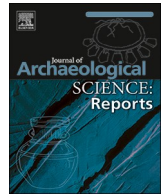




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## Understanding Middle Neolithic food and farming in and around the Stonehenge World Heritage Site: An integrated approach



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## ABSTRACT

Little synthesis of evidence for Middle Neolithic food and farming in Wiltshire, particularly in and around the Stonehenge World Heritage Site (WHS) has been possible, until now, due to a paucity of assemblages. The excavation of a cluster of five Middle Neolithic pits and an inhumation burial at West Amesbury Farm (WAF) has prompted a review of our understanding of pit sites of this period from the county. Bioarchaeological assemblages are used to investigate evidence for the consumption of animal and plant-based foods, and for agricultural and pastoral farming. For the first time Middle Neolithic zooarchaeological evidence, including strontium isotope data, is considered alongside archaeobotanical data, and radiocarbon dating.

The absence of cultivated plants from WAF and contemporary sites in the county is consistent with the hypothesis that the reduction in cereal cultivation and greater reliance of wild plants witnessed in the later part of the Neolithic in southern England began in the Middle Neolithic. The zooarchaeological evidence from the same sites demonstrates that the shift away from cereal cultivation may be concurrent with, rather than earlier than, an increase in the relative proportion of deposited pig bones relative to cattle.

Both cattle and pigs deposited in pits at WAF have strontium and sulphur isotope values consistent with the local biosphere, and therefore were potentially raised in the area. Zooarchaeological data from WAF complements that from human dental calculus and lipid residues in associated Peterborough Ware pottery that local cattle husbandry included exploitation of dairy. It also highlights the presence of consistent food preparation methods between pits as seen through butchery practice.

The faunal and archaeobotanical remains from contemporary pit deposits suggest that similar farming and subsistence strategies can be proposed across the county, though with some inter-site variation in deposition. Together these excavated pit sites are likely to represent only a sample of those present in the area. Application of a similar integrated approach to material from other Middle Neolithic pits holds potential for better understanding of food and farming in this previously neglected period.

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## 1. Introduction

As early as the mid-20th century Stuart Piggott speculated that the flourishing mixed farming economy of the Early Neolithic in southern England gave way to a more mobile, pastoral farming system by the 'Secondary Neolithic' (Piggott, 1954: 365–6).<sup>1</sup> This theme has attracted the attention of archaeobotanical research with subsequent authors commenting on a notable reduction in the number of charred cereal grains relative to wild plant remains in the Middle and/or Late Neolithic compared to the Early Neolithic of the region (Moffett et al., 1989; Robinson, 2000; Stevens and Fuller, 2012). Stevens and Fuller (2012) suggest a decline or even cessation in cereal cultivation based on the ratio of radiocarbon dated grain to seeds of wild plants, citing also a reduction in occurrence of cereal impressions in pottery and absence of quern stones spanning the Middle and Late Neolithic.

While the archaeobotanical evidence for agricultural change in the central and southern England has been proposed to coincide with the onset of the Middle Neolithic, zooarchaeological data has been used to suggest a change in the relative proportion of domestic livestock species whereby an Early Neolithic focus on cattle is replaced by a focus on pig husbandry in the Late Neolithic (Grigson, 1982; Schulting, 2008; Serjeantson, 2011: 34–6), though perhaps not across the UK (Rowley-Conwy and Owen, 2011). Some highlight the integrated ecology of farming environments and ecological tolerances of domestic animals with presence of sheep husbandry in particular associated with open, well drained landscapes which may include cultivated land, as opposed to pig and cattle husbandry, which can utilise more wooded environments (Grigson, 1982; Hamilton et al., 2009; Schulting, 2008; Smith, 1984).

To date, few studies have integrated faunal, botanical and archaeological evidence for food and farming in the Middle Neolithic period in southern England. This reflects a broader paucity of research into the period relative to the earlier and later Neolithic. The Middle Neolithic (c. 3300–2900 cal BC), typologically identified in southern England by presence of Peterborough Ware ceramics, lacks both the standing monumental earthworks and associated bioarchaeologically-rich excavated deposits of the preceding and following periods, as well as the academic driver of tracing the Early Neolithic emergence of domestic species in the region. For example, in Serjeantson's (2011) zooarchaeological regional review dataset only 11% of the 151 assemblages, and 2% of the 41,751 bones (as quantified by Number of Identified Specimens, NISP), from southern England<sup>2</sup> are Middle Neolithic, as opposed to Early or Early–Middle Neolithic (62% assemblages, 63% NISP) or Late Neolithic (28% assemblages 35% NISP) and a review of Neolithic archaeobotanical remains by Jones and Rowley-Conwy (2007) does not include the Middle Neolithic at all. Focussing study on the area surrounding the Stonehenge World Heritage Site (WHS) reduces this number considerably. An earlier study of zooarchaeological evidence from the WHS (Maltby, 1990a) excludes the Middle Neolithic entirely, citing only pits at King Barrow Ridge W59, one of which included Peterborough and Grooved Ware pottery, as being intermediate between the Early and Late Neolithic sites. We exclude this assemblage from our analyses as the nature of the feature is questioned by the excavators and radiocarbon samples from the bone assemblage produced only Early Neolithic dates (Richards, 1990: 116; Roberts et al., in preparation). However, Wiltshire has now produced a number of Middle Neolithic

Peterborough Ware pits and pit groups identified through developer funded archaeology and research excavation (Algar and Hadley, 1973; Allen and Davis, 2009; Amadio, 2010; Context One Archaeological Services Ltd, 2008; Harding and Stoodley, 2017; Heaton, et al. O'Connor, 2003; Powell et al., 2005; Roberts et al., in preparation; Smith and Simpson, 1964; Wessex Archaeology, 2014a, b, 2015a, b). These pit assemblages offer the opportunity to investigate the farming and consumption strategies, and the interaction with the environment, of the people who lived in the landscape in the centuries leading up to the construction of Stonehenge.

One such Middle Neolithic pit group was excavated by Historic England (HE) during the winter of 2015–6 at West Amesbury Farm (WAF), Wiltshire as part of a wider project to characterise the poorly understood area of the Stonehenge World Heritage Site that lies south of the A303 (Roberts et al., in preparation). Here, geophysical survey had revealed an extensive scatter of small discrete anomalies, likely to be pits and tree throws, spread across the southern slopes King Barrow Ridge (Linford et al., 2015, see also Fig. 1). A trench excavated at SU 13857 41767, on the east-facing slopes of a chalk spur overlooking the River Avon, revealed that a small sample of the anomalies included five Middle Neolithic pits, a middle Neolithic grave (Mays et al., 2018; Roberts et al., in preparation) and a series of tree throws, at least one of which pre-dated the pits (Fig. 1).

The five pits were all broadly similar in size and shape: approximately 1–1.4 m in diameter, roughly circular in plan, and near-vertical sided rounding to a slightly concave or flat base 0.6–0.8 m below the surface of the chalk bedrock. They generally had a simple sequence of fills with the majority of bioarchaeological finds concentrated in the primary anthropogenic fill (hereafter referred to as 'primary fill') of each pit (see Fig. 2), together with substantial quantities of struck flint and a significant Fengate sub-style Peterborough Ware pottery assemblage (Roberts et al., in preparation). Four of the pits clustered in the east end of the trench (Fig. 1), including two that had a stratigraphic relationship: 93208 was cut by inhumation burial 93240, which was then itself cut by 93233 (Mays et al., 2018; Roberts et al., in preparation). The fifth (pit 93201) was approximately 11 m to the north-west, towards the northern edge of the trench.

In common with other Peterborough Ware pit sites, no evidence for long-term settlement was uncovered. An alignment of four postholes was found approximately 18 m west of the main pit group but lacked definitive dating evidence. Beyond this an extensive area of animal burrowing roughly contemporary with the pits (see Roberts et al., 2017: 137) had disturbed two short north-south aligned cut features, the only other Middle Neolithic features identified (see Mays et al., 2018, Fig. 2; Roberts et al., in preparation). The pits are therefore interpreted as representing repeated short-term use of the area.

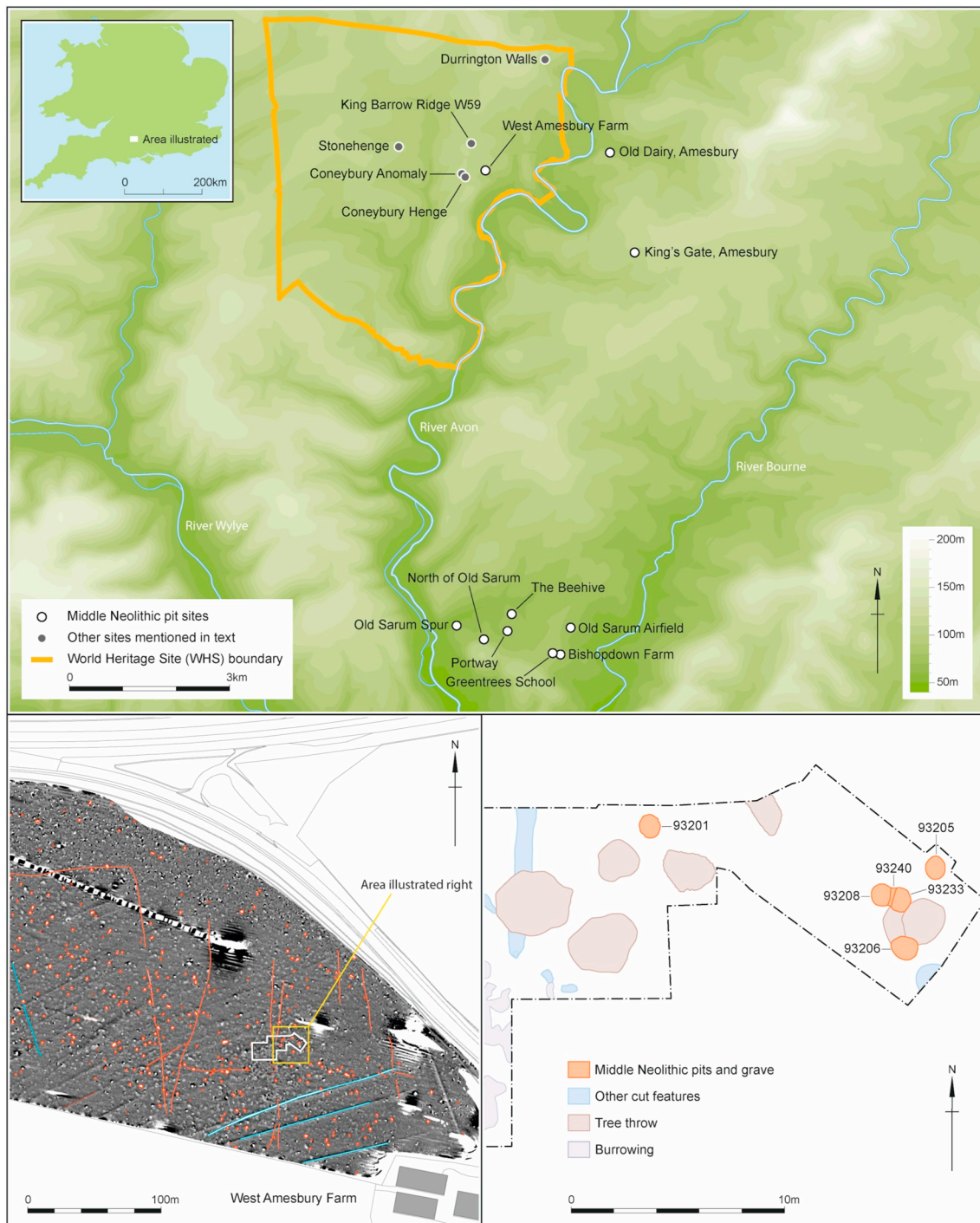
This paper aims to use the WAF pit assemblages and those from contemporary sites in the surrounding area to address three primary questions. Firstly, what evidence do the pit deposits provide for the consumption of animal and plant based foods in the Middle Neolithic and how does this compare with current understanding and expectations of the period? Secondly, what evidence do the pit deposits provide for arable or pastoral farming in the Middle Neolithic landscape surrounding West Amesbury? Thirdly, can the bioarchaeological assemblages provide insight into the activities associated with the pit-filling that occurred in the area a little over five millennia ago?

## 2. Background evidence for Neolithic farming in the Stonehenge area

Prior to the sites discussed in this paper, understanding of Middle Neolithic animal utilisation in southern England was based on finds from very few sites. Excluding around 100 bones associated with funerary monuments, Serjeantson's (2011) synthesis of published zooarchaeological data reported Middle Neolithic faunal assemblages from only five cursus ditches, two phases of Stonehenge ditch deposits

<sup>1</sup> Writing prior to the understanding brought through radiocarbon dating, Piggott defined the Secondary Neolithic as a period of consolidation of cultures and included both Peterborough and Grooved Ware Cultures. We now consider Peterborough Ware to be a Middle Neolithic pottery style and Grooved Ware to be Late Neolithic.

<sup>2</sup> Following Serjeantson's (2011) review, southern England is defined here as counties including and to the south and west of Gloucestershire, Oxfordshire, Berkshire, Surrey and Kent.



**Fig. 1.** Location and plan of West Amesbury Farm pits (bottom right) in relation to greyscale plot of magnetometer survey (bottom left) highlighting significant pits in red and showing linear anomalies transcribed from the GPR survey with high amplitude reflectors in red, low amplitude in blue (based on Linford et al., 2015 Figs. 4, 12 and 13). The top part of the figure shows locations of comparative pit sites and significant sites mentioned in the text. Tilshead Nursery School (TNS), Overton Down and West Kennet Avenue are located 12 km north-east (TNS) and c. 30 km north of West Amesbury Farm, Harnham Road Water Supply is located c. 12 km to the south (image: John Vallender). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

and two pit sites (Serjeantson, 2011: Appendix 1). Together, and with the addition of the Beehive pits (Heaton et al., 2003, which Serjeantson categorised as Late Neolithic though they contained only Peterborough Ware pottery), these sites produced only 336 bones from domestic livestock, with pit sites contributing a NISP of only 35 bones (and of these, the Beehive (Heaton et al., 2003) being the only pit site in the Stonehenge area). Though published in 2005, the pits from Old Sarum Spur and The Portway (Powell et al., 2005) were not included in

Serjeantson's review. Sixty per cent of all non-funerary site livestock bones, and of those from pits, were cattle (*Bos taurus*). While too small to draw firm conclusions about the nature of animal husbandry or utilisation, this Middle Neolithic dataset appeared to hint towards a continuation of the species proportions seen in Serjeantson's much larger sample of over 10,000 domestic livestock bones from Early Neolithic causewayed enclosures, occupation layers and pits. Excluding Runnymede in Surrey, which produced a relatively high proportion of



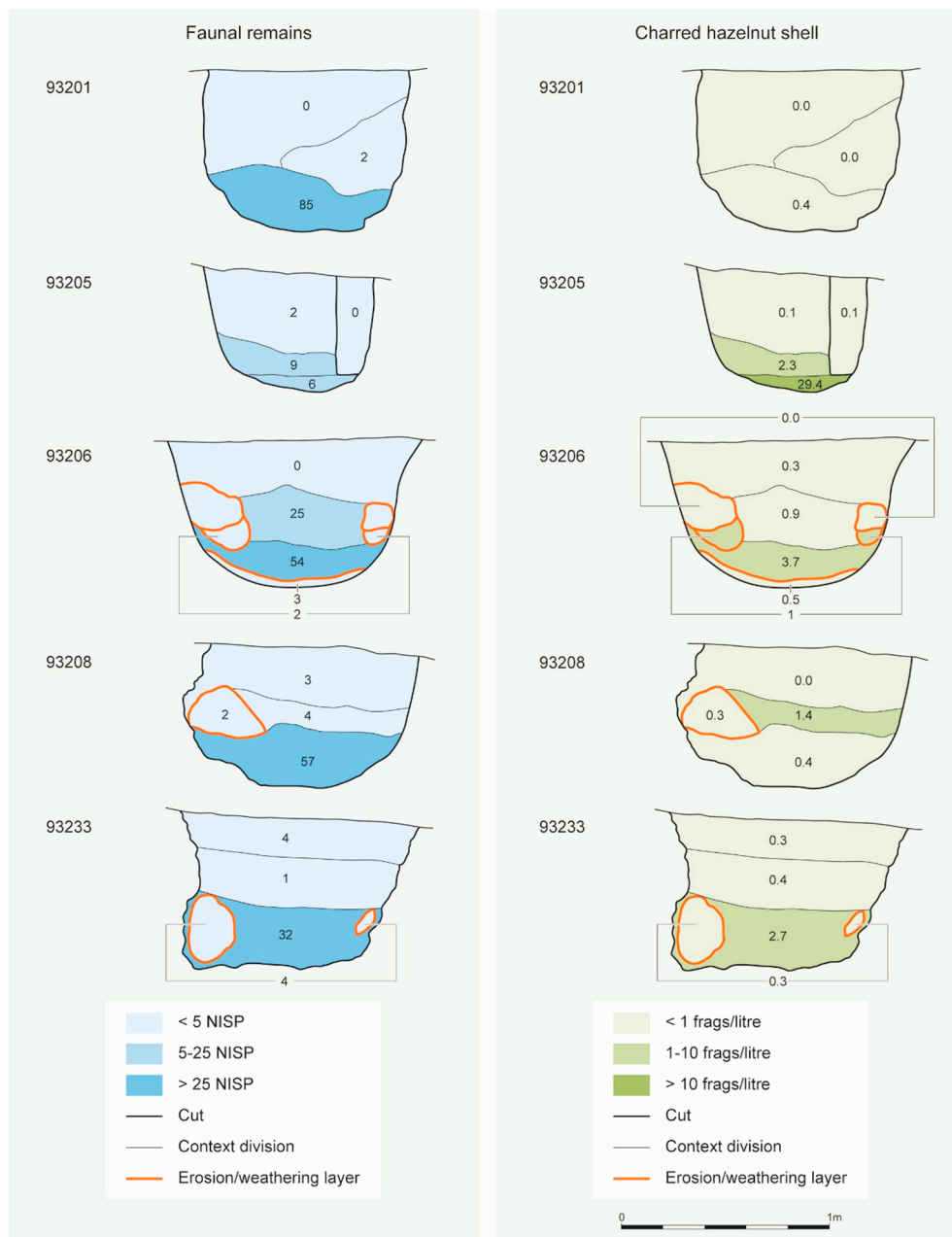


Fig. 2. Stylised sections showing density of deposition of animal bone and charred hazelnut shell in each pit fill expressed as relative abundance (shading) and absolute counts or concentration (numeric label). Faunal remains are quantified by total number of identified specimens (NISP) in context, while botanical data is presented as number of fragments per litre of flotation sample (samples were processed from all fills). See Roberts et al. (in preparation) for comprehensive section details for each pit (image: John Vallender).

pig (*Sus domesticus*) bones (Serjeantson, 1996, 2006), the pastoral element of Early and Early-Middle Neolithic agricultural economies was thus considered dominated by cattle, with pig and sheep/goat (*Ovis aries/Capra hircus*) remains occurring in similar proportions (as expressed through NISP). This strategy was suggested to have changed with the late Neolithic, for which zooarchaeological evidence showed an escalation in the exploitation of pigs, and a relative decrease in the number of cattle and sheep/goat bones recovered across southern England as a whole and when just considering pit assemblages (see Serjeantson, 2011). Throughout the Neolithic, husbandry of cattle included utilisation of ruminant dairy, as evidenced by lipid residues on pottery (e.g. Copley et al., 2003; Craig et al., 2015; Serjeantson, 2006: 122). With the exception of studies of pig and cattle teeth from the Late Neolithic site of Durrington Walls (Madgwick et al., 2012a; Viner et al.,

2010) and cattle and roe deer from the Early Neolithic Coneybury Anomaly (Gron et al., 2018), no previous studies have used strontium to consider whether livestock found in Neolithic sites in southern England were farmed locally, or transported, perhaps traded, from further afield.

Evidence for the utilisation of Middle Neolithic plant resources in the Stonehenge area has hitherto been similarly based on sparse published data, being previously reported from Old Sarum Pipeline (Powell et al., 2005) and the Beehive (Heaton et al., 2003), both of which produced only wild plants, most notably hazelnut (*Corylus avellana*) shell. The limited and scattered cereal assemblage from Middle and/or Late Neolithic contexts at the West Kennet palisade enclosures is likely to comprise or include material derived from later activity, given the range of taxa recorded and the presence of known Saxon activity on the site (Fairbairn, 1997: 137). Unlike previous interpretation of the

**Table 1**

Summary of cultivated crops in England through the Neolithic, illustrating those which have been demonstrated to be intrusive through direct radiocarbon dating and those for which dating has confirmed their Neolithic occurrence. The chronological definitions of periods given follow FISH (n.d.), regional variation is seen across England. See cited references for details of individual dates.

Cultivated crop	Early Neolithic (c.4000–3300 cal BC) contexts	Middle Neolithic (c.3300–2900 cal BC) contexts	Late Neolithic (c.2900–2200 cal BC) contexts
<i>Hordeum vulgare</i> (barley) and <i>Triticum dicoccum</i> (emmer)	Confirmed Early Neolithic date, widespread Various sites (see Stevens and Fuller, 2012: online supplementary data). Large caches of charred grain, usually in pits, have been recovered from sites across both southern England (Jones and Legge, 2008; Murphy, 1989; Pelling, 2011, 2012; Stevens, 2011; Wilkinson et al., 2012) and northern England (Jones and Bogaard, 2017). Sites local to WAF (not directly dated): Coneybury Anomaly (Carruthers, 1990), Windmill Hill (Fairbairn, 1997; Whittle et al., 2000)	Confirmed Middle Neolithic date, rare The Stumble, Essex (Wilkinson et al., 2012) Sites local to WAF: One barley grain from a Late Neolithic pit at Bulford South produced a Middle Neolithic date (UBA-34499; Supplementary Information SI.2). All other occurrences demonstrated to be intrusive.	Confirmed Late Neolithic date, rare Barley from Clifton Quarry, Worcs. (Mann and Jackson, 2018); both barley and emmer from The Stumble, Essex (Wilkinson et al., 2012) Sites local to WAF: Grains from Coneybury Henge (naked and hulled barley) and Durrington Walls (hulled barley and emmer) have been directly dated to the Early Bronze Age and later (Pelling and Campbell, 2013; Pelling et al., 2015; Supplementary information SI.2).
<i>Triticum aestivum/turdigum/durum</i> (bread/rivet/durum wheat)	Confirmed Early Neolithic date, rare Rivet/durum wheat from Isle of Thanet, Kent (Bevan, 2017; Carruthers, 2010, 2013) Status of bread wheat unclear (see Pelling et al., 2015; Stevens and Fuller, 2012)	Intrusive finds in Middle Neolithic contexts, widespread Dated examples consistently demonstrated to be intrusive. See Pelling et al. (2015), Stevens and Fuller (2012) and Supplementary Information SI.2	Intrusive finds in Late Neolithic contexts, widespread Dated examples consistently demonstrated to be intrusive. See Pelling et al. (2015), Stevens and Fuller (2012) and Supplementary Information SI.2
cf. <i>Secale cereale</i> (cf rye, likely wild)			Confirmed Late Neolithic date, rare Identification insecure. Clifton Quarry, Worcs. (Mann and Jackson, 2018)
<i>Linum usitatissimum</i> (flax)	Confirmed Early Neolithic date, rare Lismore fields, Derbs (Jones and Bogaard, 2017)		
<i>Vitis vinifera</i> (grape)	Confirmed Early Neolithic date, rare Hambleton Hill, Dorset (Jones and Legge, 2008)		

zoarchaeological data (see above), Middle Neolithic (and, within southern England, Late Neolithic) archaeobotanical data stands in contrast to those from Early Neolithic assemblages, which have produced evidence for cultivated emmer wheat (*Triticum dicoccum*), possible (tentatively identified) einkorn (*T. cf. monococcum*) and both naked and hulled forms of barley (*Hordeum vulgare*), including an assemblage from the Stonehenge WHS (Coneybury Anomaly, see Fig. 1) and Windmill Hill causewayed enclosure and surrounding pits, 30 km to the north of West Amesbury (see Table 1). Although the grain has not been dated from either site, emmer wheat and hulled and naked barley are well attested from elsewhere in southern Britain in the Early Neolithic (see Table 1). Two fragments of charred organic material interpreted as barley or mixed cereal ‘bread’ made from crushed or coarsely-ground grain found in a pit at Yarnton (Hey et al., 2016: 282–3) provide rare indication of how cereals were consumed, and consumption as beer has also been suggested (Dineley and Dineley, 2000). Carbon and nitrogen isotope analysis of Early Neolithic emmer wheat grain from Lismore Fields, Derbyshire has been used to argue for an integrated mixed farming system, at least at that site, whereby the collection of manure from stalled animals was used in arable agriculture (Jones and Bogaard, 2017).

While the relative contribution of cereal grain compared to wild fruits and nuts is difficult to assess given differences in processing requirements and preservation bias including likelihood of coming into contact with fire (Jones and Rowley-Conwy, 2007), the scant directly dated evidence for Middle or Late Neolithic cereal remains from across much of England has been attributed to a decline, or even localised cessation, of cereal cultivation as the result of climatic deterioration and population decline (Stevens and Fuller, 2012), or potential pathogens and insects (Dark and Gent, 2001), while other authors attribute it to biases in selection for radiocarbon dating (Jones and Bogaard, 2017). Exceptional finds of directly dated Late Neolithic charred grain from sites located in the English Midlands (see Table 1) do however suggest that further examples may yet be found. The current evidence from

England also contrasts with clear evidence of cereal cultivation throughout the Neolithic in Scotland, albeit with a shift from wheat and barley to a Late Neolithic focus on barley (Bishop, 2015b; Bishop et al., 2009), demonstrating regional variation in the archaeobotanical record.

Celtic bean (*Vicia faba*) and pea (*Pisum sativum*) have so far not been conclusively identified until the Bronze Age (Treasure and Church, 2017) and earlier occurrences are uncertain (directly dated examples have always returned later dates, for example see Stevens and Fuller (2012): online supplementary data; Pelling et al., 2015). Two tentatively identified charred peas in a Middle Neolithic deposit at Runnymede Bridge have not been directly dated (Greig, 1991).

### 3. Materials and methods

#### 3.1. Excavation and recovery

The five Middle Neolithic pits at WAF were initially half-sectioned, before being fully excavated. They were subjected to an intensive whole-earth sampling programme aimed at representative recovery of bioarchaeological and artefactual remains, and particularly charred plant remains. The initial strategy was to float 40 l (or 100% of smaller contexts) of sediment from each sealed layer and to hand excavate the remainder, but following the recognition of an exceptional Middle Neolithic pottery and flint assemblage from the first half-section of 93201, this strategy was supplemented by coarse-sieving all spoil to 5 mm whenever possible. A total of 40 flotation samples (totalling 1445 l) were taken and 910 l spoil were coarse-sieved from the pits during the excavation. Flotation samples were processed using a 250 µm flot mesh and a 500 µm residue mesh, and residues were further screened over a stack of 4 mm and 2 mm sieves. All flots, 100% of all > 4 mm residues and a quarter of each 2–4 mm residue were fully sorted for bioarchaeological and artefactual finds.

### 3.2. Zooarchaeological and archaeobotanical methods

Zooarchaeological and archaeobotanical methods and data are described in full elsewhere (Pelling, 2019; Worley, 2017b), with pertinent methods summarised here. Where suitably complete, and skeletally mature, *Bos* sp. were identified to species by comparison with metric data from the EUROVOL project (Manning, 2016; Manning et al., 2015). No metric data were available to distinguish between wild and domestic *Sus* sp. Where it has been possible to determine, the majority of *Sus* sp. from Neolithic sites are domestic (Hamilton et al., 2009; Serjeantson, 2011). We refer to *Sus* sp. as 'pig'. Quantification methods included NISP (Number of Identified Specimens) following a selective method based on Serjeantson's (1996) zone system, MNI (Minimum Number of Individuals) and MNE (Minimum Number of Elements), the latter two derivations taking into account zone, side, age and size and calculated by pit). Silver (1969) was followed for bone fusion ages. Mandibular tooth eruption and wear, recorded following Ewbank et al. (1964) and Grant (1982), was used to estimate age-at-death following O'Connor (2003) and Legge (1992). Data from pig isolated teeth and fragmentary mandibles was interpreted by comparison with those from more complete Late Neolithic mandibles from Durrington Walls (Wright et al., 2014). Presence of butchery marks was confirmed using low power microscopy. Grain was quantified on the basis of embryo ends and chaff on the basis of items (rachis, glume base, culm node). Quantification of hazelnut shell fragments includes a multiplier for fractioned residues, so that those from the 25% of the 2–4 mm residue have been multiplied by 4.

#### 3.2.1. Strontium, sulphur, carbon and nitrogen isotope analysis

In order to interpret pastoral farming at West Amesbury, we sought to establish whether the zooarchaeological assemblage is from livestock bred and raised locally. This should not be assumed for the Neolithic period in England, given the increasing body of evidence for animal transport (Madgwick et al., 2012a; Viner et al., 2010). Teeth from six immature or immature to subadult pigs and three cattle over six months old were subject to  $^{87}\text{Sr}/^{86}\text{Sr}$ ,  $\delta^{34}\text{S}$ ,  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  isotope analysis. This represents the maximum number of animals that could be sampled while ensuring that each is a separate individual. All samples were extracted from left sided first molars, with one exception: cattle probable second molar ID 281 (Sample WAM07/281), whose identification was made more difficult by a missing hypoconulid on the adjacent tooth. However, on the basis of its dental attrition this tooth could not have derived from the same individual as either of the other cattle samples.

For strontium isotope analysis, enamel slices were extracted from the cervical section of the cusp unit, but with at least a 3 mm separation from the REJ (root-enamel junction) for cattle molars and 1 mm separation from the REJ for pig molars. Although there is time averaging in strontium uptake during dental enamel maturation (Montgomery et al., 2010), this sampling strategy should provide a signal indicative of early life origins (< 6 months) and approximately the same period in the animals' lives for each individual. Early developing enamel sampled from the probable second molar will represent a slightly later period in the animal's development. Therefore, even if animals were husbanded in the vicinity of West Amesbury for a period prior to their slaughter, the isotope signal should represent the location where the animals were raised during early life. For sulphur, carbon and nitrogen isotope analysis, dentine from roots of the same teeth sampled for strontium were extracted, also providing a signal for early life origins and management. Methods of sample preparation and mass spectrometry are presented in Supplementary Information (SI.1).

#### 3.3. Radiocarbon dating

Given the demonstrable risk of intrusive grains in prehistoric contexts (see background evidence above and Pelling et al., 2015), the

provenance of cereal grains from WAF and comparative sites was verified through direct dating (see Supplementary Information SI.2). A number of mammal bones and charred hazelnut shells were also dated to construct a chronological model for pit filling activity at WAF (see Roberts et al., in preparation and Supplementary Information SI.2). Technical details of the methods used and full details of the chronological modelling are provided in Roberts et al. (in preparation).

#### 3.4. Comparisons with data from other Wiltshire sites

A survey of previous resource assessments and published overviews (Jones and Legge, 2008; Richards, 1990; Serjeantson, 2011; Stevens and Fuller, 2012), the county Historic Environment Record (Wiltshire Council, 2015), and queries to contracting archaeological units sought to identify other pit sites with Middle Neolithic Peterborough Ware pottery from Wiltshire. These sites are used here to contextualise the WAF bioarchaeological assemblages within the local contemporary environment and practice.

## 4. Results

### 4.1. Evidence for the plant economy at West Amesbury

A limited number and restricted range of archaeobotanical remains were recovered from all pits (Table 2). Each pit produced a small quantity of charred cultivated cereal remains (mostly barley and free-threshing wheat, with a single free-threshing wheat rachis), and one or two pulses were retrieved from each of three pits. The presence of free-threshing wheat and pulses in Neolithic contexts frequently indicates intrusive material. Free-threshing wheat was widely cultivated from the Saxon period onwards (Carruthers and Hunter forthcoming; Van der Veen et al., 2013), and where it has been recovered from early pre-historic contexts, it is typically found to be intrusive when dated (Pelling et al., 2015; Stevens and Fuller, 2012: online supplementary data). Charred pulses have not been securely dated prior to the Middle Bronze Age in the British Isles (Treasure and Church, 2017). All grain and pulses were abraded and pitted, damage likely to have occurred through burning and/or post-depositional reworking and movement. Free-threshing wheat and barley grains from two of the Middle Neolithic pits were radiocarbon dated and returned medieval dates (see Supplementary Information SI.2), confirming the hypothesis that they were intrusive from later activity on the site (Roberts et al., in preparation). The presence of intrusive macroscopic plant items warns of the likelihood of movement of other small material, particularly microscopic remains, but also small bones and lithic finds.

Charred hazelnut shell fragments were recovered from all five pits. The hazelnut shell was not evenly distributed between or within pits (Fig. 2) and only a small quantity was recovered from 93201 (Table 2). In four of the pits hazelnut shell is predominantly found in the primary fill, where it is present in concentrations of between 2.7 fragments per litre (adjusted figures) in 93233 up to 29.4 in 93205. The primary fills are also the contexts that generally contained the highest numbers of pottery sherds (Russell pers. comm.), countable zooarchaeological remains (below), and relatively high densities of larger flints (Price pers. comm.; Roberts et al., in preparation), with smaller quantities of lithics also recovered from later deposited fills in some pits. However, in 93208 the greatest concentration of hazelnut (1.4 fragments per litre) was contained within the secondary fill. The paucity of hazelnut shell in the primary fill of this pit is at odds with the distribution of animal bone in this pit.

With the exception of a single elder (*Sambucus nigra*) seed, no other wild fruits or nuts were recovered from the pits. Small quantities of charcoal were present including some identifiable to taxa (Table 2). One fragment of charred grass rhizome was also identified from 93233.

**Table 2**

Summary of plant and animal remains from the Middle Neolithic pits at West Amesbury Farm. Numbers of radiocarbon dates obtained by material type given in superscript.

Pit	93201		93205		93206		93208		93233	
Archaeobotanical remains (all charred) <sup>a</sup>	Count		Count		Count		Count		Count	
Total flotation sample volume (litres)	290		175		420		300		260	
<i>Corylus avellana</i> (hazelnut shell fragments > 2 mm)	36		634 <sup>2</sup>		554 <sup>1</sup>		163 <sup>1</sup>		274	
<i>Alnus/Corylus</i> (alder/hazel charcoal)	–		+		–		–		–	
Pomoideae (apple/hawthorn/rowan charcoal)	–		+ <sup>1</sup>		+ <sup>1</sup>		–		–	
<i>Quercus</i> sp. (oak charcoal)	++		–		+		–		–	
Other diffuse porous charcoal	+		+		–		+		+	
Poaceae (grass rhizome)	–		–		–		–		1	
<i>Sambucus nigra</i> (elder seed)	1		–		–		–		–	
Crops (intrusive)										
<i>Hordeum vulgare</i> (barley grain)	3		1		4 <sup>2</sup>		4 <sup>1</sup>		1	
<i>Secale cereale</i> (rye grain)	–		1		–		–		–	
<i>Triticum aestivum</i> s.l./ <i>turgidum</i> (naked wheat grain)	3 (+ 1 rachis)		5		3 <sup>1</sup>		3 <sup>1</sup>		2	
<i>Triticum</i> sp. (wheat grain)	3		–		9		1		4	
Cerealia indet. (cereal grain)	5		1		22		19		–	
Fabaceae (pulses)	1		–		1		–		2	
Zooarchaeological remains <sup>b</sup>	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Sus scrofa</i> (pig)	71 <sup>1</sup>	4	11	2	56 <sup>1</sup>	3	35	2	12	2
<i>Bos taurus</i> (cattle)	3	2	5 <sup>1</sup>	2	11	3	13 <sup>2</sup>	2	21 <sup>2</sup>	3
<i>Bos primigenius</i> (aurochs)	1	1	1	1	–	–	–	–	–	–
<i>Canis familiaris</i> (dog)	–	–	–	–	1	1	–	–	–	–
<i>Cervus elaphus</i> (red deer; antler)	1	1	–	–	1	1	–	–	1	1
<i>Capreolus capreolus</i> (roe deer; post-cranial)	–	–	–	–	–	–	–	–	1	1
<i>Vulpes vulpes</i> (fox)	–	–	–	–	2	1	2	1	–	–
<i>Martes martes</i> (pine marten)	–	–	–	–	3	1	1	1	–	–
Mustelid	–	–	–	–	2	1	4	1	–	–
<i>Myodes glareolus</i> (bank vole)	–	–	–	–	2	1	–	–	–	–
Small rodent	2	1	–	–	1	1	–	–	–	–
Large mammal	4	n/a	1	n/a	1	n/a	–	–	5	n/a
Small bovid/cervid (sheep/goat/deer)	1	1	–	–	–	–	–	–	–	–
Medium mammal	3	n/a	–	–	4	n/a	7	n/a	1	n/a
Bird	1	1	–	–	–	–	4	1	–	–
Total NISP	87	n/a	17	–	84	n/a	66	n/a	41	n/a
NISP burnt	7	n/a	0	–	0	n/a	30	n/a	0	n/a

<sup>a</sup> The 2–4 mm residue archaeobotanical finds have been multiplied up to show the projected likely quantities from 100% of the sample. Charcoal is quantified as + 1–5 items, ++ 6–25 items.

<sup>b</sup> Zooarchaeological remains include those recovered from samples and by hand. Five and 6% of pig and cattle NISP are probable identifications which do not affect the ubiquity of these species. Approximately half of the fox, pine marten, mustelid and bank vole identifications from 93206 and three mustelid specimens from 93208 are also to a probable level of certainty.

#### 4.2. Evidence for faunal utilisation at West Amesbury

A total of 3073 fragments of animal bones and teeth were recovered from the five pits, of which 295 fulfil the criteria to be included in the NISP (Table 2). Many specimens are fragmentary, with isolated teeth and small bone fragments making up at least 46% of the NISP for each pit (see Supplementary Information SI.4). Pigs and cattle dominate the NISP counts for all pits, with a minimum of between two and four animals of each species recovered from each pit. The majority of the NISP from most pits was recovered from the primary fills (Fig. 2) and the density of bone deposition (considered through NISP per litre of flotation samples) is similar between pits. The smallest feature (93205) shows a slightly different depositional pattern with very similar numbers of identifiable bones in the secondary and primary fills, however, the number of fragments involved is very small, and most are isolated teeth. This pit is also distinguished as the only one with evidence for a post, and mixing associated with the insertion or removal of this post may explain the contrasting pattern of deposition (Roberts et al., in preparation). Pit 93206 has a relatively high frequency of remains in both the primary and secondary deposited fills. This is also the only pit to contain gnawed bones: two bones gnawed by a carnivore rather than rodent. A minority of identifiable bone fragments were burnt from pits 93201 and 93206, but almost half from 93208 had been exposed to fire.

The total NISP of 295 includes hand collected bones, bones from > 5 mm coarse sieving and from > 4 mm flotation residues (no bones from 2 to 4 mm or smaller fractions were identifiable). The vast

majority of the NISP was from contexts that were 100% sampled (and processed through dry sieving and/or flotation). Pits 93206 and 93201 included bone-producing contexts which were not 100% sampled (approximately 16% and 20% of their volume sampled respectively). In these pits the relative ranking of species NISP persists in both the sampled and hand-collected assemblages.

The cattle and pig assemblages include all regions of the skeleton, though do not represent complete carcasses – parts of each animal must have been discarded or deposited elsewhere, or perhaps traded. There is no apparent bias to either side of the body. Head and foot elements are common, and post-cranial meat-rich elements are also present in most pits. Surface preservation of all bones was generally moderate to poor. Nevertheless evidence of carcass processing was identified on a minority of bones from each pit; ten pig bones and eight cattle bones in total. Butchering tradition is also evidenced by potential butchering units, for example an articulating pig forelimb (radius, ulna and humerus) from 93206. Seven cattle bones and three pig bones had been broken when fresh, a practice likely to be employed to access bone marrow for consumption (for example see Outram, 2001). The majority of the remaining butchered bones bear cut marks from flint tools. The only cut mark on a cattle bone is an atlas vertebra with a cluster of transverse cuts on the dorsal face, suggestive of severing the neck rather than slaughter. A pig scapula had a small number of cuts across the origin of the spine (similar to Lawverier, 1988 code 1) suggestive of dismemberment from the humerus, and a pig calcaneum had possible cut marks above and on the lateral margins of the articular complex





**Fig. 3.** Similar cut marks (highlighted with arrows) and ‘snapped’ rami recorded on mandibles from four pigs, deposited in two pits at West Amesbury. Insert on right illustrates the region of the mandibles present and the approximate location of the marks annotated onto a boar skeleton illustration © 2003, from [ArchaeoZoo.org](http://ArchaeoZoo.org), by M Coutureau (according to original drawing of [Pales and Garcia, 1981](#)) (photographs: Steven Baker, annotated by John Vallender).

(zones 3 and 5 following [Serjeantson, 1996](#)) suggestive of dismemberment of the foot. The remaining butchery marks all reflected processing of pig heads. A parietal may have been chopped sagittally, perhaps to access the brain, and four right mandibles, recovered from two pits, exhibited an apparently consistent practice for removal of the jaw by severing the muscles just below the zygomatic arch and cutting through or snapping the ramus below the condyle (code 17 following [Lauwerier, 1988](#)) (Fig. 3).

The cattle and pig bone assemblages include animals of different ages within each pit, and there are some similarities between pits (Table 3). Four of the five pits each included at least one immature pig, likely to have died during the second half of the first year of their lives (i.e. while their first molars were in early wear [stages a–c] and before their second molars had come into occlusion). Comparison of dental data from incomplete mandibles at WAF with the large Late Neolithic assemblage from Durrington Walls ([Wright et al., 2014](#)), indicated that two pits also included adult pigs (with a fourth premolar at stage f, and a second molar at stage e). The adult category is defined by the third molar coming into occlusion (i.e. after having erupted at 18–20 months of age); those from WAF include one whose third molar was likely to have been in early wear (stage a–c) and one who may have been the same age or much older (i.e. with much greater wear of the third molar). The other three pits each included a subadult to adult pig (with first molars at stage e or g, or a fourth premolar at stage e). Comparison of these incomplete jaws with [Wright et al.’s \(2014\)](#) data suggests that all three would have had third molars erupting or in early wear, i.e.

they may have died in the second half of their second year.

Each pit includes the remains of at least one young calf, some of which were neonatal. Several limb bones from at least one neonatal calf were in pits 93201 and 93206, the latter also including an older calf, perhaps up to a few months old. Dental data suggests that one calf from 93206, along with a calf from 23233, was around 1–3 months of age (following [Legge, 1992](#)). A tibia from a young calf, similar in size or perhaps slightly larger than a modern three month old Friesian calf in the HE Zooarchaeology Reference Collection (specimen HE3495), was in 93205. Pit 93208 included an animal of < 6 months, and probably a few months old while 93233 contained mandibular teeth from a 1–3 month old calf (following [Legge, 1992](#)). Older cattle were also present in each pit (Table 3).

Red deer are represented in three of the pits’ primary fills, in all cases by an antler tool: an unshed antler pick in 93233, an isolated tine in 93201 and the crown of an antler, often referred to as a ‘rake’ in 93206 (see [Worley, 2017b](#): Fig. 12). All specimens show signs of working by scorching or smoothing, and may have been tools associated with the digging of the pits. They do not provide evidence for the consumption of venison, though the pick had been cut from the head of a killed or scavenged deer carcass rather than naturally shed. Other wild species are also represented: aurochs in pits 93201 and 93205, roe deer in 93233, fox and mustelids in pits 93206 and 93208, a bank vole and small rodents in pits 93206 and 93201, and bird bones in pits 93201 and 93208. The interpretation of the presence of these taxa is not clear. None were necessarily eaten, for example, the aurochs bones are

**Table 3**  
Summary of pig and cattle age at death data from pits at West Amesbury Farm.

93201	93205	93206	93208	93233
<b>Pigs</b>				
● Im (MWS 10)	● Im	○ Young	○ < 12 mths	● Im
● Im (MWS 10)	● SA—Ad	● Im	● SA—Ad	● Ad
● Im		● SA—Ad (MWS 20—30)		
● Ad				
<b>Cattle</b>				
○ Neo	○ Young	● 1–3mths	○ Neo-young	● 1–3mths
○ Older (large mammal)	● > 30mths (prob. 3–6 yrs)	○ Neo/Neo-young	○ > 24mths	● 6–15mths
		○ > 18mths		● 15–26mths

• Dental age data. Follows [Legge \(1992\)](#) for cattle and [O’Connor \(2003\)](#) for pigs. Im – immature; SA – sub-adult; Ad – adult; MWS – Mandible Wear Stage ([Grant, 1982](#)).

○ Post-cranial age data. Follows [Silver \(1969\)](#). Neo – neonate.



**Table 4**  
Isotope sample details and results for cattle and pigs from West Amesbury Farm. Isotope data are reported as per mille (‰).

Sample no./ BoneID	Context	Pit	Tooth	Side	Tooth wear stage & age category	Sr ppm	$^{87}\text{Sr}/^{86}\text{Sr}$	$\delta^{34}\text{S}$	%S	N:S	C:S	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$	%C	%N	C:N
<b>Pig samples</b>																
WAM01/257	93213	93201	M1	Left	b: immature	56.7	0.70793	12.0	0.19	149	507	-22.32	5.02	35.98	12.29	3.4
WAM02/354	93222	93206	M1	Left	g: subadult-adult	126.9	0.70800	10.9	0.20	163	554	-21.34	6.91	40.52	13.88	3.4
WAM03/308	93234	93233	M1	Left	c: immature	83.9	0.70800	11.3	0.20	156	546	-21.95	6.44	40.37	13.47	3.5
WAM04/450	93230	93208	M1	Left	e: subadult-adult	105.7	0.70797	13.2	0.15	174	587	-20.69	6.96	33.82	11.71	3.4
WAM05/410	93242	93205	M1	Left	b: immature	98.8	0.70816	Insufficient collagen for carbon, nitrogen and sulphur analysis								
WAM06/218	91640	93201	M1	Left	b: immature	79.1	0.70779	13.0	0.17	159	553	-22.20	5.97	35.53	11.90	3.5
<b>Cattle samples</b>																
WAM07/281	93236	93233	M2	Left	B (d-f): 15–26 months (stage 5)	197.3	0.70889	12.8	0.16	173	609	-23.94	4.89	36.76	12.16	3.5
WAM08/417	93247	93205	M1	Left	k: probably 3–6 years (stage 7)	145.0	0.70856	13.1	0.16	200	690	-23.34	5.41	40.96	13.88	3.5
WAM09/280	93236	93233	M1	Left	e: 6–15 months (stage 4)	127.6	0.70917	12.3	0.17	173	592	-23.17	5.09	37.09	12.66	3.4

from first and second phalanges, elements with little associated meat, and indeed those smaller taxa in pits 93206 and 93208 may not have been intentionally deposited, as gnaw marks and restricted element distributions are consistent with some having been scavenged by mustelids, or perhaps some were pit-fall victims. Many are small bones which could also have moved through the soil profile, as seen in the cereal remains.

#### 4.3. Determining local animal husbandry

Traditional macroscopic zooarchaeological interpretation uses the presence of neonatal livestock to suggest a producer economy with local husbandry (e.g. Albarella, 2004; O'Connor, 2003, 80). At WAF, remains of young calves were found in each pit. As noted above, bones from neonatal calves were found in two pits (93201 and 93206), with dental data suggesting that calves from pits 93206 and 93233 were around 1–3 months of age (following Legge, 1992: 23; dp4 wear stage b). No neonatal pigs were found, but one piglet from 93206 is likely to have been in the first few weeks or perhaps months of life based on size comparison with neonatal and six-, and ten-month old captive bred wild boar in the HE Zooarchaeology Reference Collection. The presence

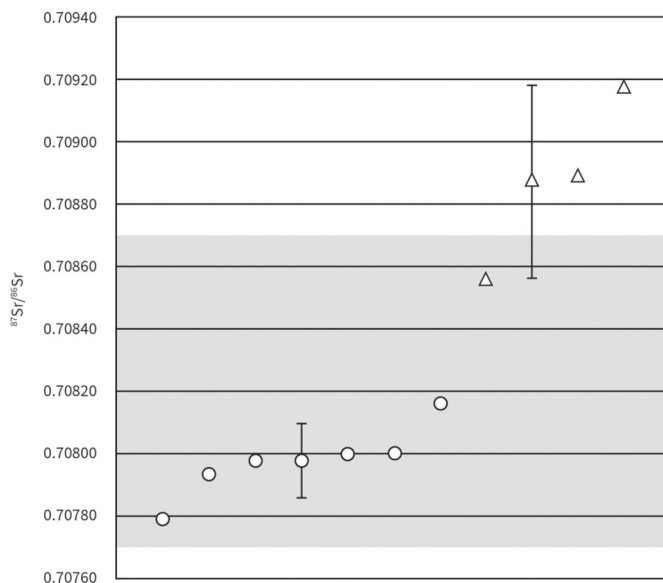
of these young animals suggests that they were either likely to have been raised locally, taken no further than they could be herded at a young age, or transported no further than their carcasses could travel before rotting in the likely absence of large scale salting or smoking (Serjeantson, 2006: 115), though see Schulting (2008: 105) and Loveday and Beamish (2012: 108).

Teeth from three cattle and six pigs were analysed to confirm whether their strontium and sulphur isotope values were consistent with the local environment. Carbon and nitrogen isotope analysis was also conducted, principally to provide quality control indicators for the sulphur isotope data (C:S and N:S ratios), but also as evidence for management strategies. In addition, outliers could be interpreted as animals having been raised in different landscape locations (e.g. Madgwick et al., 2013). All samples complied with collagen quality control criteria for sulphur (C:S ratio of  $600 \pm 300$ ; N:S ratio of  $200 \pm 100$ , Nehlich and Richards, 2009), carbon and nitrogen (C:N ratio of 2.9 to 3.6, DeNiro, 1985) (Table 4).

The  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope results for cattle and pigs are presented in Table 4 and Fig. 4. The six pig samples show a remarkable degree of homogeneity, ranging from 0.7079 to 0.7082 (1sd 0.00012). The three cattle samples are more diverse but still show only limited variation, ranging from 0.7086 to 0.7092 (1sd 0.00031). Although only nine individuals have been analysed, there is no overlap in values between the pigs and cattle. The three cattle have more radiogenic  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope values than all of the six pigs.

The Wessex chalklands represent a relatively well understood lithology in terms of the baseline  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope signal. Evans et al. (2010) documented 31 analyses of plant and dentine samples from chalk lithologies in Britain and designated chalk as between 0.7077 and 0.7087. This estimated local range is supported by the analysis of seven plants from the landscape surrounding Durrington Walls, located < 3 km from West Amesbury.  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope ratios ranged from 0.7077 (Durrington Walls) to 0.7087 (south of Woodhenge) with a mean value of 0.7082 (Viner et al., 2010). Plant samples have been demonstrated to be the most reliable indicator of baseline  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope values and all of those listed by Evans et al. (2010, see also Evans et al., 2018) fall within this range, though most derive from the Viner et al. (2010) dataset. Therefore the local biosphere range is estimated as 0.7077–0.7087.

Sulphur, carbon and nitrogen isotopes were successfully analysed from eight of the nine individuals (Table 4). Sulphur isotope values principally vary in relation to coastal proximity, with values higher than 14‰ being from an area within 50 km of the coast (and probably considerably closer), but there are also landscape/geological drivers of variation (Nehlich, 2015). Like strontium, the sulphur isotope data (plotted against strontium in Fig. 5) also show relatively limited variation (10.9‰ to 13.2‰), especially in the three cattle (12.3‰ to 13.1‰). Sulphur values can vary from -20‰ to +20‰ and have been



**Fig. 4.** Cattle (triangles) and pig (circles)  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope results from West Amesbury Farm, presented in ascending order. Error bars represent one standard deviation and are presented with the mean value for each species. The shaded area of the plot represents the estimated local range (from Evans et al., 2010) (image: Vince Griffin).

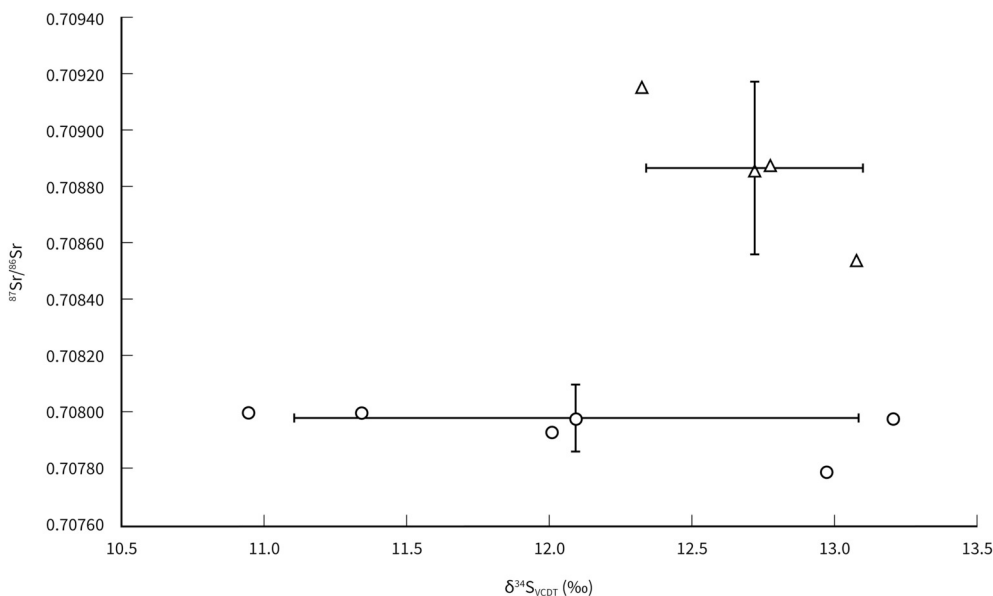


Fig. 5. Sulphur ( $\delta^{34}\text{S}$ ) isotope results plotted against strontium ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) isotope data for pigs (circles) and cattle (triangles). Error bars represent one standard deviation from the mean and are presented with the mean value for each species.

shown to have a wide range from  $-13.5\text{‰}$  to  $+19.6\text{‰}$  in terrestrial mammals in the limited sample that has so far been analysed from Britain (Madgwick et al., 2013; Madgwick et al., 2019; Nehlich et al., 2011). An interactive biosphere map provided by Evans et al. (2018) suggests that all values in the WAF dataset are too high to be local and are more characteristic of an area within c. 20 km of the coast. However, the sulphur biosphere of Britain remains poorly understood and research on sheep wool in Ireland has shown that high values can occur in inland areas (Zazzo et al., 2011). This research also suggests that variation of the order observable in the WAF dataset can occur in animals from the same location. More pertinent is the Early Neolithic faunal data from the Coneybury Anomaly, which is in very close proximity to WAF (Gron et al., 2018). This suggests sulphur values from West Amesbury Farm could be entirely consistent with a local origin. The range is far smaller than in the much larger sample of 86 pigs from nearby Late Neolithic Durrington Walls ( $-1.6$  to  $+19.6$ , Madgwick et al., 2019). The nature of local biosphere variation is unknown. The

sulphur values could therefore potentially be consistent with origins across the broader Wessex chalkland and adjacent lithological zones. Greater, albeit limited, variation in the pigs would be expected in an omnivore taxon which can occupy a broader range of dietary niches, but this does not provide evidence for diverse origins.

The carbon and nitrogen data is of limited interpretative value as larger datasets are required to make confident assertions relating to management regimes. However, as with strontium and sulphur, variation is observable between cattle and pigs (Table 4, Fig. 6). Although the strontium and sulphur results suggest that the animals all derive from the local or regional area, landscape values can vary at a micro-environmental scale (e.g. due to manuring) and therefore variation could result from the different taxa being raised in different zones of the local area. Dietary regimes provide the most likely explanation for the higher nitrogen values in pigs. This is a common feature when comparing pigs to herbivores, though tends to be more marked in later prehistoric periods in Britain (Madgwick et al., 2012b). The higher

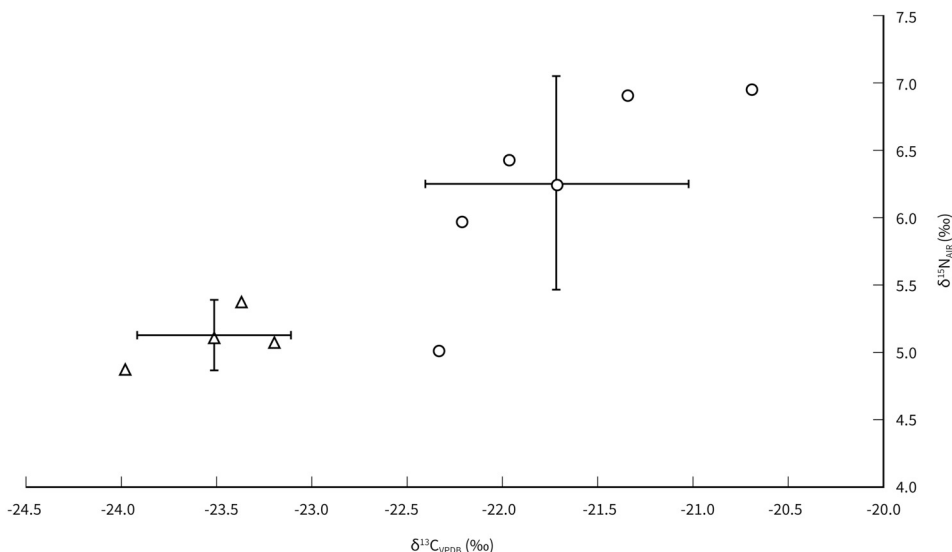


Fig. 6. Carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) isotope data for pigs (circles) and cattle (triangles). Error bars represent one standard deviation from the mean and are presented with the mean value for each species.

nitrogen values are best explained by pigs having some animal protein (e.g. meal scraps, dairy waste or excreta) in their diet. WAM01 is the exception to this, having a nitrogen value in line with cattle results that is consistent with an herbivorous diet. The variation in carbon values amongst the pigs is also likely to relate to the degree of animal protein in feeding, as this also causes a smaller trophic shift in carbon and there appears to be a positive correlation between carbon and nitrogen values (but this has not been statistically tested due to the small sample). The low carbon values indicate there is no evidence for marine input in feeding in either species, whether in the form of seaweed, fish scraps or sea-spray-affected landscapes, further reinforcing the assertion that sulphur values are consistent with an inland zone and could be local. The cattle values cluster tightly and this may indicate that the animals were raised in the same location. The cattle have markedly lower carbon values than the pigs, ranging from 23.2‰ to 23.9‰. These values are lower than nearby cattle from Early Neolithic Coneybury Anomaly (Gron et al., 2018) and Late Bronze Age/Early Iron Age Potterne (Madgwick et al., 2012b). They align more closely to roe deer values from Coneybury Anomaly and this was suggested to result from woodland grazing/browsing (Gron et al., 2018). This is a plausible explanation for the low carbon values and it may be that these animals were raised using woodland resources in areas of the landscape that were yet to be deforested.

The most striking feature of the strontium isotope dataset is the lack of variation. The nine samples have a range of 0.00138. The degree of homogeneity is particularly pronounced in the porcine sample, with the six pigs showing variation of only 0.00037. This restricted range is comparable to the results from analysis of eight cattle and four roe deer from the Early Neolithic site of Coneybury Anomaly (Gron et al., 2018), located in close proximity to WAF. Here the overall variation was 0.00109, with roe deer being particularly homogenous (a range of 0.00021), but all animals consistent with origins on the Wessex chalk. This is again in stark contrast to data from Late Neolithic Durrington Walls, with pigs (0.0092; Madgwick et al., 2019) and cattle (0.0087 [range of intra-tooth means]; Evans et al. in press) having a much greater range. The other key feature of the dataset is the clear division between cattle and pigs, with cattle being more radiogenic in all instances. Given the limited variation across the dataset, the division between cattle and pigs can be considered quite marked. However, in a dataset of only nine samples and three cattle, caution must be exercised in interpretation and this pattern could result from chance sampling. The difference may relate to feeding practices rather than mobility. Pigs can forage for food by rooting in the soil, ingesting buried mast, fungi or invertebrates. In doing so, they may consume quantities of local sediment. Therefore their biogenic  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope values might be expected to be closer to those of the local lithology than herbivore grazers such as cattle. This explanation is speculative and there may be other reasons relating to metabolism or management. The small range in pig values suggests that the animals were raised on fodder from a restricted area. It is possible that their movement was more limited than cattle, which are more likely to have been moved to exploit different areas of pasturage. Equifinality remains a substantial hurdle to interpretation and therefore the aetiology of this difference remains uncertain.

Results indicate that the fauna deposited at West Amesbury are generally consistent with being locally raised. Only two cattle (WAM07; 0.70889 and WAM09; 0.70917) are outliers but do not provide strong evidence for an allocthonous origin, as both could be produced by grazing in adjacent lithological zones (< 15 km from WAF). The limited sulphur range is also consistent with local origins and carbon and nitrogen values suggest that animals were not being managed in landscapes with diverse baseline values. Therefore, there is no evidence that these animals were brought from a substantial distance away. Strontium isotope data is useful for establishing non-local origins but cannot be used to confidently address whether these individuals were locally raised. Although higher resolution biosphere mapping of the UK is needed, Evans et al. (2010, 2018) suggest that large areas of southern

and eastern England could produce values in the range 0.708–0.709. Therefore, while the animals are consistent with local origin, it is possible that some of these animals could derive from further afield. Similarly, the mid-ranging sulphur values provide little assistance in refining origins, as limited biosphere and archaeological data suggests these values can be attained across large areas of the UK. Therefore local origins provide the most parsimonious interpretation, with cattle being raised in nearby woodland and pigs being raised on an omnivorous diet.

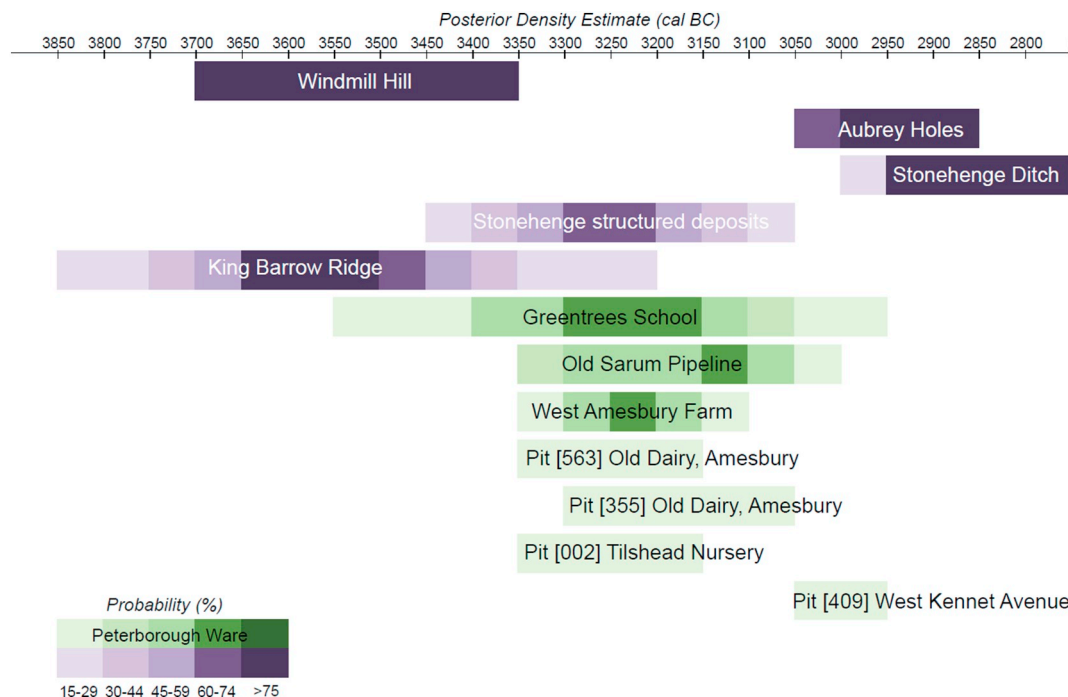
#### 4.4. Bioarchaeological evidence from other Wiltshire Peterborough Ware pits

Our resource survey identified 14 excavated sites in Wiltshire, consisting of a total of 47 Middle Neolithic (Peterborough Ware) pits, including those from WAF. Two sites are within the immediate vicinity of West Amesbury: Kings Gate (Wessex Archaeology, 2014a) and Old Dairy Amesbury (Harding and Stoodley, 2017). A group of eight sites lie approximately 8–12 km to the south: Beehive (Heaton et al., 2003), Bishopsdown Farm (Wessex Archaeology, 2014b), Greentrees School (Wessex Archaeology, 2015b), Harnham Road (Context One Archaeological Services Ltd, 2008), North of Old Sarum (Algar and Hadley, 1973, bones identified by Worley for this paper), Old Sarum Airfield (Wessex Archaeology, 2015a), Old Sarum Spur and The Portway (Old Sarum Pipeline; Knight, 2004; Powell et al., 2005) (see Fig. 1). The final three sites are Tilshead Nursery School (Amadio, 2010), 12 km to the north east of the West Amesbury pits, and West Kennet Avenue (Allen and Davis, 2009) and Overton Down (Smith and Simpson, 1964), just < 30 km to the north. Some of the sites are currently progressing through post-excavation analysis.<sup>3</sup> Where radiocarbon dated, these sites are all broadly contemporary with the West Amesbury Farm pit group (Fig. 7), and the curated deposits of Middle Neolithic animal bones found within the Stonehenge ditch (Cleal et al., 1995, for example page 449). The pit sites fall chronologically between primary phase activity at Windmill Hill and the earliest cremated individuals in the Aubrey holes (see Fig. 7).

Hazelnut shell was recovered from all pits (with the exception of The Portway 6100, for which botanical finds were not reported, and one of the Beehive pits). Hazelnut shell forms the most substantial component of the botanical assemblages from all sites (Table 5). The quantity of nutshell fragments is, however, variable. Unfortunately reports (and particularly unpublished assessment reports) do not always explicitly state whether the figures cited include nutshells from sample residues, which can inflate the figures substantially, or only those from flots. The greatest abundance was recorded from a pit at The Portway, which contained a layer of > 10,000 hazelnut shell and kernel fragments, which had been carefully placed at the base of the pit over the primary weathering fill (Powell et al., 2005, 258). A number of lithics were incorporated within the nutshell layer and a young male cattle horncore had been placed on its surface. The subsequent fill contained further hazelnut shell, a wild apple pip (*Malus cf. sylvestris*) and further finds including pig bones. The presence of hazelnut kernel fragments would imply at least some whole nuts were included in the deposit. A single elder seed was the only other potentially edible wild food plant recorded, found in another pit at the same site.

Likely intrusive cereal remains of mixed origin were present in pits at five of the sites including pits producing large quantities of hazelnut shell. Taxa identified were usually barley (*Hordeum vulgare*) and free-threshing wheat (*Triticum aestivum/turgidum*). Hulled wheat (*Triticum spelta/dicoccum*) was present in pits at Old Dairy, Old Sarum Airfield, Old Sarum Spur and The Portway; hulled wheat grain from The Portway included positively identified emmer (*Triticum dicoccum*).

<sup>3</sup> The authors are grateful to Wessex Archaeology for access to unpublished assessment level site reports.



**Fig. 7.** Schematic diagram showing the periods of use of dated Neolithic activity in the fourth and third millennia cal BC, highlighting Peterborough Ware pits. The cremation deposits in the Aubrey Holes and structured deposits in the Stonehenge ditch are also shown, together with the date of construction of the ditch at Stonehenge. The King Barrow Ridge data derives from two pits which produced Early and Late Neolithic dates. For individual dated pits, rather than showing their period of use the diagram shows their likely date. Old Sarum Pipeline includes material from Old Sarum Spur and The Portway. (image: Peter Marshall)

Grain dated from the primary fills of pits at The Portway (three *Triticum* sp. grains) and Old Dairy (one barley and one wheat grain) were demonstrated to be intrusive (see Supplementary Information SI.2), while the cereals from other sites have not yet been directly dated.

Seeds of wild herbaceous taxa are present in samples from most pit groups, generally in small numbers, and include seeds from plants of grassland or disturbed habitats including cultivation plots, or more broad habitats. Occasional rhizomes and tubers of grasses, including those of false oat grass (*Arrhenatherum elatius*) could derive from burnt turves or pulled grasses. Weed seeds may have been incorporated in fires, or given the presence of intrusive cereal remains, may represent weeds of more recent arable fields which have also worked their way through the soil profile. Particularly notable numbers of seeds were recovered from the Beehive (Heaton et al., 2003), the majority of which were of fat hen (*Chenopodium album*, 61 seeds) and docks or possible docks (*Rumex* sp., 40 seeds). The presence of a seed of corn cockle (*Agrostemma githago*), a Late Iron Age or Roman introduction to the British Isles (Preston et al., 2004), warns of the potential for recent contamination in the Beehive pits. Fat hen seeds are usually black or dark brown when fresh and are often difficult to distinguish from charred seeds. Caches of such large numbers of single species are unusual and could well represent more recent rodent hoards (likely intrusive rodent bones were recovered from one of the Beehive pits). It should also be considered that fat hen and several species of docks are edible, although the leafy parts tend to be eaten rather than the seeds.

Turning to the zooarchaeological evidence, animal bones were recovered from the majority of pits and together with the WAF finds more than double the NISP of the Middle Neolithic dataset reviewed by Serjeantson (2011). The NISP from the WAF pits is much higher than that from most other sites. The pit assemblages have a restricted and consequently fairly consistent range of species present. Like at WAF, when considered through NISP, pigs most often dominate the bone assemblages (15 records representing ten sites), with cattle more frequent in only three pits, two of which note cattle bones as only the only

osteological finds. The suite of domestic livestock included sheep/goat, a taxon absent from West Amesbury Farm, at eight sites (Table 5). Almost half the comparative sites are currently reported only to assessment level and therefore provide limited detail needed to consider evidence for Middle Neolithic utilisation of domestic species across the county dataset. However, age data for pigs suggests the culling of skeletally immature animals in most instances: a neonatal piglet and an older individual at Tilshead Nursery (Worley, 2017a), a neonate and juvenile pigs at Bishopdown Farm (Wessex Archaeology, 2014b), pigs around a year old or younger at The Portway and Old Sarum Spur (Knight, 2004; Powell et al., 2005), immature pigs at Old Sarum Airfield (Wessex Archaeology, 2015a), and two subadults at Old Dairy (Higbee, 2017). Assuming multiple farrowing wasn't practiced, the presence of neonatal pigs indicates animals which died in spring and the juveniles likely died within the first six months of life, therefore April to October (following Wright et al., 2014) the data are insufficient to suggest season of death for other pigs. Cattle age at death data are more scarce, and do not include any calves; adults at West Kennet Avenue (Grimm, 2009), and mainly mature cattle at The Portway and Old Sarum Spur (Knight, 2004; Powell et al., 2005).

Several site reports note that the surface condition of bones may have hindered the identification of cut marks. Nevertheless, marks interpreted as disarticulation of pig and cattle carcasses, of filleting pork from vertebrae and of marrow fracturing cattle bones are reported at sites on the Old Sarum Pipeline (Old Sarum Spur or The Portway; Knight, 2004). At Tilshead disarticulation and filleting cut marks were recorded on sheep bones, though their contextual security is doubted (Worley, 2017a). Tilshead also included a pig mandible with similar cut marks to those at WAF, as did one of at least four pigs found in a Grooved Ware pit (pit 418) from King Barrow Ridge (Maltby, 1990b, 122).

Wild taxa present in pits across the county show a similar range of species to those at WAF. Like three of the West Amesbury Farm pits, 14 records include deposition of antlers, in many cases tools. However,



**Table 5**

Taxonomic representation in Wiltshire Middle Neolithic pits, including summary data from West Amesbury Farm. Data are NISP, with antler quantified separately in parentheses. Where raw counts were not given the following abundance codes are used: faunal remains × × dominant; × present; botanical remains +1-5, ++ 6-25; +++ 26-100; ++++ > 100. \*dated grain (botanical remains from The Portway pit 6100 were not reported in Powell et al., 2005, but a single *Triticum* grain was later dated (see Supplementary Information SI.2).

Site	Pit	Faunal data											Archaeobotanical data										
		Pig	Cattle	Aurochs	Sheep/ goat	Dog	Red deer	Roe deer	Large mammal	Medium mammal	Small rodent/shrew	Sample volume (l)	Hazelnut shell fragments	Hazelnut kernel fragments	Crab apple (seed)	Elder seed	Grass rhizome/tubers	Large grass/cereal culm node	Seeds of wild taxa	Cereal grain/ chaff*	Cultivated pulses*		
Beehive	502	1	-	-	-	-	-	-	-	-	-	?	116	-	-	-	-	-	88	-	-		
	509	-	-	-	-	-	-	-	-	8+ <sup>b</sup>	-	?	-	-	-	-	-	-	14	-	-		
	512	1	-	-	-	-	-	-	-	-	-	?	4	-	-	-	-	-	702	-	-		
	7 pits	× ×	×	-	-	1(4)	-	-	-	-	-	n/a data presented by pit	-	-	-	-	-	-	-	-	-		
	814	Data not available by pit	-	-	-	-	-	-	-	-	-	43	+++	-	-	-	-	-	-	-	-		
	981	Data not available by pit	-	-	-	-	-	-	-	-	-	3	++	-	-	-	-	-	-	-	-		
	6 pits	17	10	2	7	-	2(1)	-	-	-	-	n/a data presented by pit	-	-	-	-	-	-	-	-	-		
	602/1010	Data not available by pit	-	-	-	-	-	-	-	-	-	?	+++	-	-	-	-	-	-	-	-		
	1060	Data not available by pit	-	-	-	-	-	-	-	-	-	44	++++	-	-	-	-	-	-	-	-		
	1069	Data not available by pit	-	-	-	-	-	-	-	-	-	38	+++	-	-	-	-	-	-	-	-		
1071	Data not available by pit	-	-	-	-	-	-	-	-	-	40	+++	-	-	-	-	-	-	-	-			
1086	Data not available by pit	-	-	-	-	-	-	-	-	-	22	+	-	-	-	-	-	-	1	1			
Harnham Road Water Supply	5008	20	10	-	-	-	-	20	21	-	172	10-30	-	-	-	-	-	-	+	-	-		
	5032	17	8	1	2	-	2(1)	11	9	-	95	10-30	-	-	-	-	-	-	-	-			
	61779	6	3	5	5	1 <sup>c</sup>	-	1	7	-	40	++++	-	-	-	-	-	-	-	-			
	61783	-	1	-	2	-	2 <sup>c</sup>	4	7	-	No data available	-	-	-	-	-	-	-	-	-			
	61790	-	-	-	-	-	-	-	-	-	40	++	-	-	-	-	-	-	1	-			
	61796 <sup>d</sup>	-	-	-	-	-	-	-	-	-	40	+++	-	-	-	-	-	-	-	-			
	61798 <sup>d</sup>	-	-	-	-	-	-	-	-	-	40	++	-	-	-	-	-	-	-	-			
	No number	1	1	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-			
	563	×	-	-	-	-	-	-	-	-	110	3046	-	-	-	-	-	-	10	32*	-		
	1816	9+	3	-	-	-	1(3)	-	-	-	319	+++	-	-	-	-	-	-	-	5	-		
Old Dairy	1840	3	-	-	-	(1)	-	-	-	-	58	+++	-	-	-	-	-	-	-	2	-		
	3119	22	1	-	3	-	-	-	-	-	30	19	-	-	-	-	-	-	-	8	-		
	3005	5	-	-	-	-	-	-	-	-	?	50	-	-	-	-	-	-	-	-	-		
	3020	19	1	-	-	-	-	-	-	-	No data available	-	-	-	-	-	-	-	-	-			
	3000	-	1	-	-	(2)	-	-	-	-	45	114	-	-	-	-	1	1	2	8	1		
	3007	-	7	-	-	-	-	-	-	-	60	639	-	-	-	-	-	-	9	-	-		
	3197	Unidentifiable animal bone only	-	-	-	-	-	-	-	-	No data available	-	-	-	-	-	-	-	-	-	-		
	No number	×	×	×	×	×	×	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	6056	3	1	-	1	-	(21)	-	-	-	-	30	478	-	-	-	-	-	-	25	2*		
	Overton Down The Portway	6061	4	1	-	-	-	-	-	-	2	50	13,652	60	1	-	2	-	-	29	5*	-	
6065		3	1	-	-	(1 <sup>e</sup> )	-	-	-	-	?	5	-	-	-	-	-	-	-	-			
6076		-	-	-	-	(1)	-	-	-	-	?	200	-	-	-	-	-	-	-	-			
6093		-	-	-	-	(3)	-	-	-	-	20	196	-	-	-	-	-	-	-	-			
6100		1	1	-	-	(6)	-	-	-	-	No data available*	-	-	-	-	-	-	-	1	3			
1 & 2		22	-	-	6 <sup>f</sup>	(×)	-	-	4	-	?	600	-	-	-	-	-	-	-	-			

(continued on next page)

Table 5 (continued)

Site	Pit	Faunal data										Archaeobotanical data									
		Pig	Cattle	Aurochs	Sheep/ goat	Dog	Red deer	Roe deer	Large mammal	Medium mammal	Small rodent/ shrew	Sample volume (l)	Hazelnut shell fragments	Hazelnut kernel fragments	Crab apple (seed)	Elder seed	Grass rhizome/ tubers	Large grass/ cereal culm node	Seeds of wild taxa	Cereal grain/ chaff <sup>a</sup>	Cultivated pulses <sup>b</sup>
West Amesbury Farm <sup>c</sup>	93201	71	3	1	1	–	–	–	4	4	2	290	36	–	1	–	–	–	15	1	
	93205	11	5	1	–	–	–	1	–	–	–	175	634	–	–	–	–	–	8	–	
	93206	56	11	–	–	1	–	1	4	4	1	420	554	–	–	–	–	38	1		
	93208	35	13	–	–	–	–	–	7	7	–	300	163	–	–	–	–	–	27	–	
West Kennett Avenue	93233	12	21	–	–	–	1	5	1	1	260	274	–	–	1	–	–	7	2		
	409	–	3	–	–	–	–	–	–	–	80	309	–	–	–	–	–	1	–		

<sup>a</sup> Includes probable intrusive material.

<sup>b</sup> Small mammal (vole and shrew) preservation relatively well good while general bone preservation in pits was very poor.

<sup>c</sup> Report doesn't specify whether specimens are antler or other elements.

<sup>d</sup> Bone noted as present but not included in assessment.

<sup>e</sup> Species not specified.

<sup>f</sup> Worley (2017a) doubts the Neolithic date of the sheep bones, one bone is sheep/deer.

<sup>g</sup> West Amesbury Farm pits 93206 and 93208 also contained fox and mustelid remains, and pits 93201 and 93208 also contained bird remains (see Table 2).

post-cranial red deer bones were also present at Old Sarum Airfield (Wessex Archaeology, 2015a), Harnham Road (Context One Archaeological Services Ltd, 2008) and Greentrees School (Wessex Archaeology, 2015b), and a bone at the latter site had been scorched and fractured for bone marrow, providing the only strong evidence for consumption of game in the dataset. Single or paired aurochs horncores were identified in Middle Neolithic pits at Bishopsdown Farm (Wessex Archaeology, 2014b) and Greentrees School (Wessex Archaeology, 2015b). Finally, rodent bones from The Portway and the Beehive were interpreted as potentially intrusive or contemporary pit fall victims (Heaton et al., 2003; Knight, 2004), with evidence of erosion in The Portway pit 6061 also suggesting that it had been open for a period prior to deposition.

## 5. Discussion

### 5.1. Middle Neolithic evidence for pastoral, but not arable production

The absence of cultivated plants from Middle Neolithic pit sites in and around the Stonehenge World Heritage site is consistent with the hypothesis that the reduction in cereal cultivation and greater reliance on collected plants witnessed across southern England in the later part of the Neolithic began in the Middle Neolithic. The zooarchaeological evidence from these sites greatly increases the Middle Neolithic dataset in the county and in doing so challenges previous conclusions regarding relative importance of species, demonstrating that the shift away from cereal cultivation may be concurrent with, rather than earlier than, an increase in the proportion of deposited pig bones relative to cattle.

#### 5.1.1. Interpreting the faunal economy

The zooarchaeological assemblages include the remains of domestic livestock (predominantly cattle and pigs), many directly radiocarbon dated to the Middle Neolithic period. It is clear from butchery marks that cattle and pig carcasses were processed (dismembered, portioned, meat filleted and long bones fractured), so we can suggest that pork and beef production was a significant motivator for husbandry. Pigs provide few resources other than meat and the presence of immature pigs in each pit at WAF is consistent with slaughter around the time of their first winter, before their body condition deteriorates, as seen at Late Neolithic Durrington Walls (see discussions in Ervynck, 2005; Wright et al., 2014). Winter slaughter is not evident at all sites in Wiltshire. While some neonatal pigs may represent natural deaths rather than slaughter, pigs may also have been killed and consumed at other times of year. Evidence that pork made a significant contribution to Middle Neolithic human diets is also tentatively offered by isotopic analysis of the human remains from WAF (Mays et al., 2018).

The sparse age at death data available for cattle at sites other than WAF suggests culling of adult animals. Though only a small assemblage, the age at death of cattle at WAF is not inconsistent with what might be expected of slaughter related to dairy utilisation. Zooarchaeological evidence for dairy economies relies on a model that sees the majority of male calves slaughtered with only small numbers of bulls kept for breeding, and herds of dairy producing cows killed only once they become less productive (see discussion of calf mortality and dairying in Gillis et al., 2016; Vigne and Helmer, 2007). In dairy herds calves may be killed as newborns, in the first weeks of life, or around the time of weaning or cessation of lactation (c. 6–9 months); European Early and Middle Neolithic examples of older and younger slaughter strategies are presented in Vigne and Helmer (2007). Utilisation of dairy products in the Early, Middle and Late Neolithic in England is corroborated from lipid analysis on pottery (Copley et al., 2003; Copley et al., 2005; Craig et al., 2015), and indeed Peterborough Ware pottery from the WAF pits has been found to have residues from ruminant dairy lipids (Roberts et al., in preparation). Proteomic analysis has the potential to provide direct evidence of dairy products in human dental calculus and a study of the WAF Middle Neolithic inhumation has demonstrated the

presence of cattle dairy proteins (Mays et al., 2018), further corroborating an interpretation of local Middle Neolithic cattle husbandry providing dairy as well as meat.

Managed domestic cattle may have their breeding cycle controlled to provide the best chance of calf survival through spring births, or to provide extended periods of milk availability through staggered births (see historical examples in Towers et al., 2017, 50–1). Late born calves would have less chance to gain body weight before the harsher winter months when vegetation is less abundant and of poorer quality. Studies of sheep populations have shown large seasonal drops in live weight over the winter months, and that animals on native grassland and without supplementary fodder have more restricted growth than those on improved grasslands (Worley et al., 2016); the same may be expected for other species. Late born calves may therefore have required supplementary feed over the winter, which in the likely absence of a local arable economy would pose more of a challenge in the Middle and Late Neolithic than the Early Neolithic or later periods, but could have been sourced from woodland resources. In Middle Neolithic areas around the Stonehenge WHS at least, the use of spent grain as fodder proposed by Dineley (2006) would not have been viable. Assuming that the cattle and pigs recovered from each pit at WAF were killed at around the same time, the pig tooth wear data ties slaughter to the autumn or winter months. If cattle breeding was controlled to provide dairy for an extended period, this seasonal slaughter would be represented by calves of various ages, c. 6–9 months old for those born in spring and younger for those born later in the year. A range of ages would similarly be expected if dairy calves born over an extended period were slaughtered at the same time for some other social or political event. Though a small dataset, the WAF calf mortality data are consistent with these models.

The age at death evidence from West Amesbury Farm suggests that the domestic animals were raised locally, but this hypothesis was tested using isotopic analysis which found a strikingly narrow range of values, consistent with the local chalk biosphere. Strontium isotope studies on fauna remain relatively rare, and there are no comparative studies with which to assess whether the finding of a tight cluster of values is typical for the Middle Neolithic in southern England. With the exception of the closely located Early Neolithic site of Coneybury Anomaly (Gron et al., 2018), this range of results is markedly smaller than in any other study of British fauna that has at least five individuals of one taxon (see Gan et al., 2018; Hughes et al., 2018; Madgwick et al., 2017; Madgwick and Mulville, 2015; Madgwick et al., 2012a; Minniti et al., 2014; Towers et al., 2011; Towers et al., 2017; Towers et al., 2010; Viner et al., 2010). Faunal sulphur isotope studies are even rarer, but the range at WAF is smaller than other British sites (Gron et al., 2018; Nehlich et al., 2011; Towers et al., 2011), suggesting limited movement and local origins. The data are also comparable to locally-interpreted cattle from the nearby Coneybury Anomaly (Gron et al., 2018). Overall, the West Amesbury assemblage is best interpreted as the consumption of locally raised animals.

### 5.1.2. Interpreting the botanical remains

Plant utilisation in Middle Neolithic Wiltshire appears to have been dominated by wild taxa, and especially hazelnut remains. This conforms to Middle Neolithic evidence from across southern England. While it is true that cereal remains might be less well represented than hazelnut shell due to differences in processing and preservation, in southern England the contrast between the Early Neolithic, for which we have a number of large directly dated cereal grain assemblages, and Middle and Late Neolithic features, in which grain is only ever present in small numbers and almost entirely intrusive, is striking. Some evidence for arable cultivation does, however, exist elsewhere in the British Isles during the Middle and Late Neolithic, particularly from Orkney and other areas of coastal Scotland (Bishop, 2015a, b; Bishop et al., 2009), the Blackwater Estuary, Essex (Wilkinson et al., 2012: 85), and from Clifton, Worcestershire (Mann and Jackson, 2018). Locally, a

single grain of barley from a Late Neolithic Grooved Ware pit at Bulford South (pit 5228; Wessex Archaeology, 2015c), unexpectedly returned a Middle Neolithic date of 3370–3020 cal BC (UBA-34499, 4505 ± 41 BP) (Supplementary Information SI.2). The analysis of dental calculus from the Middle Neolithic burial at WAF has produced starch grains including ten grains of the Triticeae tribe of grasses and eight grains of the Fabae sub-group of the Fabaceae (legume family) (Mays et al., 2018). The Triticeae tribe includes the cultivated wheat and barley cereals, but also wild taxa including wild barley and wood barley (*Hodelymus europaeus*), while the Fabae tribe includes vetches (*Vicia* spp.) and peas/vetchlings (*Lathyrus* spp.) as well as cultivated pulses (Stace, 1997). Starch is present both in the seeds and in some roots. The starch evidence, while potentially derived from wild plants, raises the possibility that the consumption of cultivated cereals and pulses, as food or drink, was taking place, possibly imported from elsewhere as grain or processed malt cakes, or cultivated locally on a scale too small to be archaeologically visible. Cultivated pulses have not yet been securely recorded from the British Isles prior to the Middle Bronze Age (Treasure and Church, 2017), thus any claims that the starch grains provide evidence for cultivated legume consumption must be tentative. Some wild leguminous taxa are edible although require considerable processing to remove toxins.

The significance of hazelnut in the Neolithic diet is difficult to establish, although they were clearly of importance. They can be consumed as whole nuts or ground as flour, and they also provide a storable winter feed for pigs (potentially causing elevated  $\delta^{13}\text{C}$  values, see Hamilton et al., 2009). The analysis of dental calculus from the WAF Middle Neolithic burial provided evidence for the human consumption of hazelnuts, with the recovery of epidermal cells of the spermoderm (Mays et al., 2018).

Hazelnuts are best stored in their shells and need to be kept dry and warm. Roasting is not necessary but may have been used to aid storage, although if burnt the nuts become inedible. The burnt nutshell fragments are indicative of discard of the waste product, and where large numbers occur it would suggest a relatively substantial processing episode. The regular inclusion of hazelnut shell fragments amongst the other every day material that was seemingly deliberately selected and placed in Peterborough Ware pits, suggests they were an important element of the pit filling process. The extraordinary hazelnut layer in a pit at The Portway, while potentially the result of a roasting or drying accident, appears to represent a carefully placed deposit either of particular significance in itself or perhaps as a readily available waste material with which to form a bed on which to place other, potentially more meaningful, objects. It is difficult to establish if hazelnut shells are over represented within the pit fills compared to other wild foods because they have been deliberately selected, or because of survival and taphonomic processes (they survive charring particularly well and may be burnt as a waste product), or a combination of both.

It is unlikely that the only wild plant food consumed by the Middle Neolithic population of Wiltshire was hazelnut, and a far more diverse plant based diet than indicated is possible. The presence of a crab apple seed at The Portway (Powell et al., 2005) hints at least at some exploitation of wild fruits, even if they are not immediately readily edible. The presence of Pomoideae charcoal, which includes apple, pear, hawthorn and rowan (the charcoal of this group of trees is not identifiable to genus) at West Amesbury indicates the likely availability of fruits locally. Bast fibres were found within human dental calculus at WAF (Mays et al., 2018); these point towards the working of herbaceous plants, such as nettle for fibre, although nettle and other archaeologically less visible leafy plants could also have been eaten.

## 6. Conclusions

This paper sought to address three primary questions based on the material recovered from WAF and pit sites in the wider area. Firstly we sought evidence for animal and plant based foods in the Middle

Neolithic in and around the Stonehenge World Heritage Site. Our data have demonstrated an animal protein component of the diet including pork, beef, bone marrow and dairy, the latter confirmed by absorbed residues recovered from accompanying pottery assemblages and proteomic evidence for cattle dairy proteins in human dental calculus from WAF, and the consumption of pork being consistent with tentative interpretation of dietary isotope evidence from the human remains (Mays et al., 2018). There is no strong evidence for a hunted meat dietary component at WAF, but this is not the case at all Peterborough Ware pit sites examined, and particularly Greentrees School, where a red deer bone had been processed for bone marrow (Wessex Archaeology, 2015b). Where found, post-cranial bones of wild taxa are never more prevalent than those of domestic species. Plant-based foods are more elusive in the pit fills, and conclusive evidence for domestic cereal crops is absent. Burnt hazelnut shells are relatively common, and presumably derive from human food preparation waste, as corroborated by remains in the human dental calculus at WAF, though hazelnuts may have also been valued as a source of stored winter fodder. Other less archaeologically visible wild plant foods are likely to have also contributed to human diets such as nettle, fat hen or sorrel, as well as fruits and nuts. The bioarchaeological remains therefore corroborate some previous conclusions regarding Middle Neolithic diets in the region, suggesting a dramatically greater reliance on pastoral rather than mixed farming systems than had been the case in the Early Neolithic, the consumption of pork, beef and milk products, and a greater reliance on wild plant foods, particularly hazelnuts, rather than cereals or pulses (for example, Copley et al., 2005; Serjeantson, 2011; Stevens and Fuller, 2012). However, our data also suggests that the relative importance of pork as opposed to beef (as represented by numbers of bone fragments, rather than meat weight or minimum numbers of individuals slaughtered) was higher in the Middle Neolithic than previously thought. The change to pig dominated assemblages had previously been attributed to the Late Neolithic (e.g. Serjeantson, 2011).

Turning to our second question, the bioarchaeological remains from the pit fills at WAF and across Wiltshire provide no evidence for a contemporary arable economy in the local landscape, but suggest that pig and cattle herding was practised, with the strontium isotopes from the WAF animals' teeth consistent with local values. Variation in practice (or at least deposition) is suggested by the additional presence of sheep/goat bones at some sites. Evidence of dairy production and use, together with birthing cycles of modern and historic feral cattle herds (for example, see discussions in Gron et al., 2015; Towers et al., 2017) raise the possibility that the community staggered the breeding of their cows to provide an extended period of milk production. However, incremental isotope analysis of dental enamel would be required to investigate this. Both the cattle and pig herds would begin to lose condition as the quality of their forage decreased and the weather deteriorated through winter. Perhaps in the preceding weeks or once winter had arrived, young animals not needed for breeding the following year, along with some older individuals, would be slaughtered, an interpretation supported by pig mandibular tooth wear at WAF. Some pit sites with evidence for younger pigs show that slaughter and pit-filling was not consistently limited to the winter months across Wiltshire.

Finally, we sought to investigate evidence for the activities associated with the pit-filling on the West Amesbury hillside and across the wider landscape. The Peterborough Ware pits all show similar patterns of animal and plant deposition and suggest that animals were killed and deposited a few at a time. The resulting meat would nevertheless have been sufficient to feed a large group of people, for example a 14 month old female wild boar may produce around 38 kg of meat (derived from weights in Rowley-Conwy et al., 2002). The assemblages are therefore most likely the result of community activities, and could perhaps be described as small-scale feasting (as concluded by Serjeantson, 2011 for Late Neolithic pit assemblages). Carcasses were processed using fine bladed tools, perhaps including some of the flints also recovered from

the pits. The carcass processing routine included butchering the pig heads, filleting meat and smashing long bones to retrieve the bone marrow, particularly cattle bones. Though it is at least partly functional and therefore may be undertaken in diverse cultural traditions, the occurrence of consistently placed butchery marks on pig mandibles in two of the four pits at WAF and in two further pit assemblages (Tilshhead and a King Barrow Ridge Late Neolithic pit) suggests that this action was part of the Middle-Late Neolithic butchery routine, and indeed that a standardised butchery tradition may have been followed. Some bones and teeth would be used to make artefacts (the small number of worked bones recovered from WAF are reported in Worley, 2017b), and the skins and sinew would probably similarly be utilised. The entire carcasses were not processed and discarded in one place. Some butchery portions were taken elsewhere, perhaps traded, or further prepared at a different location, or deposited in other pits on the hillside or further afield. Waste bones and partially processed carcass parts were sometimes first burnt before being separated from the majority of the fire debris and then dumped into one or more pits, with a handful or more of burnt hazelnut shells and broken Peterborough Ware pottery, some of which had been used to prepare or store meat and milk. Other bones and probably defleshed carcass parts were deposited into the bottom of the pits without being burnt. The deposits were covered relatively quickly, preventing scavenging from wild animals or perhaps domestic dogs.

The pits excavated at WAF represent only a very small proportion of those likely to be present on the hillside (Linford et al., 2015; Roberts et al., in preparation) and the distribution of contemporary pits across the wider area is similarly likely to be underestimated and largely related to the location of modern development and associated fieldwork projects. Known clusters of Middle Neolithic pits are located within walking distance of each other, such as those distributed around modern Amesbury, or to the north of Salisbury. Perhaps such sites were returned to time after time and on those occasions when it was appropriate, another one or two pits would be used to deposit select cultural materials – often the remains of slaughtered animals, Peterborough Ware pottery, burnt hazelnut shell, and antlers – before being backfilled. At WAF this activity often took place in autumn or winter, but was not limited to this time of year at all excavated sites. Perhaps some pits were filled following seasonal culls of the local community's animals, but elsewhere the activity reflected other events. Currently too few pits have been excavated, and too few in depth analyses conducted, to investigate whether patterns can be discerned from materials deposited in the pits, perhaps associated with different groups of farmers, times of year or landscape locations, but these aspects should be considered for future investigation. In particular careful analysis of the distribution of butchery marks and further isotopic studies may hold potential for examining inter-site variation or consistency in practice. It is also vital that any future consideration of Middle Neolithic arable agriculture be verified with direct radiocarbon dating.

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## Declarations of interest

None.

## Appendix A. Supplementary Information

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jasrep.2019.05.003>.

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