope Study of Dietary and Physiological Status among Children Afforded Differential Burial’, *American Journal of Physical Anthropology* 167, no. 3 (November 2018): 644–55, <https://doi.org/10.1002/ajpa.23691>; Charlotte L. King et al., ‘A Comparison of Using Bulk and Incremental Isotopic Analyses to Establish Weaning Practices in the Past’, *STAR: Science & Technology of Archaeological Research* 3, no. 1 (1 January 2017): 126–34, <https://doi.org/10.1080/20548923.2018.1443548>.

⁵⁷ Beaumont et al., ‘Infant Mortality and Isotopic Complexity’; Beaumont et al., ‘Comparing Apples and Oranges’; Kayla D. Crowder et al., ‘Childhood “Stress” and Stable Isotope Life Histories in Transylvania’, *International Journal of Osteoarchaeology* 29, no. 4 (2019): 644–53, <https://doi.org/10.1002/oa.2760>; Fuller et al., ‘Nitrogen Balance and $\Delta^{15}\text{N}$ ’; B.T. Fuller et al., ‘Isotopic Evidence for Breastfeeding and Possible Adult Dietary Differences from Late/Sub-Roman Britain’, *American Journal of Physical Anthropology* 129, no. 1 (January 2006): 45–54, <https://doi.org/10.1002/ajpa.20244>; Haydock et al., ‘Weaning at Anglo-Saxon Raunds’.

⁵⁸ Daryl Codron et al., ‘The Confounding Effects of Source Isotopic Heterogeneity on Consumer–Diet and Tissue–Tissue Stable Isotope Relationships’, *Oecologia* 169, no. 4 (1 August 2012): 939–53, <https://doi.org/10.1007/s00442-012-2274-3>; Daryl Codron et al., ‘Within Trophic Level Shifts in Collagen–Carbonate Stable Carbon Isotope Spacing Are Propagated by Diet and Digestive Physiology in Large Mammal Herbivores’, *Ecology and Evolution* 8, no. 8 (25 March 2018): 3983–95, <https://doi.org/10.1002/ece3.3786>; Jim, Ambrose, and Evershed, ‘Stable Carbon Isotopic Evidence for Differences in the Dietary Origin of Bone Cholesterol, Collagen and Apatite’; Susan Jim et al., ‘Quantifying Dietary Macronutrient Sources of Carbon for Bone Collagen Biosynthesis Using Natural Abundance Stable Carbon Isotope Analysis’, *British Journal of Nutrition* 95, no. 6 (June 2006): 1055–62, <https://doi.org/10.1079/BJN20051685>.

dietary studies show significant differences between people with no animal protein intake compared with those who have various levels of omnivory (whether it be secondary animal products like milk, cheese or eggs, or meat).⁵⁹

1. Other bioarchaeological evidence

For our purposes, the great benefit of stable isotope analysis is that, despite the range of possible confounding factors, it can yield insights into the relative significance of different foodstuffs within early medieval diets. There are of course other forms of bioarchaeological evidence for diet which can enrich our understanding of foodway economics in early medieval England by providing finer-grained detail on the types of food that were eaten, even if it is more difficult to bring them to bear on questions about their overall significance in

⁵⁹ M. Anne Katzenberg and H. Roy Krouse, 'Application of Stable Isotope Variation in Human Tissues to Problems in Identification', *Canadian Society of Forensic Science Journal* 22, no. 1 (1 January 1989): 7–19, <https://doi.org/10.1080/00085030.1989.10757414>; Masao Minagawa, 'Reconstruction of Human Diet from $\Sigma^{13}\text{C}$ and $\Sigma^{15}\text{N}$ in Contemporary Japanese Hair: A Stochastic Method for Estimating Multi-Source Contribution by Double Isotopic Tracers', *Applied Geochemistry* 7, no. 2 (1 March 1992): 145–58, [https://doi.org/10.1016/0883-2927\(92\)90033-Y](https://doi.org/10.1016/0883-2927(92)90033-Y); T.C. O'Connell et al., 'The Diet-Body Offset in Human Nitrogen Isotopic Values: A Controlled Dietary Study', *American Journal of Physical Anthropology* 149, no. 3 (November 2012): 426–34, <https://doi.org/10.1002/ajpa.22140>; T. C. O'Connell and R. E. M. Hedges, 'Investigations into the Effect of Diet on Modern Human Hair Isotopic Values', *American Journal of Physical Anthropology* 108, no. 4 (1999): 409–25, [https://doi.org/10.1002/\(SICI\)1096-8644\(199904\)108:4<409::AID-AJPA3>3.0.CO;2-E](https://doi.org/10.1002/(SICI)1096-8644(199904)108:4<409::AID-AJPA3>3.0.CO;2-E); Klaus J. Petzke, Heiner Boeing, and Cornelia C. Metges, 'Choice of Dietary Protein of Vegetarians and Omnivores Is Reflected in Their Hair Protein ^{13}C and ^{15}N Abundance', *Rapid Communications in Mass Spectrometry* 19, no. 11 (2005): 1392–1400, <https://doi.org/10.1002/rcm.1925>; Lars Ellegård et al., 'Distinguishing Vegan-, Vegetarian-, and Omnivorous Diets by Hair Isotopic Analysis', *Clinical Nutrition* 38, no. 6 (1 December 2019): 2949–51, <https://doi.org/10.1016/j.clnu.2018.12.016>.

Beyond breastfeeding and weaning, it has been suggested that differences in metabolism at different life stages or between the sexes causes isotopic fractionation. There is evidence from non-humans for age stages causing isotopic shifts, but the data for humans seems to suggest any age-related isotopic differences are culturally mediated beyond breastfeeding, however more experimental work needs to be done. Iulia Bădescu et al., 'A Novel Fecal Stable Isotope Approach to Determine the Timing of Age-Related Feeding Transitions in Wild Infant Chimpanzees', *American Journal of Physical Anthropology* 162, no. 2 (2017): 285–99, <https://doi.org/10.1002/ajpa.23116>; Asunción Borrell et al., 'Stable Isotopes Provide Insight into Population Structure and Segregation in Eastern North Atlantic Sperm Whales', *PLoS ONE* 8, no. 12 (6 December 2013), <https://doi.org/10.1371/journal.pone.0082398>; M. Anne Katzenberg, Shelley R. Saunders, and William R. Fitzgerald, 'Age differences in stable carbon and nitrogen isotope ratios in a population of prehistoric maize horticulturists', *American Journal of Physical Anthropology* 90, no. 3 (1993): 267–81, <https://doi.org/10.1002/ajpa.1330900302>; Kirsteen M. MacKenzie et al., 'Stable Isotopes Reveal Age-Dependent Trophic Level and Spatial Segregation during Adult Marine Feeding in Populations of Salmon', *ICES Journal of Marine Science* 69, no. 9 (1 November 2012): 1637–45, <https://doi.org/10.1093/icesjms/fss074>; A. J. Waterman, R. H. Tykot, and A. M. Silva, 'Stable Isotope Analysis of Diet-Based Social Differentiation at Late Prehistoric Collective Burials in South-Western Portugal', *Archaeometry* 58, no. 1 (2016): 131–51, <https://doi.org/10.1111/arc.12159>; Kendall, Millard, and Beaumont, 'The "Weanling's Dilemma" Revisited'; Beaumont et al., 'Comparing Apples and Oranges'; M. Minagawa and E. Wada, 'Stepwise Enrichment of ^{15}N along Food Chains: Further Evidence and the Relation between $\Delta^{15}\text{N}$ and Animal Age', *Geochimica et Cosmochimica Acta* 48 (1984): 1135–40.

As yet there is no experimental evidence for differences between male and female ^{13}C and ^{15}N values (excluding pregnancy and nursing effects) however some differences have been observed and it has been suggested these are due to physiology rather than culturally defined. Minagawa, 'Reconstruction of Human Diet from $\Sigma^{13}\text{C}$ and $\Sigma^{15}\text{N}$ in Contemporary Japanese Hair'; Leggett, "Tell Me What You Eat, and I Will Tell You Who You Are", 242–45.

ordinary diets. These include zooarchaeology, archaeobotany, biomolecular studies of residues in pottery (lipids and proteins) and dental calculus (calcified dental plaque/tartar which can be studied in a variety of ways to look at what food has been preserved within it – light microscopy to identify visibly distinctive food remnants, isotope analysis, lipids, proteomics, and DNA). Pottery residues and dental calculus work are rapidly evolving and as yet have limited usage in the early medieval period.

The majority of the zooarchaeological literature on our period is focused on East Anglia due to the extraordinary excavations at West Stow, however there are multitudes of site-specific studies on early medieval animal bones in site reports and grey literature from commercial archaeology with recent efforts attempting some synthesis.⁶⁰ Recent studies suggest that with Romanization in Britain came animal “improvement” (enlargement for meat) for major domesticates such as sheep, cattle and pigs, but with the collapse of control in the fringes of the Empire these larger meat-heavy animals and an emphasis on these kinds of animal surplus for meat seem to have disappeared in fifth century Britain.⁶¹ Kill patterns (age and sex of butchered animals), animal pathologies (e.g. foot bone disease from use as traction animals) and butchery marks on bones also give insight into animal husbandry practices, meat cuts and processing of animals for other secondary products.⁶² Zooarchaeologists have suggested that in the post-Roman period domestic livestock were killed predominantly as either part of herd management (e.g. killing younger males earlier in life so as to keep females for dairy and breeding) or later in life after their utility for traction, breeding or secondary products like dairy or wool was at an end, rather than the meat-heavy emphasis of the Roman period.⁶³ Recent work from Zoe Knapp on the high-status site of Lyminge in Kent shows feasting layers rich in red meat which changes over time with Christianisation to a larger emphasis on chickens and fish, which she related back to the laws of Wihtrred of Kent which imposes fines

⁶⁰ Dan Stansbie and Sarah Mallet, ‘Big, Bad (?) Data: New Approaches to the Study of Food, Identity and Landscape in Early Medieval England’, *Medieval Settlement Research* 30 (2015): 16–24; Pam J. Crabtree, ‘Production and Consumption in an Early Complex Society: Animal Use in Middle Saxon East Anglia’, *World Archaeology* 28, no. 1 (June 1996): 58–75, <https://doi.org/10.1080/00438243.1996.9980331>; Pam J. Crabtree, ‘Animal Husbandry and Farming in East Anglia from the 5th to the 10th Centuries CE’, *Quaternary International*, Agrarian Archaeology in Early Medieval Europe, 346 (30 September 2014): 102–8, <https://doi.org/10.1016/j.quaint.2013.09.015>; Pam J. Crabtree, *Middle Saxon Animal Husbandry in East Anglia*, East Anglian Archaeology 143 (Bury St Edmunds, Suffolk: Suffolk County Council Archaeological Service, 2012).

⁶¹ Mauro Rizzetto, Pam J. Crabtree, and Umberto Albarella, ‘Livestock Changes at the Beginning and End of the Roman Period in Britain: Issues of Acculturation, Adaptation, and “Improvement”’, *European Journal of Archaeology* 20, no. 3 (August 2017): 535–56, <https://doi.org/10.1017/eea.2017.13>; Matilda Holmes, ‘Does Size Matter? Changes in the Size of Animals throughout the English Saxon Period (AD 450–1066)’, *Journal of Archaeological Science* 43 (March 2014): 77–90, <https://doi.org/10.1016/j.jas.2013.12.007>.

⁶² Holmes, ‘Does Size Matter?’

⁶³ Knapp, ‘The Zooarchaeology of the Anglo-Saxon Christian Conversion: Lyminge, a Case Study’; Holmes, ‘Does Size Matter?’; Rizzetto, Crabtree, and Albarella, ‘Livestock Changes at the Beginning and End of the Roman Period in Britain’; Crabtree, ‘Animal Husbandry and Farming in East Anglia from the 5th to the 10th Centuries CE’; Pam J. Crabtree, ‘Agricultural Innovation and Socio-Economic Change in Early Medieval Europe: Evidence from Britain and France’, *World Archaeology* 42, no. 1 (March 2010): 122–36, <https://doi.org/10.1080/00438240903430373>.

for those found to be eating meat during fasting periods.⁶⁴ Knapp's identification of feasting deposits, distinct from other midden material implies that consumption of pigs, sheep/goat and cattle, whilst consumed in higher quantities at Lyminge, may have been reserved for distinctive special feasting events rather than regular day-to-day consumption, and that what was acceptable or in fashion to consume at feasts changed throughout the early medieval period. This suggests that meat from livestock was not a regular occurrence, even at high-status sites.

The archaeobotany of early medieval England suggests that there were indeed shifts in agriculture from the Roman period into the fifth and sixth centuries; however, the major agricultural transitions occurred in the seventh and eighth centuries onwards.⁶⁵ The shifts are in the species and cultivars of cereal crops grown, and their relative proportions to one another, as well as changes in plough technology and therefore the kinds of soils cultivated. It appears some of these changes in how cereals were grown may have impacted the crop isotopic values, namely by enriching $\delta^{15}\text{N}_{\text{coll}}$ values due to fertilisation and/or physiological stress from non-ideal soil conditions. Therefore, these agricultural transitions may have impacted $\delta^{15}\text{N}_{\text{coll}}$ values up the food chain passing ^{15}N enrichment onto human consumers making them look like they were eating more protein when in fact the whole food chain has been enriched.⁶⁶ A full exploration of this is forthcoming and outside the scope of this article but poses interesting questions about dietary shifts in the later part of the early medieval period in England.

Other biomolecular approaches such as genomics, proteomics, metabolomics, and lipid residue analyses can also shed light on early medieval diets, and these techniques are showing great promise but remain underutilised for our period, with specialists primarily focussing on prehistoric contexts. Genetics studies in particular are still very much intent on human population studies and hunting down pathogens rather than what plants and animals are left behind in peoples' fossilised food.⁶⁷ There has been interesting work on medieval

⁶⁴ Knapp, 'The Zooarchaeology of the Anglo-Saxon Christian Conversion: Lyminge, a Case Study'; Dorothy Whitelock, 'The Laws of Wihtred, King of Kent (695)', in *English Historical Documents Volume I, c.500-1042*, vol. I, English Historical Documents (London; New York: Routledge, 1994), <http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=85138>.

⁶⁵ Mark James McKerracher, *Anglo-Saxon Crops and Weeds: A Case Study in Quantitative Archaeobotany*, Access Archaeology (Oxford: Archaeopress Publishing Ltd, 2019); Mark McKerracher, *Farming Transformed in Anglo-Saxon England: Agriculture in the Long Eighth Century* (Bollington: Windgather Press, 2018); Helena Hamerow et al., 'An Integrated Bioarchaeological Approach to the Medieval "Agricultural Revolution": A Case Study from Stafford, England, c. Ad 800–1200', *European Journal of Archaeology*, 2020, 1–25, <https://doi.org/10.1017/eea.2020.6>.

⁶⁶ Hamerow et al., 'An Integrated Bioarchaeological Approach to the Medieval "Agricultural Revolution"'; Leggett, "'Tell Me What You Eat, and I Will Tell You Who You Are'".

⁶⁷ Jessica Hendy, 'Ancient Protein Analysis in Archaeology', *Science Advances* 7, no. 3 (January 2021): eabb9314, <https://doi.org/10.1126/sciadv.abb9314>; Jessica Hendy et al., 'Proteomic Evidence of Dietary Sources in Ancient Dental Calculus', *Proceedings of the Royal Society B: Biological Sciences* 285, no. 1883 (25 July 2018): 20180977, <https://doi.org/10.1098/rspb.2018.0977>; Stephen Leslie et al., 'The Fine-Scale Genetic Structure of the British Population', *Nature* 519, no. 7543 (March 2015): 309–14, <https://doi.org/10.1038/nature14230>; Bruce Winney et al., 'People of the British Isles: Preliminary Analysis of Genotypes and Surnames in a UK-Control Population', *European Journal of Human Genetics* 20, no. 2 (February 2012): 203–10, <https://doi.org/10.1038/ejhg.2011.127>; Michaela Harbeck et al., 'Yersinia Pestis DNA

dental calculus in the past few years, but these are few and far between, and tend towards the exceptional rather than every day.⁶⁸ New work on dental calculus from early medieval cemeteries in Cambridgeshire may indicate social differentiation in diet through the species meat and dairy are sourced from but these results are not yet published, and more work needs to be done.⁶⁹

The handful of studies on early medieval pottery and other cooking residues have demonstrated that foodways may indeed shift across the first millennium AD, and certainly after the Norman Conquest, with a homogenising of dietary signatures related to marketisation.⁷⁰ Sherds from pre-Conquest Oxford pottery shows vessels were used for cooking beef, lamb and possibly also goat, with some limited dairy processing, but this shifted in the post-Conquest period away from dairy, as pork and chicken meat processing became predominant. In both periods these vessels also showed plant biomarkers, with leafy greens such as brassicas being particularly clear in the residues. Similarly, residue analyses from West Cotton Raunds (c. 950-1450 AD) show specialisation in pottery types for certain kinds of food processing and storage, with evidence for animal meat consumption in the forms of stews or pottages, dairy processing, some porcine fats, mixing of animal products and plants in cookery and even some honey/beeswax signatures.⁷¹ However, the picture is largely of meat and carcass fats being cooked with dairy as an additional or supplemental protein depending on social status reflected in the type of site and pottery styles. These studies are several centuries later than our period of focus here, however they also rely on

from Skeletal Remains from the 6th Century AD Reveals Insights into Justinianic Plague', ed. Nora J. Besansky, *PLoS Pathogens* 9, no. 5 (2 May 2013): e1003349, <https://doi.org/10.1371/journal.ppat.1003349>; Marcel Keller et al., 'Ancient *Yersinia Pestis* Genomes from across Western Europe Reveal Early Diversification during the First Pandemic (541–750)', *Proceedings of the National Academy of Sciences*, 4 June 2019, 201820447, <https://doi.org/10.1073/pnas.1820447116>; Mélanie Roffet-Salque et al., 'From the inside out: Upscaling Organic Residue Analyses of Archaeological Ceramics', *Journal of Archaeological Science: Reports* 16 (1 December 2017): 627–40, <https://doi.org/10.1016/j.jasrep.2016.04.005>; Enrico Cappellini et al., 'Ancient Biomolecules and Evolutionary Inference', *Annual Review of Biochemistry* 87, no. 1 (20 June 2018): 1029–60, <https://doi.org/10.1146/annurev-biochem-062917-012002>.

⁶⁸ One of the handful of dental calculus studies on a (later) medieval individual reported lapis lazuli in the dental plaque of a religious woman, suggesting she was involved in the production of manuscripts, see A. Radini et al., 'Medieval Women's Early Involvement in Manuscript Production Suggested by Lapis Lazuli Identification in Dental Calculus', *Science Advances* 5, no. 1 (January 2019): eaau7126, <https://doi.org/10.1126/sciadv.aau7126>. But as yet the more detailed findings on this skeleton and other medieval individuals and the implications for diet have not yet been published or made accessible e.g. Anita Radini, 'Particles of Everyday Life. Past Diet and Living Conditions as Evidenced by Micro- Debris Entrapped in Human Dental Calculus: A Case Study from Medieval Leicester and Surrounding' (phd, University of York, 2016), <http://etheses.whiterose.ac.uk/17602/>.

⁶⁹ C. Scheib, *pers comm*.

⁷⁰ Elizabeth Craig-Atkins et al., 'The Dietary Impact of the Norman Conquest: A Multiproxy Archaeological Investigation of Oxford, UK', *PLOS ONE* 15, no. 7 (6 July 2020): e0235005, <https://doi.org/10.1371/journal.pone.0235005>.

⁷¹ J. Dunne et al., 'Reconciling Organic Residue Analysis, Faunal, Archaeobotanical and Historical Records: Diet and the Medieval Peasant at West Cotton, Raunds, Northamptonshire', *Journal of Archaeological Science* 107 (July 2019): 58–70, <https://doi.org/10.1016/j.jas.2019.04.004>; J. Dunne et al., 'Fit for Purpose? Organic Residue Analysis and Vessel Specialisation: The Perfectly Utilitarian Medieval Pottery Assemblage from West Cotton, Raunds', *Journal of Archaeological Science* 120 (1 August 2020): 105178, <https://doi.org/10.1016/j.jas.2020.105178>.

these long-held assumptions of a meat-focussed diet, particularly for elites, with the protein of choice changing in post-Conquest England (i.e. pork).

However, some exciting new work has very recently been done on c. fifth-to-seventh century “roasting pits” in Suffolk. Residue analysis on burnt stones from these pits implies they were used for cooking whole ruminant animals (cattle, sheep, or goats but not horses or pigs), and the archaeological evidence in and around these structures suggest they were used for periodic feasting events.⁷² This in combination with the zooarchaeological evidence for feasting, and perhaps less regular daily consumption of meat adds further weight to our argument and supports the isotopic evidence explored below.

MATERIALS AND METHODS

The data used to explore social status and diet here are pulled from the datasets collated in Leggett et al. (2021). Those databases consist of 8910 isotopic data points for human and animal diet and mobility in the first millennium AD from across western Europe. Here we have used a subset of that data consisting of bone collagen data from early medieval England and the associated contextual information including osteological sex, grave goods and chronological designations for those burials which is also available within the datasets.⁷³

Statistical analyses and graphics were conducted using Free and Open-Source R version 4.0.4 and Rstudio version 1.4.1106.⁷⁴ The code is freely available as part of the supplementary material and data available as part of Leggett et al. (2021). For DetectingDeviatingCells (DDC) analysis the data had to be re-organised for the package algorithm and the spreadsheet is available in the supplementary material. For further details on DDC analysis see below in the regional specific analysis for Wessex.

We investigated links between diet, social status, and funerary practices by looking for correlations between several funerary variables with possible relevance to social status (number of grave goods, number of foreign grave goods, body position and grave orientation) and dietary signatures as measured from bone collagen $\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{15}\text{N}_{\text{coll}}$ values. Some funerary variables were not analysed here but are included in the Leggett et al. (2021) databases. For instance, interment style had too many variants that are not easily standardised for visualisation or statistical analyses. Number of grave goods is a rough measure of wealth and status, so too are the number of foreign grave goods as their rarity in graves and having the means to obtain items from overseas (or bring them with you) could be an additional

⁷² Jo Caruth, ‘Revealing Lipid Analysis at Anglo-Saxon Sites in Suffolk’, *Cotswold Archaeology* (blog), 20 January 2021, <http://cotswoldarchaeology.co.uk/revealing-lipid-analysis-at-anglo-saxon-sites-in-suffolk/>.

⁷³ Sam Leggett et al., ‘Multi-Tissue and Multi-Isotope ($\Delta^{13}\text{C}$, $\Delta^{15}\text{N}$, $\Delta^{18}\text{O}$ and 87/86Sr) Data for Early Medieval Human and Animal Palaeoecology’, *Ecology* 102, no. 6 (2021): e03349, <https://doi.org/10.1002/ecy.3349>.

⁷⁴ R Development Core Team, *R: A Language and Environment for Statistical Computing*, version 4.0.4 ‘Lost Library Book’, MacOS, R, 2021, <http://www.r-project.org/>; RStudio Team, *RStudio: Integrated Development Environment for R*, version 1.4.1106 ‘Tiger Daylily’, MacOS, R (Boston, MA: RStudio, Inc., 2021), <http://www.rstudio.com/>.

signifier of status.⁷⁵ Grave orientation and body position become standardised over time with earlier variability linked to social status and religious practices, so differences in diet and cultural change are tentatively investigated through these variables.⁷⁶

First this was done using bone at a whole England level from the Roman through to the Anglo-Norman period (n=2023, Figure 1), with individuals coloured on plots by broad period to make broad chronological patterns in both diet and funerary treatment more readily discernible. Figures 1-4 highlight these larger chronological trends in both funerary and dietary change in England in the first millennium AD. We then focused more tightly on gender and number of grave goods for adult burials dating roughly from the fifth to the eighth century AD (n=1463, Figure 5 and Figure 6), both because this is the period during which the prevalence of grave goods gives us the most information on the social status of individual burials and because it predates the shift towards greater use of marine resources associated with the arrival of Scandinavian migrants. To further reduce the noise in the data, we then analyse adult diet in Wessex (n=321) to compare contemporary and regionally appropriate adult burials more directly with the royal food render specified in the Laws of Ine (Figures 7 and 8), and end with DDC analysis of both adult and juvenile data from Wessex (n=517) to look for overall outliers in the region (Figure 9).

Since isotopic analyses are used here to infer dietary intake, especially of animal protein, and therefore trophic position (how high you sit up the food chain), we need to consider the isotopic variability of the animals theoretically being consumed. This can differ greatly due to environmental factors and animal husbandry practices, despite sitting at the same trophic level, and can cause problems when we then try to make interpretations of human consumption without comparison with said animals. This is usually referred to as constructing an isotopic baseline, and allows for less erroneous estimations of dietary protein intake and trophic level relative to appropriate food sources.⁷⁷ Animal isotopic baselines were obtained by averaging species group bone $\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{15}\text{N}_{\text{coll}}$ values from England from the faunal data in Leggett et al. (2021). Not all species were available for all regions analysed, so England-wide averages were used as broad proxies for trophic level. The values for the groups are summarised in Table 1.

SPECIES GROUP	$\delta^{13}\text{C}_{\text{coll}}$ AVERAGE (‰)	$\delta^{15}\text{N}_{\text{coll}}$ AVERAGE (‰)
MARINE FISH	-13.37	15.03

⁷⁵ Geake, *The Use of Grave-Goods in Conversion-Period England, c.600-c.850*; John M. King, ‘Grave-Goods as Gifts in Early Saxon Burials (ca. AD 450-600)’, *Journal of Social Archaeology* 4, no. 2 (1 June 2004): 214–38, <https://doi.org/10.1177/1469605304041076>; Lucy, *The Anglo-Saxon Way of Death*.

⁷⁶ Brownlee, ‘Connectivity and Funerary Change in Early Medieval Europe’; Brownlee, ‘Grave Goods in Early Medieval Europe’; Brownlee, ‘The Dead and Their Possessions’; Edward James, ‘Burial and Status in the Early Medieval West’, *Transactions of the Royal Historical Society* 39 (December 1989): 23–40, <https://doi.org/10.2307/3678976>; Sian Mui, ‘Dead Body Language: Deciphering Corpse Positions in Early Anglo-Saxon England’ (Doctoral, Durham, England, Durham University, 2018), <http://etheses.dur.ac.uk/12829/>.

⁷⁷ Michelle M. Casey and David M. Post, ‘The Problem of Isotopic Baseline: Reconstructing the Diet and Trophic Position of Fossil Animals’, *Earth-Science Reviews* 106, no. 1 (1 May 2011): 131–48, <https://doi.org/10.1016/j.earscirev.2011.02.001>.

FRESHWATER FISH	-22.52	11.38
COMPANION ANIMALS (CATS AND DOGS)	-19.84	9.63
DOMESTIC FOWL	-20.20	8.99
PIGS	-21.31	6.90
LARGE DOMESTIC HERBIVORES (CATTLE AND EQUIDS)	-21.87	5.38
MEDIUM DOMESTIC HERBIVORES (OVICAPRIDS)	-21.54	5.57
WILD HERBIVORES	-22.59	5.08

Table 1: Isotopic averages of major faunal species groups in Early Medieval England, calculated from data in Leggett et al. (2021).⁷⁸

Another helpful benchmark is isotopic data from modern hair samples with defined diets (see Table 2).⁷⁹ These values should be used with some caution as comparing across tissues (i.e. here from hair keratin to bone collagen) and across time and space comes with many caveats.⁸⁰ From the background information given about the samples, the individuals in these studies do not appear to be on a diet comparable to what has been imagined for early medieval elites but are nonetheless a useful guide for where these early medieval individuals may sit within the nutritional literature.

DIET	ANIMAL PROTEIN FREQUENCY	O'CONNELL AND HEDGES (1999)		ELLEGÅRD ET AL. (2019)	
		$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
VEGAN	None	-20.9±0.8	6.9±0.5	-21.3±0.4	5.6±1.2

⁷⁸ Leggett et al., 'Multi-Tissue and Multi-Isotope ($\Delta^{13}\text{C}$, $\Delta^{15}\text{N}$, $\Delta^{18}\text{O}$ and $87/86\text{Sr}$) Data for Early Medieval Human and Animal Palaeoecology'.

⁷⁹ O'Connell and Hedges, 'Investigations into the Effect of Diet on Modern Human Hair Isotopic Values'; Ellegård et al., 'Distinguishing Vegan-, Vegetarian-, and Omnivorous Diets by Hair Isotopic Analysis'; Tamsin C. O'Connell, 'Comment on Ellegård et al. Clinical Nutrition 2019 "Distinguishing Vegan-, Vegetarian-, and Omnivorous Diets by Hair Isotopic Analysis"', *Clinical Nutrition* 40, no. 8 (1 August 2021): 4912–13, <https://doi.org/10.1016/j.clnu.2021.07.006>.

⁸⁰ Beaumont et al., 'Comparing Apples and Oranges'; Tieszen et al., 'Fractionation and Turnover of Stable Carbon Isotopes in Animal Tissues'; Larry L. Tieszen and Tim Fagre, 'Effect of Diet Quality and Composition on the Isotopic Composition of Respiratory CO_2 , Bone Collagen, Bioapatite, and Soft Tissues', in *Prehistoric Human Bone: Archaeology at the Molecular Level*, ed. Joseph B. Lambert and Gisela Grupe (Berlin/Heidelberg: Springer, 1993), 121–55, https://doi.org/10.1007/978-3-662-02894-0_5; Tamsin Christina O'Connell, 'The Isotopic Relationship between Diet and Body Proteins: Implications for the Study of Diet in Archaeology' (DPhil, Oxford, University of Oxford, 1996); O'Connell et al., 'The Diet-Body Offset in Human Nitrogen Isotopic Values'; Webb et al., 'The Influence of Varying Proportions of Terrestrial and Marine Dietary Protein on the Stable Carbon-Isotope Compositions of Pig Tissues from a Controlled Feeding Experiment'.

OVO-LACTO VEGETARIAN	Average	-21.0±0.3	8.7±0.5	-21.0±0.4	7.6±1.0
	Intermediate		8.3±0.2		
	Frequent		8.9±0.4		
	Daily		9.4		
OMNIVORE	Average	-20.2±0.7	8.8±0.6	-20.9±0.5	8.9±0.9
	Intermediate		8.3±0.2		
	Frequent		8.7±0.1		
	Daily		9.5±0.1		

Table 2: Modern human hair sample $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for vegan, ovo-lacto vegetarian and omnivore diets and frequency of animal protein intake. Daily is defined as once or more per day, frequent as more than twice a week and intermediate consumption as once or twice weekly. Data from O’Connell and Hedges (1999) and Ellegård et al. (2019).

As our reference point for a possible “elite” diet, we took the food list given in clause 70.1 of the laws of King Ine of Wessex. In our companion article, we estimate that fifty-five per cent of the calories contained in Ine’s list derived from animal protein, and if we assume a single loaf represents a single meal (which is probable) an individual portion would have been 4140kcal. As noted above, the scale and proportions of these food lists lead us to believe that these texts should be understood as lists of provisions for occasional grand feasts, and not as the general food supplies that sustained itinerant royal households. But if they were what royal households routinely ate – and what was consumed in the many other elite households endowed with rights to royal “food renders” – then we might expect to see more nutritionally related pathologies in high status individuals. We would also expect $\delta^{15}\text{N}_{\text{coll}}$ values from collagenous tissues well in excess of 11‰ if these foods were eaten more than once a day, or even once daily alongside more simplistic plant-based meals for the majority of these individuals’ lives given modern and Late Medieval dietary data.⁸¹

⁸¹ Ellegård et al., ‘Distinguishing Vegan-, Vegetarian-, and Omnivorous Diets by Hair Isotopic Analysis’; Petzke, Boeing, and Metges, ‘Choice of Dietary Protein of Vegetarians and Omnivores Is Reflected in Their Hair Protein ^{13}C and ^{15}N Abundance’; O’Connell and Hedges, ‘Investigations into the Effect of Diet on Modern Human Hair Isotopic Values’; Minagawa, ‘Reconstruction of Human Diet from $\Sigma^{13}\text{C}$ and $\Sigma^{15}\text{N}$ in Contemporary Japanese Hair’; Pinal S Patel et al., ‘Serum Carbon and Nitrogen Stable Isotopes as Potential Biomarkers of Dietary Intake and Their Relation with Incident Type 2 Diabetes: The EPIC-Norfolk Study’, *The American Journal of Clinical Nutrition* 100, no. 2 (1 August 2014): 708–18, <https://doi.org/10.3945/ajcn.113.068577>; Hedges and Reynard, ‘Nitrogen Isotopes and the Trophic Level of Humans in Archaeology’; ‘Reference Intakes Explained’, nhs.uk, 27 April 2018, <https://www.nhs.uk/live-well/eat-well/what-are-reference-intakes-on-food-labels/>; Angela L. Lamb et al., ‘Multi-Isotope Analysis Demonstrates Significant Lifestyle Changes in King Richard III’, *Journal of Archaeological Science* 50 (1 October 2014): 559–65, <https://doi.org/10.1016/j.jas.2014.06.021>; Gundula Müldner and M.P. Richards, ‘Stable Isotope Evidence for 1500 Years of Human Diet at the City of York, UK.’, *American Journal of Physical Anthropology* 133 (2007): 682–97; O’Connell, ‘Comment on Ellegård et al.

THE ISOTOPIC EVIDENCE FOR DIET AND SOCIAL STATUS IN C. FIFTH-TO-ELEVENTH CENTURY ENGLAND

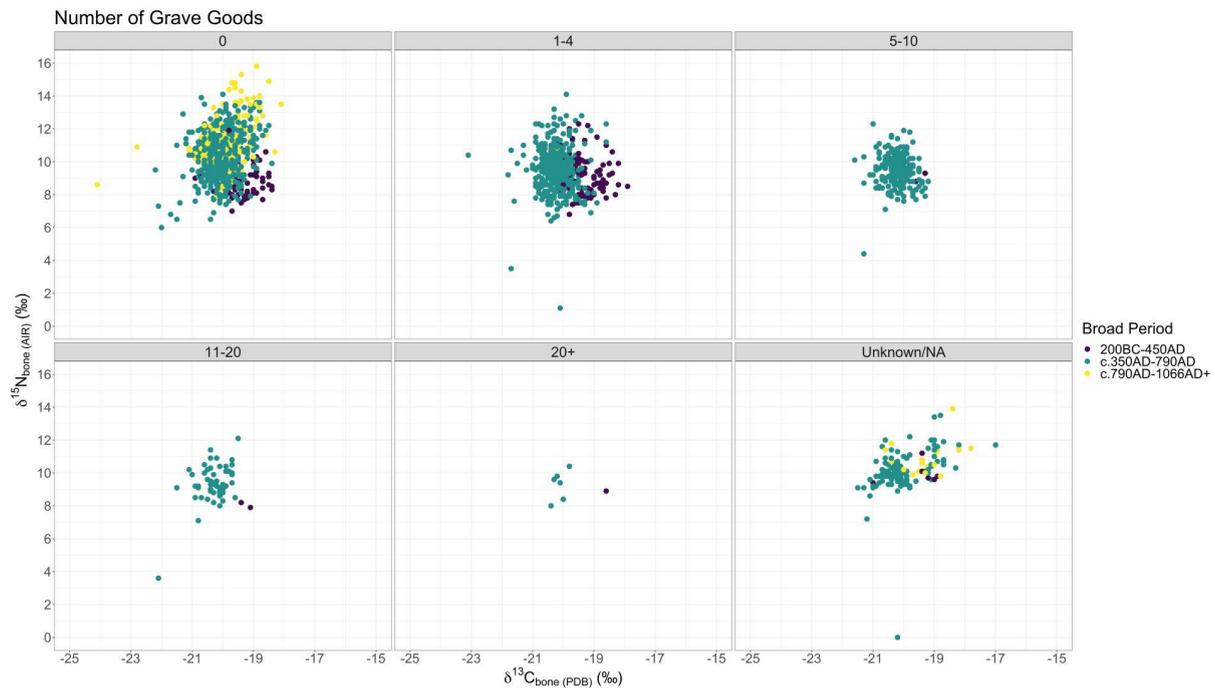


Figure 1: Scatterplots of human bone $\delta^{13}C_{coll}$ and $\delta^{15}N_{coll}$ values from England by number of grave goods, coloured by period.

We start here with total number of grave goods per grave from across England from the late Roman to Anglo-Norman period in Figure 1, and what is apparent is that not only are graves with over 10 grave goods relatively rare among those that have been studied isotopically, but also that the trends in diet are more chronological than wealth based. There are shifts from the Roman to Early Medieval period, and from the late eighth century onwards, but this seems to have nothing to do with grave provisioning, and therefore possible wealth during life.

Figure 2 shows the number of “foreign” grave goods as designated by the original site reports. As mentioned above such items are relatively rare and could therefore be an additional indicator of status through the ability to obtain luxury items from overseas, or by having the means to travel distances with said items. Figure 2 shows a very similar, but reduced, pattern to Figure 1 – mostly chronological shifts in diet, and nothing to suggest people with more grave goods or more exotic artefacts had higher $\delta^{15}N_{coll}$ values, and therefore ate more animal protein.

The individuals that do have higher $\delta^{15}N_{coll}$ values, and potentially also indicate some marine resource consumption, are generally those coloured yellow in Figure 1 and Figure 2. These individuals either have no grave goods or are part of the “unknown/NA individuals” group who are mostly from the commingled and mass grave contexts of St John’s College Oxford

Clinical Nutrition 2019 “Distinguishing Vegan-, Vegetarian-, and Omnivorous Diets by Hair Isotopic Analysis”.

and Ridgeway Hill, Weymouth; these individuals have been identified by the original investigators as of probable Scandinavian origin.⁸² This suggests that diets in England were not dictated by social status or changed by the *Fish Event Horizon*⁸³ in the Early Middle Ages, but the high trophic level and marine dietary signatures evident above are the result of incoming people. Further work on re-investigating the *Fish Event Horizon* using human isotopic evidence is forthcoming and outside the scope of this work here.

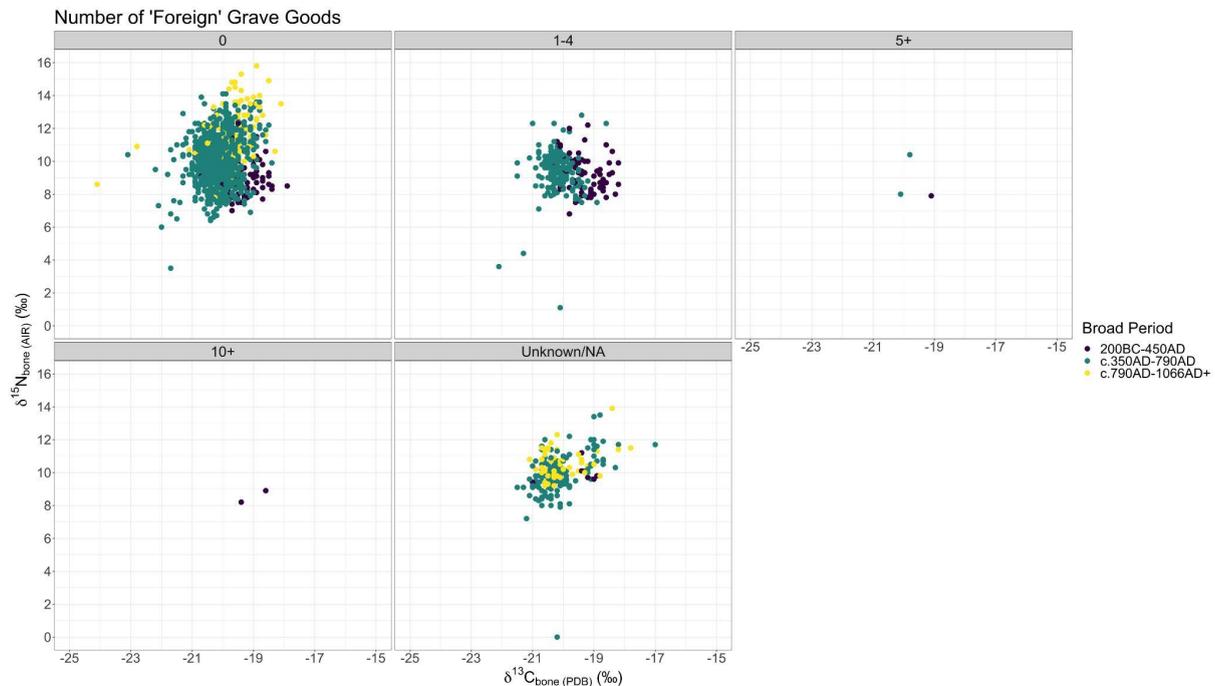


Figure 2: Scatterplots of human bone $\delta^{13}C_{coll}$ and $\delta^{15}N_{coll}$ values by number of 'foreign' grave goods, coloured by period.

⁸² Carolyn A. Chenery et al., 'A Boat Load of Vikings?', *Journal of the North Atlantic* 7, no. sp7 (November 2014): 43–53, <https://doi.org/10.3721/037.002.sp704>; Louise Loe, 'Given to the Ground': A Viking Age Mass Grave on Ridgeway Hill, Weymouth / by Louise Loe, Angela Boyle, Helen Webb and David Score ; with Contributions by Lesley Abrams [and 17 Others] ; Illustrations by Magdalena Wachnik [and 5 Others]., Dorset Natural History and Archaeological Society Monograph Series ; No. 22 (Dorchester: Dorset Natural History and Archaeological Society, 2014); A.M. Pollard et al., "'Sprouting Like Cockle Amongst the Wheat": The St Brice's Day Massacre and the Isotopic Analysis of Human Bones from St John's College, Oxford', *Oxford Journal of Archaeology* 31, no. 1 (February 2012): 83–102, <https://doi.org/10.1111/j.1468-0092.2011.00380.x>.

⁸³ The *Fish Event Horizon* is a phenomenon which builds over the course of the ninth and tenth centuries, reaching its peak in the year 1000 AD, whereby increasing amounts of marine fish bones have been found on archaeological sites in Britain, suggesting an increasing demand for and consumption of marine fish, which goes on to be a major economic shift in North Sea fisheries in the central and later Middle Ages. Outside of Scandinavia, the main isotopic evidence for this from human bones comes from Orkney and York, and Scandinavian settlers, and still proves elusive in the rest of Early Medieval human isotopic data. See: James H. Barrett and Michael P. Richards, 'Identity, Gender, Religion and Economy: New Isotope and Radiocarbon Evidence for Marine Resource Intensification in Early Historic Orkney, Scotland, UK', *European Journal of Archaeology* 7, no. 3 (2004): 249–71, <https://doi.org/10.1177/1461957104056502>; James H. Barrett, Alison M. Locker, and Callum M. Roberts, "'Dark Age Economics" Revisited: The English Fish Bone Evidence AD 600-1600', *Antiquity* 78, no. 301 (September 2004): 618–36, <https://doi.org/10.1017/S0003598X00113262>; Müldner, 'Marine Fish Consumption in Medieval Britain: The Isotope Perspective from Human Skeletal Remains'; James Barrett and David Orton, *Cod and Herring - The Archaeology and History of Medieval Sea Fishing* (Oxford: Oxbow Books, 2016).

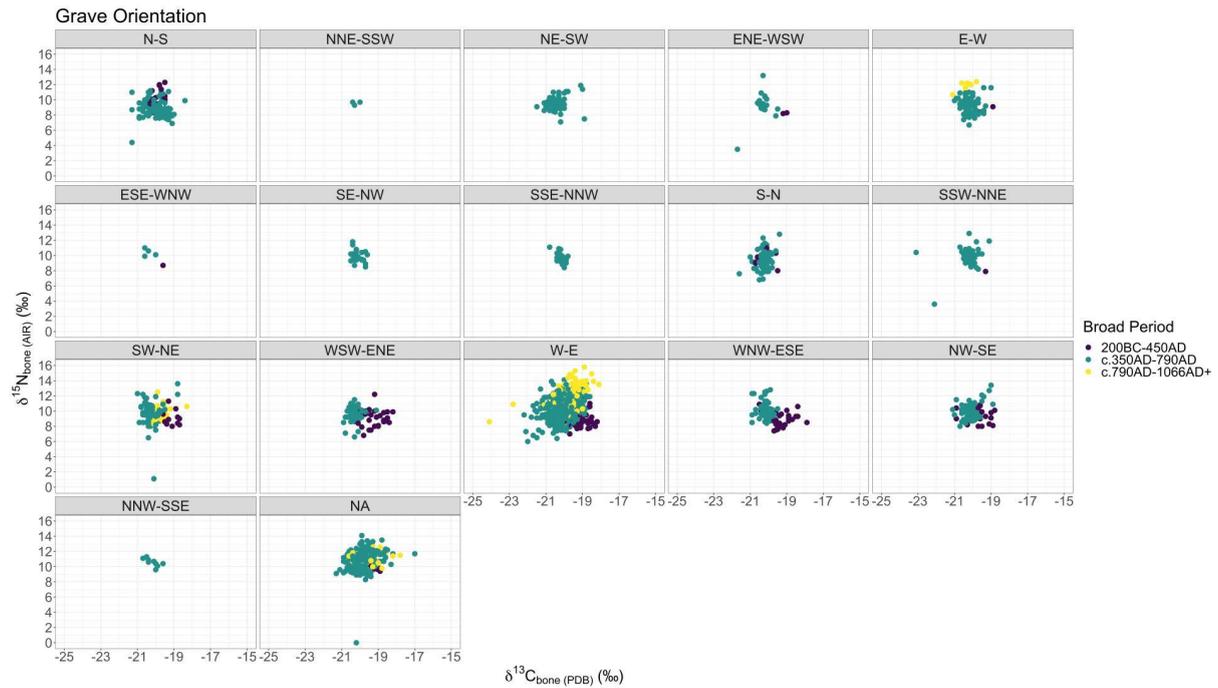


Figure 3: Scatterplots of human bone $\delta^{13}C_{coll}$ and $\delta^{15}N_{coll}$ values by grave orientation, coloured by period.

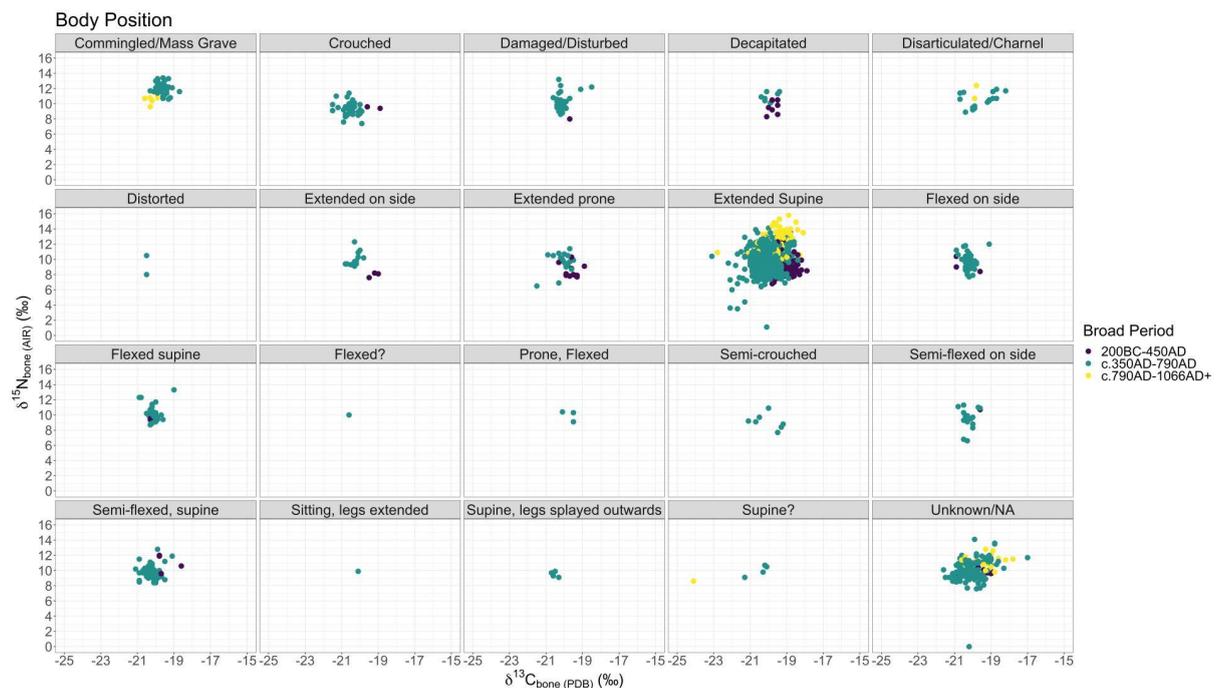


Figure 4: Scatterplots of human bone $\delta^{13}C_{coll}$ and $\delta^{15}N_{coll}$ values by body position, coloured by period.

As with grave goods above, Figure 3 and Figure 4 demonstrate the same trends but with grave orientation and body position as well. The trends appear to be, once again, chronological, and not easily linked to any one aspect of burial practice. Other aspects of burial practices are too nuanced and variable to easily compare with the isotopic evidence as it currently stands and were therefore outside the scope of this current work (e.g. burial plot within a cemetery, or how close a burial is to the altar, internment type – stone-lined,

ash-halo, *in-the-green*, various types of wooden structures, coffins, barrows etc.). This approach does not include some high-status graves such as bed burials as separate categories, which are marked out as exceptional by the quality rather than quantity of grave goods. However, as mentioned above, the isotopic evidence we have for these four burials does not indicate they had higher proportional intake of animal protein than other contemporary burials.⁸⁴ These are a rare phenomenon, and in the absence of definitively royal data, these proxies are our best starting point for furnished cemeteries.

Health and diet

If members of England's early medieval elite ordinarily consumed the rich diet implied by food lists such as the one in Ine's laws, we would perhaps expect to find evidence of associated health complications. People eating red-meat and animal-fat heavy diets, accompanied by regular alcohol consumption, are prone to develop conditions such as gout, type 2 diabetes, cardio-vascular disease, and cancer, generally decreasing their overall life expectancy.⁸⁵ Some of these health implications would only affect soft-tissue and are thus archaeologically invisible, however gout and excess protein should show up osteologically and isotopically respectively. Gout in particular is associated with purine-rich diets and excessive alcohol consumption and has been found to be associated with "rich" diets in later medieval individuals.⁸⁶ Certainly early medieval people knew of gout and had remedies for it, with Gregory the Great and other early medieval 'celebrities' suffering from the condition, although diet was not always seen as a contributing factor in antiquity.⁸⁷ Constipation and other gut related issues might also be attributed to unbalanced diets, and as with gout, there are remedies for these in the leech books and other medical texts, however linking them to

⁸⁴ These are the burials at Trumpington Meadows, Edix Hill (x2) and Coddendam, and their $\delta^{15}\text{N}_{\text{coll}}$ values range from 9.4-11.4‰, with the average being 10.5‰.

⁸⁵ Chhabi Lal Ranabhat, Myung-Bae Park, and Chun-Bae Kim, 'Influence of Alcohol and Red Meat Consumption on Life Expectancy: Results of 164 Countries from 1992 to 2013', *Nutrients* 12, no. 2 (February 2020): 459, <https://doi.org/10.3390/nu12020459>; Keren Papier et al., 'Meat Consumption and Risk of 25 Common Conditions: Outcome-Wide Analyses in 475,000 Men and Women in the UK Biobank Study', *BMC Medicine* 19, no. 1 (2 March 2021): 53, <https://doi.org/10.1186/s12916-021-01922-9>; Evelyne Battaglia Richi et al., 'Health Risks Associated with Meat Consumption: A Review of Epidemiological Studies', *International Journal for Vitamin and Nutrition Research* 85, no. 1–2 (1 December 2015): 70–78, <https://doi.org/10.1024/0300-9831/a000224>; Frank Qian et al., 'Red and Processed Meats and Health Risks: How Strong Is the Evidence?', *Diabetes Care* 43, no. 2 (1 February 2020): 265–71, <https://doi.org/10.2337/dci19-0063>; Gaafar Ragab, Mohsen Elshahaly, and Thomas Bardin, 'Gout: An Old Disease in New Perspective – A Review', *Journal of Advanced Research* 8, no. 5 (September 2017): 495–511, <https://doi.org/10.1016/j.jare.2017.04.008>.

⁸⁶ Jenna M. Dittmar et al., 'Gout and "Podagra" in Medieval Cambridge, England', *International Journal of Paleopathology* 33 (1 June 2021): 170–81, <https://doi.org/10.1016/j.ijpp.2021.04.007>; Ragab, Elshahaly, and Bardin, 'Gout'; Gino Fornaciari et al., 'A Remarkable Case of Gout in the Imperial Rome: Surgery and Diseases in Antiquity by Osteoarchaeological, Paleopathological, and Historical Perspectives', *International Journal of Osteoarchaeology* 29, no. 5 (2019): 797–807, <https://doi.org/10.1002/oa.2792>.

⁸⁷ John D. Hosler, 'Gregory the Great's Gout: Suffering, Penitence, and Diplomacy in the Early Middle Ages', *Where Heaven and Earth Meet: Essays on Medieval Europe in Honor of Daniel F. Callahan*, 1 January 2014, 9–32, https://doi.org/10.1163/9789004274167_003.

the diets described in the food renders is difficult as the causes for the ailments are rarely given.⁸⁸

We checked the dataset for correlations between pathological data, age at death, number of grave goods and ^{15}N enrichment and could not find any clear links between these variables as the data stands. Of the 561 adults in England with bone $\delta^{15}\text{N}_{\text{coll}}$ values above 10.3‰, 286 had pathological data recorded. The one individual with a possible gout diagnosis has a $\delta^{15}\text{N}_{\text{coll}}$ value of 10.8‰ which is slightly above the 5‰ upper limit of trophic enrichment from faunal baselines (see below), but this is not sufficiently high to suggest an excess of protein compared to their contemporaries.⁸⁹ Since this case is medically inconclusive it is therefore hard to extrapolate from. Similarly, there were fifteen cases of osteomas (bone cancer) and they averaged $\delta^{15}\text{N}_{\text{coll}}$ values of 9.5‰ (range of 7.5-13.5‰), again with no discernible link between social status (most individuals with osteomas had no grave goods), although twice as many women suffered from osteomas than men (ten females, five males). This is not to say that those with protein-heavy diets did not suffer from other forms of cancer, but unless it reached their skeleton it is invisible to this study. As diet is linked to oral health, we also searched for oral pathologies and links with $\delta^{15}\text{N}_{\text{coll}}$ values.⁹⁰ Out of the full adult dataset for England (n=1793) there are 209 individuals with caries recorded and 232 individuals with dental calculus (often on the same individual). 54 of the 209 individuals with caries (25.84%) showed some ^{15}N enrichment; similarly, 62 of the 232 individuals (26.72%) with dental calculus had $\delta^{15}\text{N}_{\text{coll}}$ values above 10.3‰. This suggests these oral pathologies cannot strictly be linked to ^{15}N enrichment.

Sulphur or amino acid specific isotopic studies would help to distinguish between different causes for ^{15}N enrichment (e.g. stress, excess protein and different protein sources) more effectively but these kinds of analyses are less common than carbon and nitrogen studies, however in coming years more light may be shed on this.⁹¹ As the data currently stands there is no palaeopathological evidence for many individuals suffering from diseases associated with rich diets as those described in the food render texts, as were experienced by other early and later Medieval individuals eating excessively rich diets;⁹² nor can we link any such pathologies with isotopic enrichment or funerary status.

⁸⁸ Bald, 'Bald's Leechbook' (Winchester, mid-10th century), http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Royal_MS_12_D_XVII; Frances Watkins et al., 'Anglo-Saxon Pharmacopoeia Revisited: A Potential Treasure in Drug Discovery', *Drug Discovery Today* 16, no. 23 (1 December 2011): 1069–75, <https://doi.org/10.1016/j.drudis.2011.07.002>; Conan Turlough Doyle, 'Anglo-Saxon Medicine and Disease: A Semantic Approach' (PhD, Cambridge, University of Cambridge, 2011), <https://www.repository.cam.ac.uk/handle/1810/268228>.

⁸⁹ This is a twenty-six to thirty-five year old male, grave 26 at Stanton in Suffolk with 2 grave goods – a knife and a belt buckle.

⁹⁰ Paula Moynihan, 'The Interrelationship between Diet and Oral Health', *Proceedings of the Nutrition Society* 64, no. 4 (November 2005): 571–80, <https://doi.org/10.1079/PNS2005431>.

⁹¹ Reitsema, 'Beyond Diet Reconstruction'; Nehlich, 'The Application of Sulphur Isotope Analyses in Archaeological Research'.

⁹² Dittmar et al., 'Gout and "Podagra" in Medieval Cambridge, England'; Hosler, 'Gregory the Great's Gout'.

Diet and Social Status in c. fifth-to-eighth century England: the isotopic evidence

Removing the Roman and definitively Viking Age and Anglo-Scandinavia/Norman individuals produces Figure 5. This demonstrates that for the whole of England between the fifth and eighth centuries AD there is a relatively tighter range in bone $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values than in the figures above, as evidenced by the marginal box plots, with tails of individuals for both elements in higher and lower values beyond the interquartile ranges. There is a spread of over 14‰ in $\delta^{15}\text{N}$ values, which is much larger than we would expect if everyone was consuming at roughly the same trophic level. As this dataset spans several hundred years and from the southwest of England up to the northeast, variation could be due to any number of factors such as regional variation in isotopic baselines (different geologies or grazing grasses, sea spray etc.), regional variation in foodways, and diachronic changes to diets and farming techniques altering baselines (e.g. manuring). We try to filter out some of these effects at the end of this section by focusing on just Wessex, but this larger dataset remains valuable for its size (n=1463). It just requires careful interpretation.

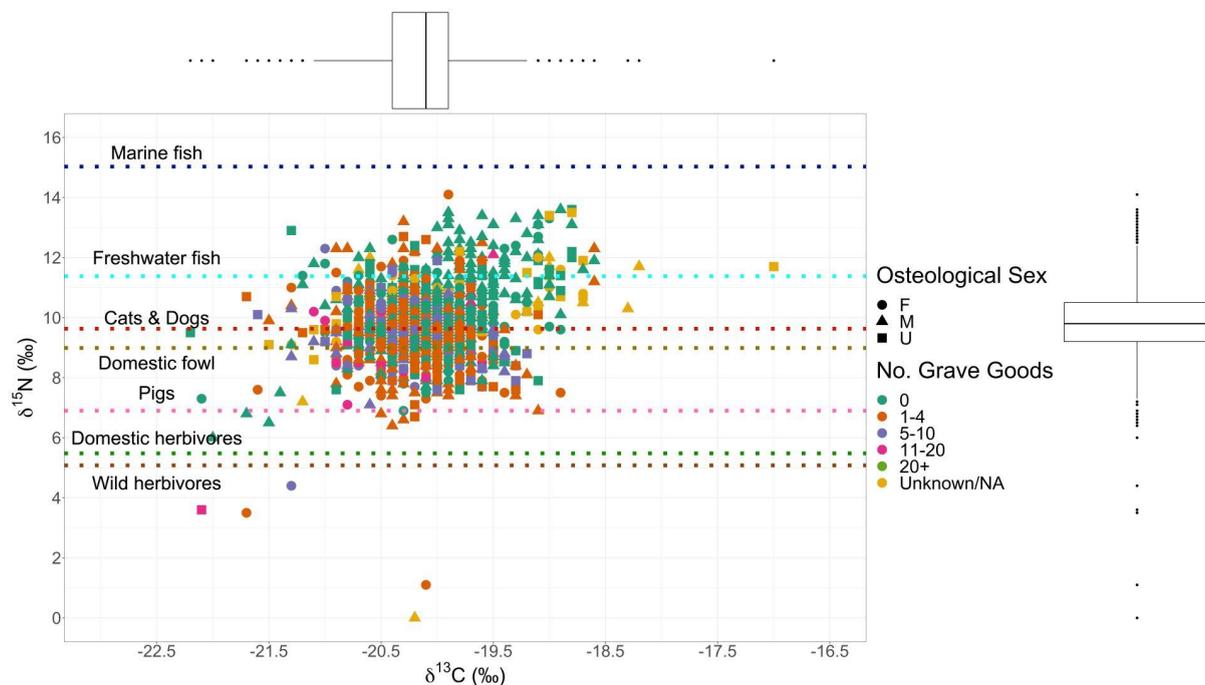


Figure 5: Scatterplot with marginal boxplots of bone $\delta^{13}\text{C}_{coll}$ and $\delta^{15}\text{N}_{coll}$ values of c. fifth-to-eighth century individuals in England with animal base lines as labelled horizontal lines.

Given our assumptions about elite diets drawn from the literature and food render texts themselves, we should also consider not only animal baselines but also as a point of comparison animal protein variation in modern diets as outlined in Table 1 and Table 2 above. Figures 5-8 have the faunal nitrogen averages from England from Table 1 overlaid, and there are several key observations we can draw from this.

This suggests that domestic fowl, cats, and dogs during the period are being fed broadly similar diets to humans, with possibly some supplementary scavenging/hunting due to the

similarity in their isotopic signatures which is supported by other studies.⁹³ This means that these animals are poor indicators of higher trophic levels but useful for understanding aspects of companion animals and farming practices. Comparing the human values to the herbivore baselines and given the 14.1‰ spread in $\delta^{15}\text{N}_{\text{coll}}$ values, it appears that there is a wide variety of diets being consumed across England in this period, with significant differences in animal protein consumption.

We took the assumed 5‰ upper limit of trophic level enrichment (the maximum increase you might expect to see when you step up the food chain, see above) for $\delta^{15}\text{N}_{\text{coll}}$ ⁹⁴ and applied it to the combined herbivore average here (5.34‰) we get a rough benchmark of 10.34‰ above which we can be satisfied people are eating moderate to high levels of animal protein in their diets. For the overall adult dataset this gives us 418 individuals (28.6% of the total). Conversely this means over seventy per cent of individuals are eating negligible to moderate animal protein. The temptation at this point might be to assume that the 418 individuals with high $\delta^{15}\text{N}_{\text{coll}}$ values represent a social elite, defined in part by their privileged access to animal-based foodstuffs.

However, when we look more closely it becomes apparent that this interpretation is not viable. Of these 418 individuals 191 are from East Anglia which is known to have ^{15}N enrichment compared with the rest of the country, presumably due to a mixture of the wetter Fenland environments causing isotopic enrichment at the base of the food chain and a regional preference for freshwater fish given said environs (e.g. Westfield Farm Ely⁹⁵), amongst other factors.⁹⁶ This regional ^{15}N enrichment seems to have been what skewed Hull and O'Connell's (2011) original conclusions of early medieval diet in England consisting of moderate to high protein intake, since the majority of Hull's (2007) data was from East Anglia with little comparative data to draw on at the time.⁹⁷ It is probable that many of the other burials with $\delta^{15}\text{N}_{\text{coll}}$ values over this threshold are actually from after this period, appearing in this dataset because of issues with dating. Ninety-nine burials are either definite or probable Scandinavians or individuals who likely date to the eighth-to-eleventh centuries but were included here due to the ambiguity of dates (either there are none, they have very broad radiocarbon estimations or there is a very broad chronological designation for the site).

⁹³ Crabtree, *Middle Saxon Animal Husbandry in East Anglia*; J.A. Evans et al., 'Anglo-Saxon Animal Husbandry Techniques Revealed Through Isotope and Chemical Variations in Cattle Teeth', *Applied Geochemistry* 22, no. 9 (September 2007): 1994–2005, <https://doi.org/10.1016/j.apgeochem.2007.03.059>; Hull, 'Social Differentiation and Diet in Early Anglo-Saxon England'; Müldner and Richards, 'Stable Isotope Evidence for 1500 Years of Human Diet at the City of York, UK.'; Knapp, 'The Zooarchaeology of the Anglo-Saxon Christian Conversion: Lyminge, a Case Study'; Pam J. Crabtree, 'A Note on the Role of Dogs in Anglo-Saxon Society: Evidence from East Anglia: Dogs in Anglo-Saxon Society', *International Journal of Osteoarchaeology* 25, no. 6 (November 2015): 976–80, <https://doi.org/10.1002/oa.2358>.

⁹⁴ Bocherens and Drucker, 'Trophic Level Isotopic Enrichment of Carbon and Nitrogen in Bone Collagen'; Minagawa and Wada, 'Stepwise Enrichment of ^{15}N along Food Chains: Further Evidence and the Relation between $\Delta^{15}\text{N}$ and Animal Age'; Hedges and Reynard, 'Nitrogen Isotopes and the Trophic Level of Humans in Archaeology'.

⁹⁵ Lucy et al., 'The Burial of A Princess?'

⁹⁶ Boulden, 'A Bioarchaeological Reassessment of Land-Use Practices from the Neolithic to the Roman Period in Central Southern Britain Using Stable Isotope Analysis and Machine Learning Methods.'; Mallet, 'Diets in England'; Hull, 'Social Differentiation and Diet in Early Anglo-Saxon England'.

⁹⁷ O'Connell and Hull, 'Diet: Recent Evidence from Analytical Chemical Techniques'.

These include thirty-eight skeletons from St John's College Oxford (Scandinavian origins),⁹⁸ ten burials from Repton (predominantly war dead from the Viking Great Army but some possible earlier monastic skeletons),⁹⁹ twenty-nine skeletons from the cemetery at Black Gate Newcastle (presumed to date to the eleventh-to-thirteenth centuries but some burials date to the seventh-to-ninth),¹⁰⁰ and twenty-two individuals from Priory Orchard Godalming which has a similar date range and lack of chronological resolution to Black Gate.¹⁰¹ Five interesting burials in this group are from Bishopstone in East Sussex.¹⁰² Bishopstone, whilst within our chronological range, is definitively Christian (it is an early churchyard cemetery) and the burials lack grave goods, but they are assumed to be elites or their retainers based in and around the manor. Zooarchaeological evidence from Bishopstone and its contemporary in Kent – Lyminge, suggests that fish became a larger part of these elite sites after Christianisation, around the same time burial started in the churchyard, and the manor moved location.¹⁰³ So it is therefore hard to attribute the ¹⁵N enrichment at Bishopstone purely to status, although undoubtedly that played a role, when there is a clear shift in all aspects of life there in the late-seventh to early-eighth century linked to Christianisation. The other burials above this trophic boundary are scattered across wide ranging sites with no particular patterns in their chronology or gender (ignoring the Viking or monastic sites with majority males) and most of these individuals have no or very few grave goods which is clear in Figure 5 and Figure 6.

Those individuals at the very top of the tight splurge in Figure 5 above the freshwater fish line at 11.38‰ account for 9.8% (n=143/1463) of the total adult data for England dated to roughly the fifth-to-eighth centuries. Many of these individuals have already been accounted for above with the major cemeteries contributing to this group being Westfield Farm Ely (n=19), St John's College Oxford (n=32), Caister-by-Yarmouth (n=16) and Black Gate Newcastle (n=11). Westfield Farm, being on the isle of Ely, is presumed to have such high $\delta^{15}\text{N}_{\text{coll}}$ values due to high freshwater fish (eels included) consumption;¹⁰⁴ Caister-by-Yarmouth is assumed to be an early monastic centre with adherents consuming more aquatic resources than the laity;¹⁰⁵ and Black Gate and St John's Oxford were mentioned in more detail above. The other burials which are probable or definite incoming Scandinavians with “fishy” diets in

⁹⁸ Pollard et al., “SPROUTING LIKE COCKLE AMONGST THE WHEAT”.

⁹⁹ Catrine L. Jarman et al., ‘The Viking Great Army in England: New Dates from the Repton Charnel’, *Antiquity* 92, no. 361 (February 2018): 183–99, <https://doi.org/10.15184/aqy.2017.196>.

¹⁰⁰ Diana Louise Mahoney Swales, ‘Life and Stress: A Bio-Cultural Investigation into the Later Anglo-Saxon Population of the Black Gate Cemetery, Newcastle-upon-Tyne’ (PhD, Sheffield, UK, University of Sheffield, 2012); Diana Mahoney Swales, ‘A Biocultural Analysis of Mortuary Practices in the Later Anglo-Saxon to Anglo-Norman Black Gate Cemetery, Newcastle-upon-Tyne, England’, *International Journal of Osteoarchaeology* 29, no. 2 (March 2019): 198–219, <https://doi.org/10.1002/oa.2729>; John Nolan, ‘The Early Medieval Cemetery at the Castle, Newcastle upon Tyne’, *Archaeologia Aeliana*, 5th Series, 39 (2010): 147–287.

¹⁰¹ Leggett et al., ‘Multi-Tissue and Multi-Isotope ($\Delta^{13}\text{C}$, $\Delta^{15}\text{N}$, $\Delta^{18}\text{O}$ and 87/86Sr) Data for Early Medieval Human and Animal Palaeoecology’.

¹⁰² Gabor Thomas, *The Later Anglo-Saxon Settlement at Bishopstone: A Downland Manor in the Making*, CBA Research Report 163 (York: Council for British Archaeology, 2010).

¹⁰³ Knapp, ‘The Zooarchaeology of the Anglo-Saxon Christian Conversion: Lyminge, a Case Study’; Thomas, *The Later Anglo-Saxon Settlement at Bishopstone*.

¹⁰⁴ Lucy et al., ‘The Burial of A Princess?’

¹⁰⁵ Hull, ‘Social Differentiation and Diet in Early Anglo-Saxon England’.

this group are five individuals from Repton, one from Coppergate in York and one burial from Masham in Yorkshire.¹⁰⁶ Like Caister-by-Yarmouth the interred people at South Acre (n=7) and Burgh Castle (n=8) are also assumed to be early Christian monastic adherents.¹⁰⁷ For the rest of the individuals with $\delta^{15}\text{N}_{\text{coll}}$ values above 11.38‰ we could find no common attributes in their demography or funerary treatment to suggest a link between social status and diet as seen through stable isotope analysis. If anything, regionality and chronology play more of a role with ^{15}N enrichment in Early Medieval England.

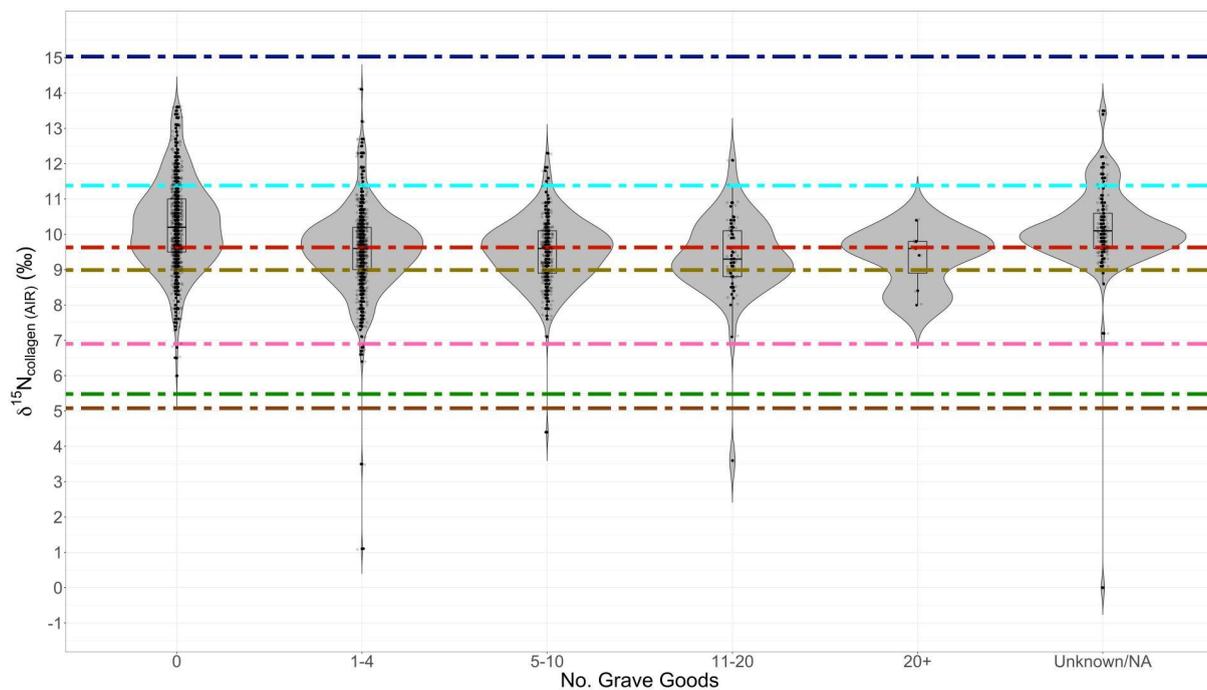


Figure 6: Violin plot of bone $\delta^{15}\text{N}_{\text{coll}}$ values of c. fifth-to-eighth century individuals in England, animal base lines top-bottom: marine fish, freshwater fish, domestic cats and dogs, domestic fowl, domestic pigs, domestic herbivores (cattle, sheep/goats), and wild herbivores as per Figure 5 above.

Figure 6 demonstrates more clearly the lack of relationship between ^{15}N enrichment and wealth/social status as defined through grave good provisioning. The mean $\delta^{15}\text{N}_{\text{coll}}$ values for the grave good groups are within 1‰ of each other (less than one trophic level which is generally assumed to be 3-5‰) with the highest being 10.3‰ and the lowest at 9.3‰. What is even more apparent here is that the individuals with the highest $\delta^{15}\text{N}_{\text{coll}}$ values have at most 4 grave goods.

These averages are similar to the daily protein consumption data for both ovo-lacto vegetarians and omnivores in Table 2. As mentioned above, it is therefore likely that most individuals, regardless of social status, ate some form of animal protein daily but this does

¹⁰⁶ Jo Buckberry et al., 'Finding Vikings in the Danelaw', *Oxford Journal of Archaeology* 33, no. 4 (November 2014): 413–34, <https://doi.org/10.1111/ojoa.12045>; Müldner and Richards, 'Stable Isotope Evidence for 1500 Years of Human Diet at the City of York, UK.'; Jarman et al., 'The Viking Great Army in England'.

¹⁰⁷ Hull, 'Social Differentiation and Diet in Early Anglo-Saxon England'.

not equate to one or more meals a day at over fifty per cent animal protein of the kind suggested by Ine's laws and similar texts.

Case Study: Early Medieval Wessex

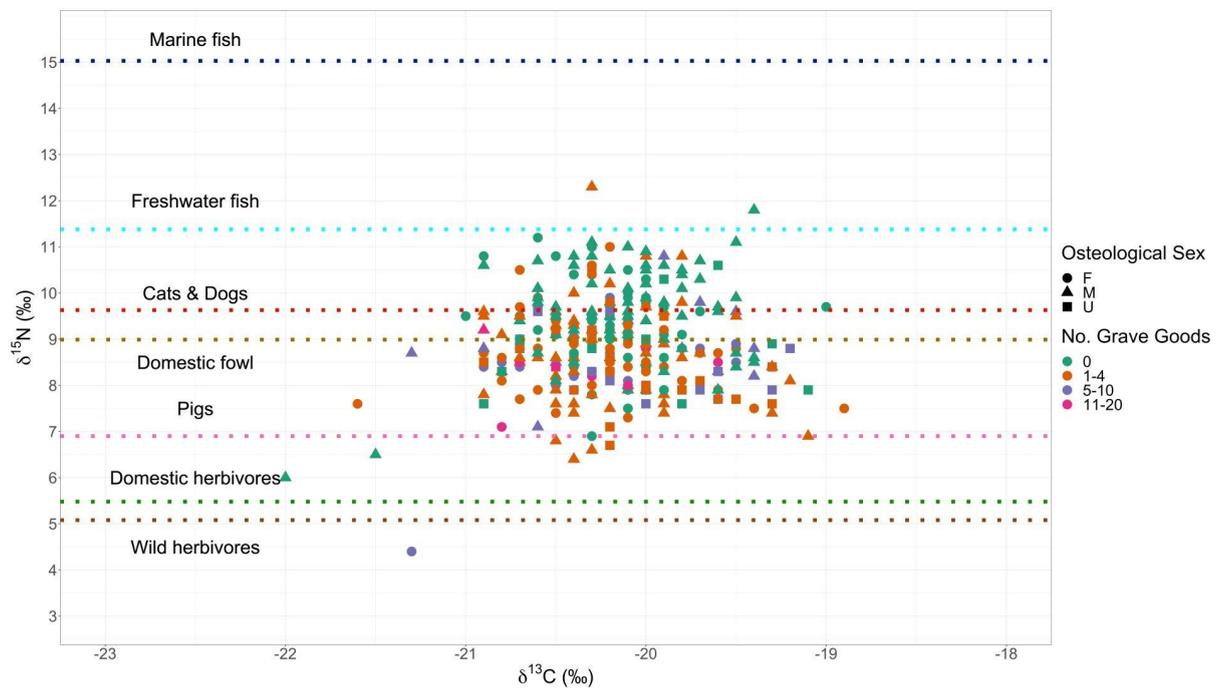


Figure 7: Scatterplot of bone $\delta^{13}C_{coll}$ and $\delta^{15}N_{coll}$ of c. fifth-to-eighth century individuals in the region of Wessex with animal base lines as labelled horizontal lines.

We then focussed on one region to eliminate some of the noise in the data (such as regional variation) and chose Wessex both because it is the origin of our earliest food list in Ine's laws and because it saw fewer Scandinavian settlers in the ninth and tenth centuries, reducing the risk of our sample including misdated later burials that reflect imported foodways. Wessex is defined here as early medieval cemeteries clustering in the modern counties of Dorset, Hampshire, Somerset, Surrey, West Sussex, and Wiltshire. Figure 7 shows a more constrained cluster than the whole of England in Figure 5. Diets in Wessex show less ^{15}N enrichment than the larger dataset with most individuals having $\delta^{15}N_{coll}$ values between the herbivore baselines and the fowl/cat/dog base lines, indicating negligible to moderate animal protein consumption. There are thirty-five individuals with $\delta^{15}N_{coll}$ values above the trophic benchmark of 10.34‰, twenty-two of which are buried at Priory Orchard Godalming, three at Beckery Chapel, three at Worthy Park Kingsworthy, three at Winnall II (Winchester), two at Alton, and one each at Droxford and Portway Andover. Only one of these burials, grave 50 at Worthy Park, has more than four grave goods (five to be exact). One of these items is a spear, and he is the only weapons burial in this higher $\delta^{15}N_{coll}$ range.

Palaeopathological data was not available for all individuals but aside from caries and other oral pathologies which are relatively common in this period, there is nothing particularly unusual or striking to link these thirty-five individuals in their pathologies. What is striking is that in Wessex most of these individuals are men, with little to suggest that they are incomers

importing more protein rich diets with them as for some of the sites mentioned above. However, Beckery Chapel and Priory Orchard Godalming are both Christian burial grounds associated with churches. Therefore, they might be reflecting Christianised diets with fish consumption (probably freshwater given their $\delta^{13}\text{C}_{\text{coll}}$ values) causing ^{15}N enrichment. Furthermore, these men with ^{15}N enrichment could be ecclesiastics, or perhaps this suggests some social differentiation in diet in Wessex based on gender. Of these thirty-five individuals only two have $\delta^{15}\text{N}_{\text{coll}}$ values above the freshwater fish line (11.38‰) – grave 17B from Worthy Park and skeleton 1023 from Priory Orchard Godalming. Both are osteologically male and the Priory Orchard individual has no grave goods, whereas the Worthy Park individual has three (knife, key/girdle hanger and a Roman coin); this with the chronological distance between the two (500-570AD for Worthy Park and 770-1150AD for Priory Orchard) suggests their isotopic enrichment is due to different factors and not a straightforward interpretation of status.

Figure 8 shows a clear drop in $\delta^{15}\text{N}_{\text{coll}}$ values with increasing numbers of grave goods which adds further weight to our hypothesis that the driving factor for ^{15}N enrichment in early medieval England is not (purely) social status as viewed through funerary treatment. Changes through time to do with Christianisation and other socio-economic factors are instead probable driving factors.

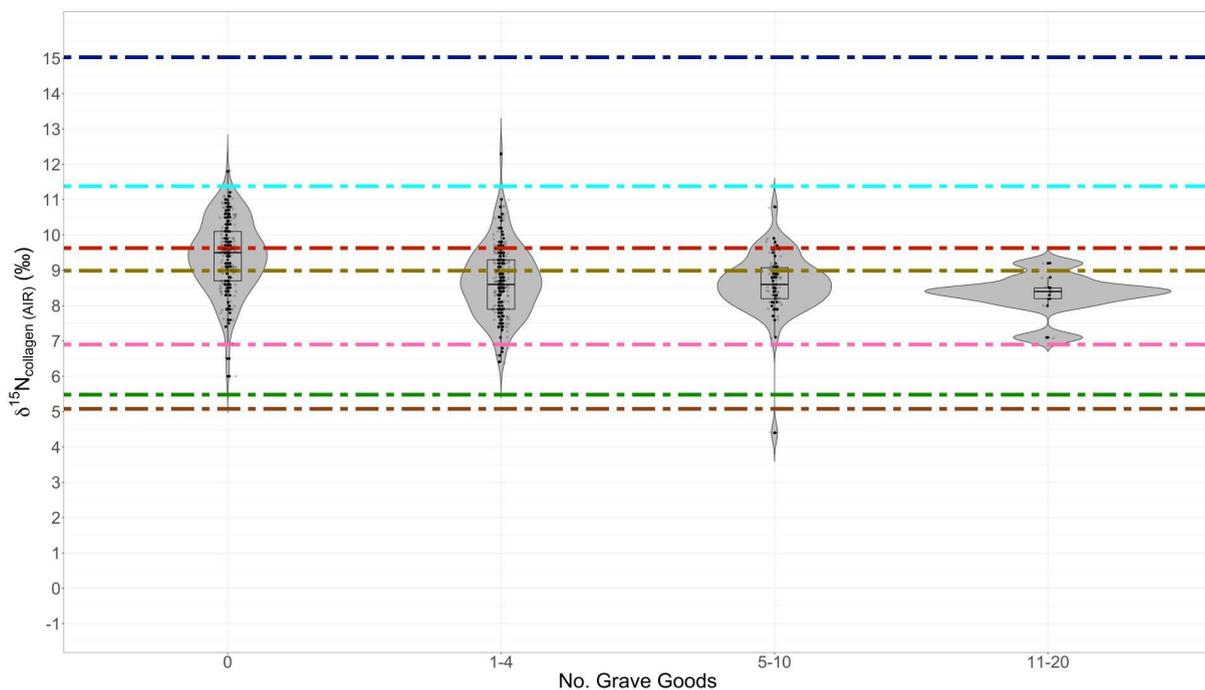


Figure 8: Violin plot of bone $\delta^{15}\text{N}_{\text{coll}}$ values of c. fifth-to-eighth century individuals in the region of Wessex, animal base lines top-bottom: marine fish, freshwater fish, cats and dogs, domestic fowl, pigs, domestic herbivores (cattle, sheep/goats), and wild herbivores as per Figures 5-7 above.

Finally, we sifted the Wessex burials dataset for outliers. Rather than doing this subjectively, risking unconsciously introducing selection biases, we used the DetectingDeviatingCells (DDC) algorithm to detect outlying cells in the numeric data available (e.g. isotopic values or

number of grave goods) not excluding children and infants here as we did above to avoid selection bias in the algorithm. DDC was run using the R package *cellWise*.¹⁰⁸ DDC as run by *cellWise* can only be used on numeric data, and it excludes individuals from analysis who have over fifty percent missing data as well as any variables which do not have much variation. It uses the whole of the data matrix to establish what cells have higher or lower values than expected given all the other data for an observation (here an individual burial). It produces a graphic called a cell map (see Figure 9) with red cells indicating higher than predicted values, blue cells lower than predicted, yellow cells are as predicted, and orange and purple cells are scales between the extremes. White cells indicate missing values. If individuals are flagged with black or grey dots this signals them as an outlier for the whole matrix due to having a high number of flagged cells. Therefore, DDC can tell us which burials stand out for one or more variables given the data for, in this case, their region.

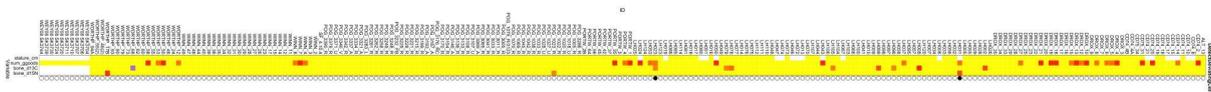


Figure 9: Detecting deviating cells cellmap for Wessex. Cells which are red have higher values than expected, blue are lower than expected, yellow are “normal” and white are missing values for that variable.

The DDC cellmap presented in Figure 9 further demonstrates the lack of correlation between number of grave goods and diet (and stature) for Wessex. Rarely are individuals flagged by the algorithm with unexpected values for more than one variable. The two individuals who have higher than expected numbers of grave goods for their contexts and unexpected dietary values are LH023 (grave 1640) and LH031 (grave 118) – burials from the Late Roman cemetery at Lankhills, Winchester.¹⁰⁹ Grave goods are uncommon in this cemetery, and more generally in Late Roman graves, so these two individuals having four objects each is noteworthy. LH023 is an older female with significant pathologies throughout her skeleton, who was buried in a coffin with four different Roman coins of 4th century date. Her bone $\delta^{13}\text{C}_{\text{coll}}$ value (but not $\delta^{15}\text{N}_{\text{coll}}$) is flagged as being higher than expected at -18.4‰ and might suggest she consumed marine and/or C_4 resources during life which stands out amongst the rest of the region with predominantly C_3 signals. LH031 is an infant who was buried in a coffin with two bone bracelets, a copper alloy bracelet and a necklace of glass and amber beads. This infant’s $\delta^{15}\text{N}_{\text{coll}}$ values are flagged as being higher than expected at 12.2‰. Due to the age of the individual (c. 1-1.5 years old) ^{15}N enrichment is likely due to one or more factors including breastfeeding (i.e. trophic enrichment as well as ^{15}N enrichment of breast milk), physiological differences in infant metabolism, and physiological stress (nutritional or otherwise) which is linked to the osteological paradox of a dead infant – they were clearly not

¹⁰⁸ Jakob Raymaekers et al., *CellWise: Analyzing Data with Cellwise Outliers*, version 2.1.1, 2020, <https://CRAN.R-project.org/package=cellWise>; Peter J. Rousseeuw and Wannes Van Den Bossche, ‘Detecting Deviating Data Cells’, *Technometrics* 60, no. 2 (3 April 2018): 135–45, <https://doi.org/10.1080/00401706.2017.1340909>.

¹⁰⁹ Paul Booth et al., eds., *The Late Roman Cemetery at Lankhills, Winchester: Excavations 2000-2005*, Oxford Archaeology Monograph, no. 10 (Oxford, [England]: Oxford Archaeology, 2010).

a healthy baby to be deceased in infancy.¹¹⁰ Therefore despite their relatively rich funerary treatment we cannot take their ¹⁵N enrichment at face value due to these complicating biological factors.

Other individuals flagged by DDC with unexpected isotopic signatures are listed below in Table 3. None of these individuals were flagged for other variables, and most are late Roman individuals with similar suggestions of marine and/or C₄ resource consumption as for LH023. Worthy Park grave 17B and Priory Orchard skeleton 1023 have been discussed above. Worthy Park grave 68 is interesting due to her lower $\delta^{13}\text{C}_{\text{coll}}$ value combined with a relatively low $\delta^{15}\text{N}_{\text{coll}}$ value which is similar to the pig, vegan and some of the ovo-lacto vegetarian values in Table 1 and Table 2 above, suggesting she had a diet more reliant on plant-based protein.

SITE	GRAVE/SKELETON	SEX	NUMBER OF GRAVE GOODS	FLAGGED FOR?	$\delta^{13}\text{C}_{\text{coll}}$ (‰)	$\delta^{15}\text{N}_{\text{coll}}$ (‰)
WORTHY PARK	17B	Male	3	High nitrogen	-20.28	12.31
WORTHY PARK	68	Female	1	Low carbon	-21.61	7.58
PRIORY ORCHARD GODALMING	1023	Male	0	High nitrogen	-19.41	11.81
LANKHILLS	LH002/Gr 25	Male	1	High carbon	-18.2	9.9
LANKHILLS	LH008/Gr 451	Male	1	High carbon	-17.9	8.5
LANKHILLS	LH078/Gr 1223	Male?	1	High carbon	-18.30	8.00
LANKHILLS	LH079/Gr 1227	Female	2	High carbon	-18.40	9.30
LANKHILLS	LH096/Gr 554	Male	0	High carbon	-18.40	8.50

¹¹⁰ Fuller et al., ‘Nitrogen Balance and $\Delta^{15}\text{N}$ ’; Beaumont et al., ‘Infant Mortality and Isotopic Complexity’; Haydock et al., ‘Weaning at Anglo-Saxon Raunds’; Fuller et al., ‘Isotopic Evidence for Breastfeeding and Possible Adult Dietary Differences from Late/Sub-Roman Britain’; Kendall, Millard, and Beaumont, ‘The “Weanling’s Dilemma” Revisited’; Thomas Siek, ‘The Osteological Paradox and Issues of Interpretation in Paleopathology’, *Vis-à-Vis: Explorations in Anthropology* 13, no. 1 (2013): 92–101; DeWitte and Stojanowski, ‘The Osteological Paradox 20 Years Later’.

LANKHILLS	LH099/Gr 616	Male	1	High carbon	-18.20	8.60
LANKHILLS	LH105/Gr 914	Female	0	High carbon	-18.40	8.30

Table 3: Individuals from Figure 9 flagged by the DDC algorithm for only dietary results.

The upshot of this is that no post-Roman burials (highly furnished or otherwise) from the Wessex region were flagged for both number of grave goods and nitrogen isotope values, and the majority of dietary deviation flagged was C₄/marine consumption signals from the Roman period. DDC flagged many burials with higher-than-expected grave goods but there was no statistical association between rich grave provisioning and diet in these data.

CONCLUSIONS

What we have demonstrated here is a general lack of elite isotopic differentiation in $\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{15}\text{N}_{\text{coll}}$ values. From the data available it is implausible that the individuals with the highest $\delta^{15}\text{N}_{\text{coll}}$ values represent early medieval elites. No matter how this was investigated (gender, grave goods, body position etc.) there was a lack of correlation between social status in death and isotopic signals for diet. There is some suggestion that regionally gender differences might be more pronounced as we have found with Wessex; however, excavation and sampling biases cannot be ruled out due to uneven numbers of females and males with available isotopic data.

There are certainly many caveats to be aware of here: sampling issues, problems with chronology, difficulties with identifying elites archaeologically, to name a few. But despite these caveats none of the analyses showed any clear relationships between funerary practices, social status, and diet. Some chronological differences are, however, visible where more than one time period is present for a funerary variable. This suggests that social status and wealth as judged by funerary practice does not correlate with significantly higher protein consumption or eating different resources (e.g. marine fish), in the periods where furnished burial was still the norm. The well-known changes in burial practice from the end of the Roman period to churchyard burials in the eighth/ninth centuries are clearly shown in this smaller subset of burials with stable isotope data.¹¹¹ It supports and expands the findings of Hannah and Hull that there is no link between social identity/status and dietary isotopes for this period but contradicts the smaller scale correlations seen at sites such as Berinsfield, which reflect researchers actively hunting for variation in samples too small to sustain their

¹¹¹ Brownlee, 'Connectivity and Funerary Change in Early Medieval Europe'; Helen Geake, 'Persistent Problems in the Study of Conversion-Period Burial in England', in *Burial in Early Medieval England and Wales*, ed. S. Lucy and Andrew Reynolds, No. 17 (London, UK: The Society for Medieval Archaeology, 2002); Helen Geake, 'The Control of Burial Practice in Anglo-Saxon England', in *The Cross Goes North: Processes of Conversion in Northern Europe, AD 300-1300*, ed. M. O. H. Carver (Woodbridge, Suffolk UK: The Boydell Press, Woodbridge, 2003); Geake, *The Use of Grave-Goods in Conversion-Period England, c.600-c.850*; Lucy, *The Anglo-Saxon Way of Death*.

conclusions.¹¹² We suggest that the social hierarchy seen in early medieval cemeteries and the foodways of these communities may be biochemically ephemeral, played out through politics, material culture and specific kinds of food (e.g. special cuts or types of animal, fruits etc.) rather than an increased amount of protein or environmentally different resources (e.g. marine foods) that would show up in isotopic data. There is some zooarchaeological evidence from high status sites of marine fish (Bishopstone and Lyminge), which it is believed are linked to the Christianisation of these sites, as well as their higher social status (in the case of Lyminge moving from great hall complex to a minster).¹¹³ The fact that decline in furnished burial, the increase in fish consumption, calendarization of Christian feast days all coincide makes it nearly impossible to link burial practice, social status and diet for these sites - especially when we often cannot associate a cemetery with any given settlement.¹¹⁴ It is a case of correlation does not equal causation.

The isotopic evidence as it stands gives a picture of fifth-to-eighth-century diets which are more homogeneous than has commonly been supposed, where what people ate was more dictated by regional trends (environmental differences as well as regionally different foodways) and seasonality than purely by social status. This is perhaps unsurprising in many ways, yet narratives of social stratification causing drastically different diets have been persistent in the literature.

Across these two companion articles, we have demonstrated both the power of a multi-disciplinary approach and the potential for further bioarchaeological research which will only add to our knowledge of the interaction between foodways and social status, and the broader socio-economic implications thereof. With improvements in methodology, technology, statistics and physiological research, reassessments of the isotopic data on a broader scale with more nuanced interpretations are possible.

Palaeoproteomics is now coming of age, and alongside aDNA and lipids, these emerging data are beginning to fill the gaps in our archaeological knowledge of agriculture, food, cookery, cuisine, and diet in this period. It is now possible to look at the cookery contexts and food

¹¹² Hannah et al., 'Anglo-Saxon Diet in the Conversion Period'; Hull, 'Social Differentiation and Diet in Early Anglo-Saxon England'; O'Connell and Hull, 'Diet: Recent Evidence from Analytical Chemical Techniques'; Privat, O'Connell, and Richards, 'Stable Isotope Analysis of Human and Faunal Remains from the Anglo-Saxon Cemetery at Berinsfield, Oxfordshire'.

¹¹³ Knapp, 'The Zooarchaeology of the Anglo-Saxon Christian Conversion: Lyminge, a Case Study'; Gabor Thomas, 'Life before the Minster: The Social Dynamics of Monastic Foundation at Anglo-Saxon Lyminge, Kent', *The Antiquaries Journal* 93 (September 2013): 109–45, <https://doi.org/10.1017/S0003581513000206>; Gabor Thomas and Alexandra Knox, 'A Window on Christianisation: Transformation at Anglo-Saxon Lyminge, Kent, England', *Antiquity Bulletin*, 2012, <http://www.antiquity.ac.uk/projgall/thomas334/>; Thomas, *The Later Anglo-Saxon Settlement at Bishopstone*.

¹¹⁴ Knapp, 'The Zooarchaeology of the Anglo-Saxon Christian Conversion: Lyminge, a Case Study'; Rebecca Virginia Reynolds, 'Food for the Soul: The Dynamics of Fishing and Fish Consumption in Anglo-Saxon England: C. A.D. 410-1066' (PhD, Nottingham, UK, University of Nottingham, 2015); Hagen, *Anglo-Saxon Food & Drink*; Banham, *Food and Drink in Anglo-Saxon England*; Whitelock, 'The Laws of Wihtrred, King of Kent (695)'.

crusts themselves to add more dimensions to the story.¹¹⁵ As these datasets grow our understanding of the social and economic implications of food will only deepen.

The cautious conclusion we draw here is that we need to rethink the idea that the food lists we find in the laws of Ine and associated texts represent the institutionalised ‘expropriation of the poor to feed the powerful’.¹¹⁶ The assumption that the food supplies listed constitute blueprints for everyday elite diets is not consistent with the bioarchaeological evidence as it currently stands. People were eating animal protein to varying degrees, but those with the highest $\delta^{15}\text{N}_{\text{coll}}$ values seem to be eating more fish because they were Scandinavian incomers or observing religious dietary restrictions, and not because they were routinely eating the remarkably meat-heavy diets those texts imply.¹¹⁷

¹¹⁵ Hendy, ‘Ancient Protein Analysis in Archaeology’; Cappellini et al., ‘Ancient Biomolecules and Evolutionary Inference’; Dunne et al., ‘Reconciling Organic Residue Analysis, Faunal, Archaeobotanical and Historical Records’.

¹¹⁶ Rosamond Faith, *The Moral Economy of the Countryside: Anglo-Saxon to Anglo-Norman England* (Cambridge: Cambridge University Press, 2020), 50, <https://doi.org/10.1017/9781108766487>.

¹¹⁷ The authors would like to thank Lesley Abrams, Debby Banham, Jack Durand, Ros Faith, Alban Gautier and Helena Hamerow for their feedback on various versions of these papers, and the London Society for Medieval Studies, Alex Sanmark and Mark Hall for giving us the opportunity to present and workshop this research. We would also like to thank the articles’ anonymous readers for their constructive and detailed feedback. Sam Leggett would like to thank everyone in the Dorothy Garrod lab group for their support and feedback over the years, especially her doctoral supervisors Susanne Hakenbeck and Tamsin O’Connell. We gratefully acknowledge Sam Leggett’s doctoral funders’ support of this research – Newnham College and the Cambridge Trust (App No: 10386281), and the Cambridge Philosophical Society for their grant of a studentship.