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Agricultural innovations at a Late Iron Age oppidum: Archaeobotanical evidence for flax, food and fodder from Calleva Atrebatum, UK

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ABSTRACT

The development of oppida in the late first millennium BC across north-western Europe represents a major change in settlement form and social organisation. The construction of extensive earthwork systems, the presence of nucleated settlement areas, long-distance trade links and the development of hierarchical societies have been evidenced. These imply that changes in the style and organisation of agriculture would have been required to support these proto-urban population centres. Hypotheses of the subsistence bases of these settlements, ranging from a reliance on surplus arable production from local rural settlements, to an emphasis on pastoral activities, are here reviewed and grounded against a wider understanding of the expansion of agriculture in the Late Iron Age. These agricultural models have not been previously evaluated.

This paper presents archaeobotanical data from six well fills from large-scale excavations at Late Iron Age and Early Roman Silchester, a Late Iron Age territorial oppidum and subsequent Roman civitas capital located in central-southern Britain. This is the first large-scale study of waterlogged plant macrofossils from within a settlement area of an oppidum. Waterlogged plant macrofossils were studied from a series of wells within the settlement. An assessment of taphonomy, considering stratigraphic and contextual information, is reported, followed by an analysis of the diverse assemblages of the plant remains through univariate analysis. Key results evidence animal stabling, flax cultivation, hay meadow management and the use of heathland resources. The staple crops cultivated and consumed at Late Iron Age and Early Roman Silchester are consistent with those cultivated in the wider region, whilst a range of imported fruits and flavourings were also present. The adoption of new oil crops and new grassland management shows that agricultural innovations were associated with foddering for animals rather than providing food for the proto-urban population. The evidence from Silchester is compared with other archaeobotanical datasets from oppida in Europe in order to identify key trends in agricultural change.

1. Introduction

A major change in the character and organisation of settlement occurred at the end of the first millennium BC in north-west Europe with the emergence of oppida (Collis, 1984). Although the urban status of oppida has been extensively debated (Woolf, 1993), these sites mark a clear change in the organisation of daily life for their inhabitants. Evidence for, or the lack of, agricultural activity at settlements has long been used as key criterion in their urban classification (Childe, 1950; Weber, 1958; Finley, 1981), but today a wide range of variation has been recognised in the type of agricultural activities undertaken at urban centres (Cowgill, 2004, p. 540). Nevertheless, an understanding of the range and scale of agricultural practices undertaken at oppida will elucidate how these settlements emerged in the last few centuries before Roman expansion, as well as the social structure of the groups that inhabited them. Oppida developed in central and western Europe from the 2nd century BC (Collis, 2000; Moore et al., 2013). A wide range of settlement forms are now recognised, from fortified hilltop settlements to large, lowland agglomerations. In Britain, oppida emerged later, from c. 100BC to AD70, and again, whilst diverse in form, have shared characteristics of imported material culture, craft production, ritual activities, elite residence and extensive enclosure systems (Haselgrove, 2000; Pitts, 2010).

The scale of agriculture has been considered within long term cycles of settlement dispersal and agglomeration throughout first millennium BC Europe (Haselgrove, 1996; Kristiansen, 1998).

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Regions of poor soils (Salač, 2000) and the intersections of contrasting soil types were widely used as the locations for oppida (Haselgrove, 1976, p. 40; Collis, 1984, p. 174). This pattern has led to the perception that agricultural activities were not significant at these settlements (Salač, 2000), or alternatively, that agricultural innovations and intensification were adopted in areas of marginal soil (Hill, 1995, pp. 60–62, p. 84). Intensified agricultural production has also been seen as a prerequisite for oppida development, providing sufficient food for a large non-agricultural population (Brun, 1995; Danielisová et al., 2015, p. 207). Recently, the role of agriculture has been evaluated for several Late Iron Age oppida in Europe (Danielisová and Hajnalová, 2014), but many of the examples rely on limited archaeobotanical datasets with only charred plant remains investigated, and with the exclusion of British case studies.

The lack of inclusion of British evidence into the wider European debates makes it vital to present a detailed archaeobotanical case study of the agricultural basis of a territorial oppidum, in this case *Calleva Atrebatum* or Silchester. There has been a long history of research focus on external stimulus to the development of oppida in Britain (Haselgrove, 1976). After a reaction against these models (Hill, 2007), there has been an emphasis within Britain on the landscape context of oppida (Moore, 2012), ritualised activities (Bryant, 2007; Garland, 2013) and individual political power (Creighton, 2006) at the expense of agricultural and economic activities. Oppida today are often situated under subsequent Roman, medieval and modern urban centres, hindering large-scale excavations. Thus, there is very little archaeobotanical evidence available from British oppida (Burnham et al., 2001; Van der Veen et al., 2007), which can be integrated into broader European debates concerning agricultural intensification and urbanisation. Limited excavations have been undertaken at enclosed oppida such as Oram's Arbour, Winchester, while those at Abingdon Vineyard remain unpublished (Haselgrove, 2000). Discrete activity areas have been investigated at territorial oppida, such as Camulodunum, Chichester and Verulamium, but many of these investigations were undertaken before the application of archaeobotanical sampling.

Models of agriculture in southern Britain have been interlinked with those of oppida development since the 1970s, in terms of long-term agricultural trajectories (Jones, 1981), and the short-term need to exchange cereals with the Roman world (Cunliffe, 1976) and within southern Britain (Sharples, 2010, p. 173). Currently, three broad models are available for the type and scale of agriculture practised at oppida in Britain. In parallel with European oppida, the first model argues that agricultural innovations developed in the later first millennium BC, which enabled populations to move into areas with marginal soils (Haselgrove and Millett, 1997; Hill, 2007). Agricultural innovations improve the quantity and quality of food produced (Van der Veen, 2010). Field drainage, the cultivation of clay soils and the adoption of bread wheat have all been stated as innovations in this period (Jones, 1981), and whilst the latter has now been disproven (Campbell and Straker, 2003), the further practices of spring sowing and mono-cropping have also been identified in the Late Iron Age Danebury environs region (Campbell and Hamilton, 2000). These innovations, however, have only been identified from rural settlements, rather than at oppida themselves.

The second model is of oppida as surplus cereal-producers. In a reflection of the core–periphery models of the 1970s, an absence of storage features and grain-rich charred cereal assemblages alongside the presence of imported ceramics in the Late Iron Age have been presented as evidence for the production of cereal surpluses and their movement beyond the local region in exchange for imported food and material culture (Van der Veen and Jones, 2006, p. 226). Archaeobotanical evidence has been used sparingly in this model, with the only example being grain-rich, Middle Iron Age grain deposits at Danebury hillfort. Contra to this model, storage pits do continue into the Late Iron Age period (Campbell, 2008), and the likelihood of long distance movement of cereals has been downplayed due to the difficulties of overland transport (Collis, 2000, p. 236).

The third model argues against the importance of arable production at oppida, asserting that these settlements were reliant on cereals produced in nearby areas of fertile soil (Cunliffe, 2012), such as the Thames Valley or the Hampshire chalk downs (Sharples, 2010, p. 173). Specifically, an emphasis on pastoral activity over arable farming has been stated, for Silchester itself (Creighton, 2000, p. 18; Mattingly, 2007, p. 59), and at polyfocal complexes (Moore, 2012, pp. 409, 411). Limited palynological studies have been undertaken of buried podzolised soils at the nearby amphitheatre (Van Scheepen, 1989) and anthropogenic sediments from wells at the forum-basilica site, which have been interpreted as evidence of the open nature of the landscape (Wooders and Keith-Lucas, 2000), but no archaeobotanical evidence has been used to identify the agricultural practices undertaken at oppida themselves.

A greater understanding of agricultural practice at oppida in Britain is vital for evaluating these three models and investigating the structure and organisation of social groups resident at these settlements (Hill, 2011). This paper addresses the lack of archaeobotanical data from British oppida by presenting the analysis of a substantial assemblage of waterlogged plant remains from excavations within the Insula IX area (Fig 1) of the territorial oppidum at Silchester (Fulford et al., 2013). These plant remains originated from mixed anthropogenic deposits in wells within the settlement. Analysis is ongoing of palaeoentomological, palynological and anthracological data (Fulford et al., forthcoming). A combination of univariate and contextual analysis has enabled agricultural activities to be identified from depositional contexts which have long been recognised as taphonomically complex (Greig, 1988a). This analysis will address whether agricultural activities can be established through the investigation of mixed waterlogged deposits, and how this can inform upon the relationship between urbanisation and agricultural developments, as well as the character of the society that lived in the earliest urban settlements in Britain.

2. Study site

Silchester is situated in lowland central-southern Britain, between the Thames Valley and the Hampshire chalk downs (Fig. 1). The oppidum is located on a gravel terrace of the River Kennet, a tributary of the Thames, overlying an area of tertiary clay and sand deposits at the edge of the London Basin. Cretaceous chalk emerges to the north-west as the Berkshire Downs, and to the south as the Hampshire chalk downs (Mathers and Smith, 2000). The soils on the gravel plateau are well-drained brown-earth soils, surrounded by a mosaic of clayey, loamy and sandy soils between the Kennet and Loddon valleys (Jarvis, 1968). This area is generally perceived as having limited agricultural potential in prehistory (Fulford, 1993; Cunliffe, 2012), and is also recorded as being difficult to cultivate in modern times (Ditchfield and Anker Simmons, 1907; Curtler, 1912, p. 493). The site is located at 95 m above sea level, with a temperate oceanic-climate of warm summers, cool winters, and 650–750 mm of rainfall a year (Met Office, 2015). Modern vegetation in the region has been heavily transformed by conifer plantations and agricultural improvements. On the gravel plateau there are surviving areas of ancient woodland and heathland. Away from the gravel plateau the area is mostly pasture or rough grassland (Brewis et al., 1996; Crawley, 2005). Palaeoenvironmental studies of Late Bronze Age and Early Iron Age sites in the Lower Kennet Valley and Mid-Thames Valley indicate a largely cleared environment (Carruthers, 1992;

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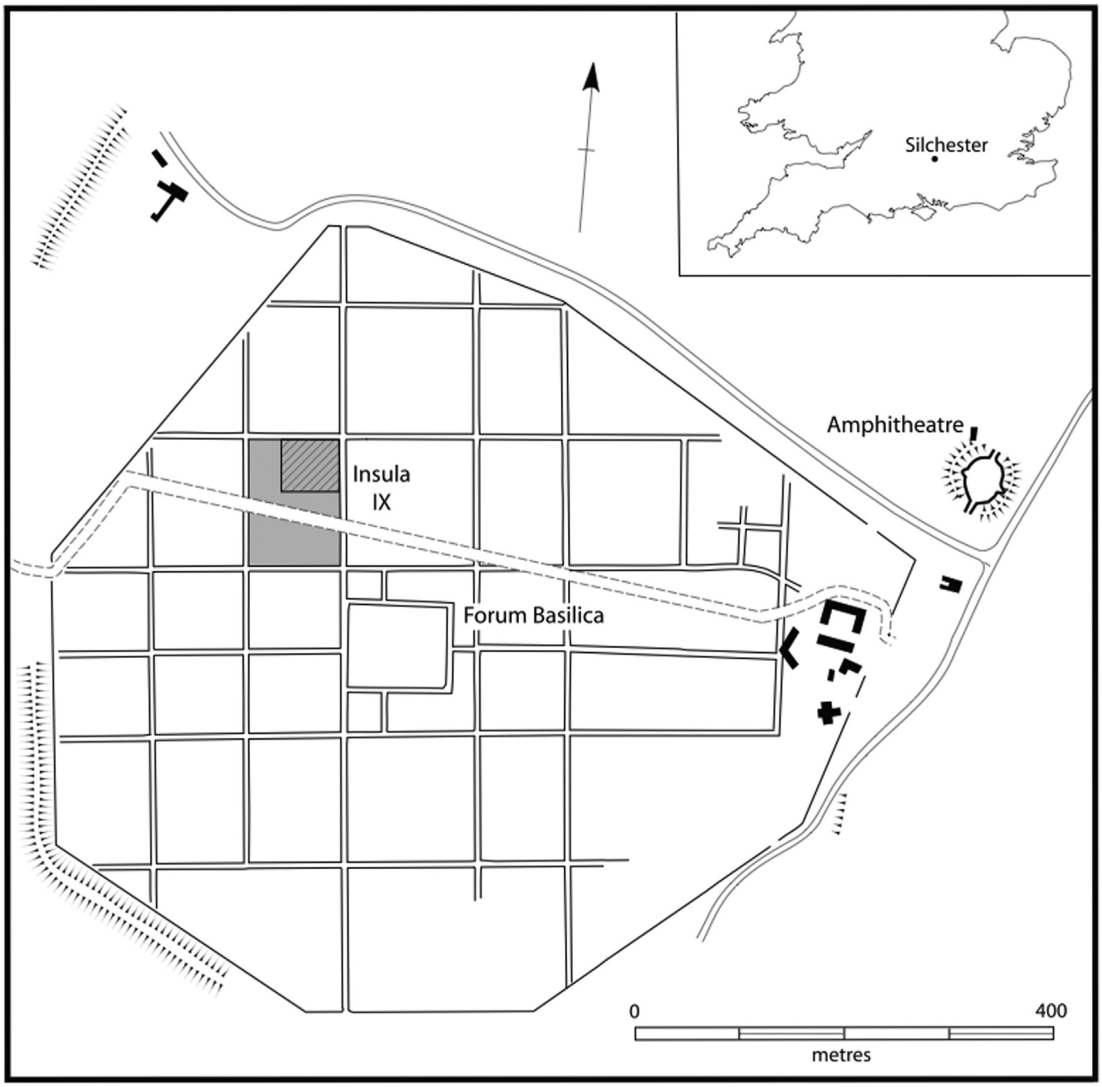

Fig. 1. Plan of Roman Silchester showing the location of Silchester within central-southern Britain and the excavation area within Insula IX.

Keith-Lucas, 1997; Scaife, 2004). Heathland development is evidenced by pollen analysis at Late Bronze Age Aldermaston Wharf (Bradley et al., 1980) and from a Late Bronze Age to Early Iron Age sequence from Thames Valley Park (Keith-Lucas, 1997).

Late Iron Age Silchester has been the site of archaeological investigations for several centuries which have elucidated the character of the oppidum, alongside field surveys and numismatic evidence. The Inner Earthwork, a construction currently dated to the very end of the first century BC, enclosed an area of 32 ha, with the discontinuous Outer Earthwork covering a wider area, and more extensive earthworks still poorly understood (Fulford and Timby, 2000) (Fig. 2). Large-scale antiquarian excavations, undertaken 1890–1909, lacked sufficient attention to stratigraphy to recognise chronological phases and non-masonry buildings (Fulford et al., 2002). Small-scale excavations across the town have shown that much of the area within the Inner Earthwork was occupied, with the most detailed evidence for the character of the settlement coming from excavations at the site of the Roman forum-basilica in the centre of the oppidum (Fig. 2). An initial phase of settlement from c. 25BC consisted of several wells and roundhouses, with the addition of metalled streets, palisaded enclosures and rubbish pits from c. 15BC to AD44 (Fulford and Timby, 2000). Material culture evidence shows much evidence for trade with northern France and the Mediterranean, which has been used to argue that the origins of the oppidum community is in a migrant population from northern France (Fulford and Timby, 2000, p. 564). The Roman civitas capital, featuring several major public buildings including a forum-basilica, public baths, a mansio, several Romano-Celtic temples and an amphitheatre beyond the town walls (Fig. 1) (Boon, 1974), was located directly over the Late Iron Age oppidum with strong evidence for continuity in population (Fulford et al., 2013). The construction of the Roman street grid is currently dated to the later first century AD (Fulford and Clarke, 2009), and “Insula IX” here refers to the area of excavation rather than the region of the later street grid.

A larger area of Late Iron Age occupation within the oppidum has been recorded through the recent University of Reading Insula IX excavations. Insula IX is located to the north-west of the forum-

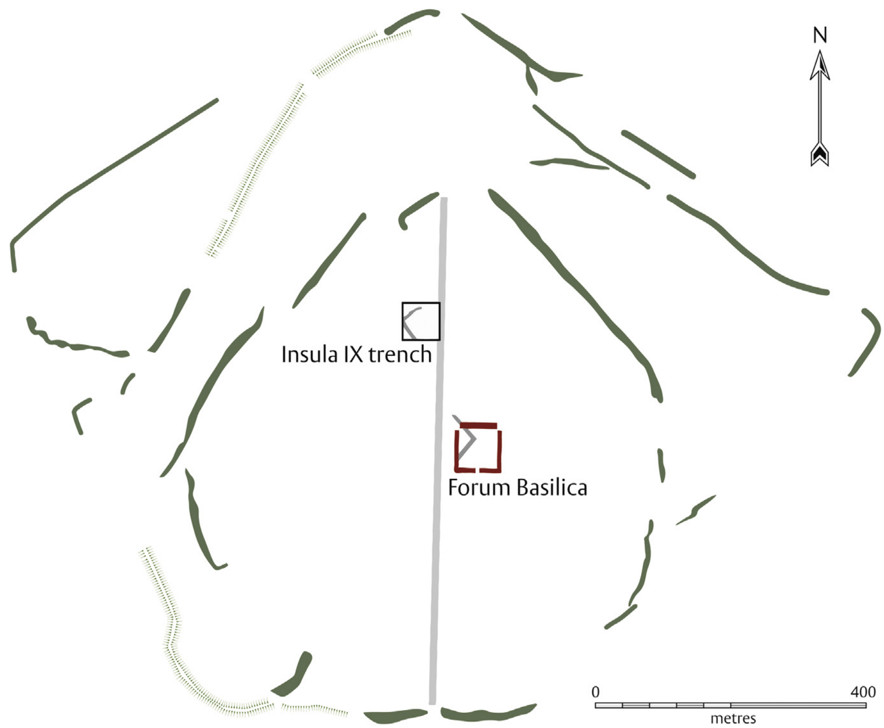

Fig. 2. Plan of Late Iron Age Silchester, showing the excavation site at Insula IX and the surrounding earthworks.

basilica, bordered by the main north-south and east–west streets through the town (Fig. 1). The 'Town Life' project excavated a 55 × 55 m area in the north-east of Insula IX from 1997 to 2014. The Mid and Late Roman phases have been published (Fulford et al., 2006; Fulford and Clarke, 2011a), and post-excavation analysis is ongoing on the Late Iron Age and Early Roman phases of occupation. The earliest activity is a v-shaped ditch, on a north-west south-east alignment, dated to c. 20BC. From 20BC to AD10/20, a Great Hall was constructed, overlying the southern end of the earlier ditch. This building was accompanied by several wells, enclosures and buildings. The last phase of pre-conquest activity consisted of two trackways, wells, enclosures and rectangular buildings (Fulford et al., 2013). In the post-conquest Claudio-Neronian period (AD43–68), there was an intensification of activity, but continuation in settlement characteristics despite the imposition of the main north-south street through the town. At the end of this period, c. AD70/80, there is widespread evidence for destruction and settlement reorganisation within Insula IX (Fulford et al., 2011).

Plant macrofossils have previously been studied from several areas within the town. Clement Reid analysed waterlogged plant remains from the eastern Insulae, producing evidence for a wide range of wild taxa, including wet ground, heathland, ruderal plants and imported plant foods, but the study lacked any chronological context or quantitative analysis (Lodwick, forthcoming). Analysis of waterlogged sediments from a marsh-like deposit outside the south-east gate produced evidence for damp grassland, waste ground and some scrub plants (Monk, 1984). At the excavations at the forum-basilica, waterlogged plant remains were studied from two Late Iron Age wells dated to c. 25–15BC. A small range of plants of disturbed and damp ground were identified, along with hazelnut shells, wild fruit stones and charred cereal processing remains (Jones, 2000). Charred, mineralised and waterlogged plant remains have previously been studied from the Mid and Late Roman phases of Insula IX, with evidence for food imports and settlement vegetation (Robinson et al., 2006; Robinson, 2011).

3. Materials and methods

3.1. Sampling and analysis

This study addresses the agricultural practices undertaken at Late Iron Age Silchester through the analysis of waterlogged sediments from a series of Late Iron Age and Early Roman wells. The local geology of well-drained, sandy, flint gravels overlying London clay (Mathers and Smith, 2000) results in a perched water table, around 2 m below the modern ground surface of the Silchester gravel plateau. The Late Iron Age settlement was 6 km from the nearest rivers, the Kennet and Loddon; hence the population was reliant on wells throughout occupation at the site, with several present in each Insula (Boon, 1974, p. 85).

Waterlogged plant remains from six wells have been investigated in this study (Table 1). The phasing of contexts is based on ceramic dating and stratigraphy. Two wells have been studied from Late Iron Age Period 0 (Fig. 3). Well 10421 was located in the centre of the excavation area, to the north of the Great Hall. The well was an unlined circular shaft. Four contexts were analysed, dated to c. 20/10BC–AD10/20. Well 8328 was located in the north-west corner of the excavation area, an unlined 3.7 m deep circular shaft. Five contexts were studied dated to AD30–55. Four wells were studied from Period 1, dated to c. AD43–70/80. Well 1586 was located at the southern edge of the north-east – south-west Iron Age lane (Fig. 4). It was an unlined 2.95 m deep circular shaft, and waterlogged plant remains were studied from two contexts. Well 3171 was located on the eastern edge of Insula IX, between two clay-floored buildings (Fig. 4). The well was an unlined 3.6 m deep circular shaft, and waterlogged plant remains were studied from seven contexts. The only lined well was 5100, situated in the centre of the excavation between two clay-floored buildings and lined with a reused barrel. Waterlogged plant remains were studied from one context. Well 5791 was located in an open area in the western half of the

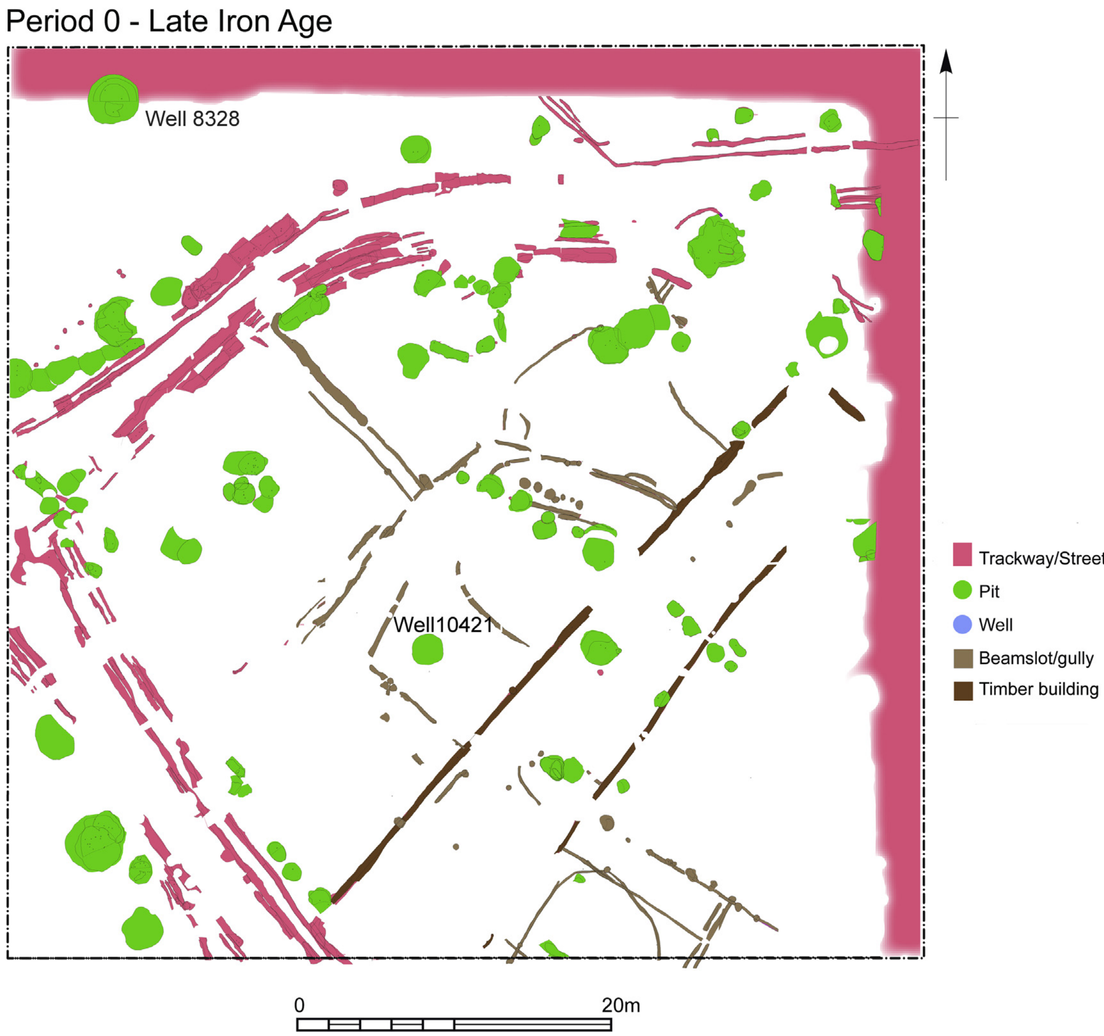

Fig. 3. Plan of Period 0 Insula IX, indicating the location of wells 8328 and 10421.

excavated area. It was an oval-shaped, unlined, shaft, over 2 m deep, with waterlogged plant remains were studied from 10 contexts.

Table 1
Summary of features studied for waterlogged plant remains from Late Iron Age and Early Roman Insula IX. Totals exclude semi-quantified samples.

Well	Period	Date	No. of contexts	Average seeds/L	$\sum$ (seeds)
10421	0	20/10BC–AD10/20	4	21.9	1600
8328	0	AD30–55	5	155.4	2045
1586	1	AD43–70/80	2	24.1	404
3171	1	AD43–70/80	7	9.8	3997
5100	1	AD43–70/80	1	1.5	22
5791	1	AD43–70/80	10	27.8	4378

Bulk samples of 1–40 L were taken from defined contextual units within each well fill, with a total volume of 525 L of sediment processed. Wells were excavated in plan. Large samples were taken due to the low density of plant remains recovered previously from Mid and Late Roman wells (Robinson et al., 2006; Robinson, 2011). Sediment samples were processed in a modified 'Siraf' flotation tank, using a 0.25 mm flot mesh and 1 mm residue mesh. The flots were stored in water, and sorted and identified under 20–40× magnification using a binocular microscope. The 0.25 mm–0.5 mm fraction was sub-sampled due to a hyper-abundance of *Juncus* spp. seeds. Samples with good preservation and a large number of items were fully quantified. Vegetative plant remains were either fully-quantified or semi-quantified using a four-point scale of abundance. Plant remains were identified using the seed reference collection housed in the Oxford University Museum of Natural History with reference to published seed atlases (Neef et al., 2011; Cappers et al., 2012). Nomenclature follows Stace (1997), with additions from Flora Europaea (Tutin and Akeroyd, 1993).

3.2. Interpretative methods

In terms of their depositional processes, wells have an intermediate position between lake-shore settlement deposits (Jacomet,

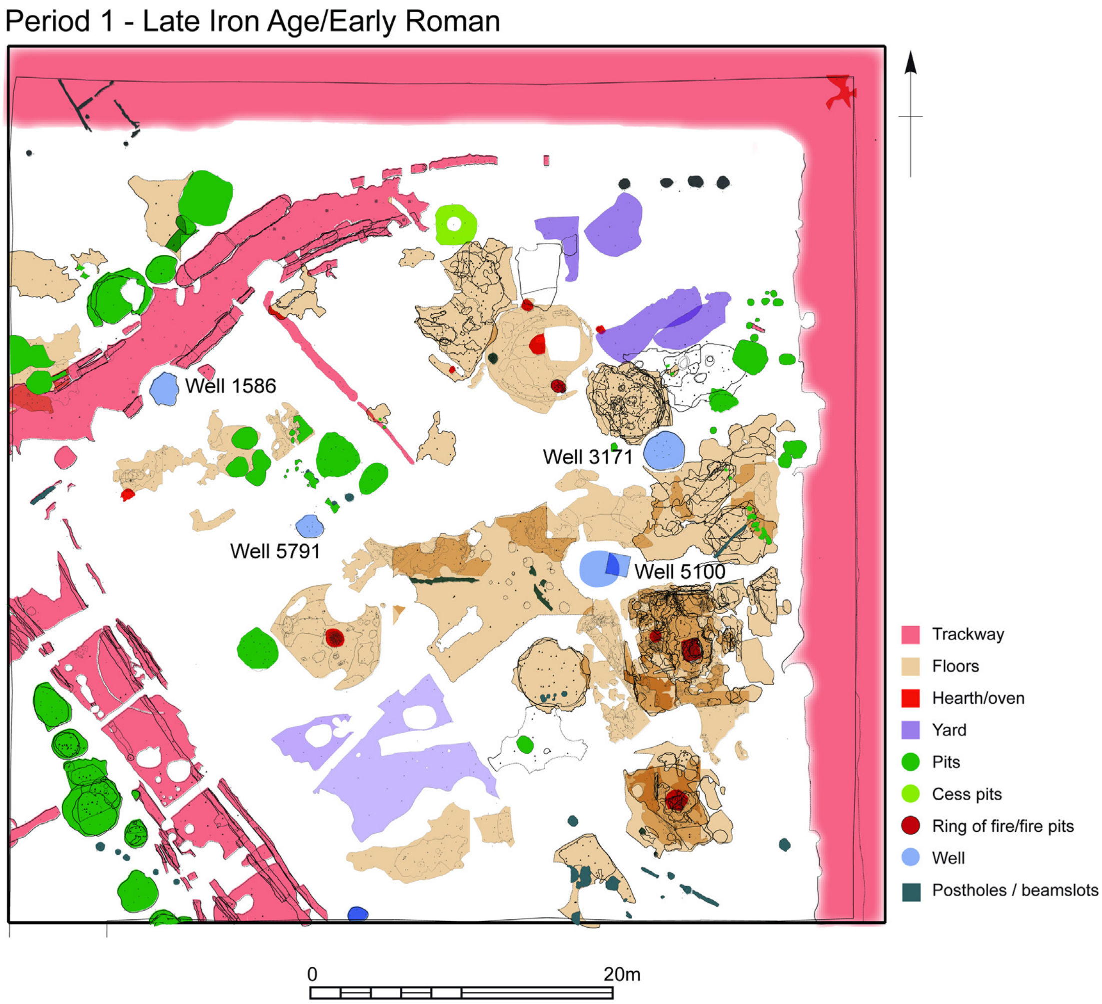

Fig. 4. Plan of Period 1 Insula IX, indicating the location of wells 1586, 3171, 5100 and 5791.

2013) and natural sequences of sediments (Birks, 2014) as multiple anthropogenic and natural processes contribute to the accumulation of plant remains (Greig, 1988a). Iron Age and Roman wells are commonly backfilled with a range of domestic and agricultural refuse (Hall et al., 1980; Kenward et al., 1986), and are common loci for ritualised or structured deposits (Fulford, 2001). The majority of waterlogged samples from wells typically consist of wild taxa from a diverse range of vegetation types. Thus, univariate and qualitative analyses are here used to disentangle the range of agricultural practices which contributed to these assemblages. Univariate analysis consisted of the calculation of sums and frequencies of seeds per taxa, per context. Data standardisation was undertaken by merging all cf. and definite identifications. Each taxon was placed in a broad habitat group based on British and local flora (Tables 2 and 5) (Brewis et al., 1996; Stace, 1997; Crawley, 2005). These groupings were used to calculate the sum of taxa per habitat group per contexts. Qualitative analysis was undertaken based on the abundance of taxa per samples. Plant communities present in the British National Vegetation Classification (NVC) groups were used as a broad interpretative tool through the comparison of individual samples with NVC floristic tables (Rodwell, 1993).

Qualitative analysis was also undertaken of the stratigraphic and artefactual sequence within each well shaft in order to identify the range of formation processes which contributed to each context and the range of sources from which plant remains may have originated. A typology of deposit types was created with reference

Table 2
Summary of habitat groups used to classify waterlogged plant remains.

Habitat group		Description
C	Cultivated	Cultivated cereals, oil crops, introduced plant foods.
D	Disturbed	Perennials of permanent waste ground communities.
D (a)	Disturbed (arable)	Annuals of nitrogen rich ground, also arable weeds.
G	Grassland	Marshy grassland, meadows, pastures, short grassland.
H	Heathland	Lowland heathland.
W	Wet ground	Aquatic plants, bankside plants of seasonally inundated conditions.
Wo	Woodland	Dry and wet woodland, scrub.

to previous work on well formation processes (Hall et al., 1980; Kenward et al., 1986; Greig, 1988a; Robinson, 2011; Van Haasteren and Groot, 2013), which was used to identify each context as a primary fill, gradual accumulation or organic/non-organic dump based on context descriptions, stratigraphy and archaeological inclusions (Table 3). Artefactual information was also used alongside archaeobotanical data to enable the identification of indicator groups and packages – characteristic assemblages of plant, animals and artefacts which represent a specific activity or ecology (Kenward and Hall, 1997; Hall and Kenward, 1998, 2003; Kenward and Hall, 2012). Artefactual data are available online through the Silchester Integrated Archaeological Database (Fulford and Clarke, 2011b).

Complete data are available in ESM Table 1. These taxa originate from seven different habitat groups (Table 2). A small range of cultivated plants, 10 taxa, were present (Table 5). These included four herbaceous plants used as condiments (*Anethum graveolens* – dill; *Apium graveolens* – celery; *Coriandrum sativum* – coriander; *Foeniculum vulgare* – fennel), two oil plants (*Linum usitatissimum* – flax; *Brassica* cultivar – cultivated brassica), two cereals (*Hordeum* sp. – barley; *Triticum spelta* – spelt wheat) and two fruits (*Olea europaea* – olive; *Prunus avium* – sweet cherry). The largest group of taxa is that found on frequently disturbed and/or arable ground, which contained 47 taxa, the most frequent of which were *Polygonum aviculare*, *Stellaria media* and *Urtica urens* (Table 5). The most frequent taxa in the second largest group,

Table 3
Summary of well deposit type classification scheme.

Deposit type	Origins	Stratigraphic description	Bulk finds	Key references
Primary fill	Sediment accumulated during well use.	Base of well shaft, homogeneous sediment, consistent with upper well shaft. Lenses of material, horizontal content boundaries.	Few archaeological inclusions, objects for drawing water, ladders, lost personal items.	Greig, 1988a; Van Haasteren and Groot, 2013.
Gradual accumulation	Post abandonment accumulation.	Lenses of silty material, horizontal context boundaries.	Objects for drawing water, ladders, lost personal items, settlement waste; pottery, animal bones, charcoal.	Greig, 1988a; Van Haasteren and Groot, 2013.
Non-organic dump	Dumps of non-organic material.	Deep contexts with sloping boundaries, heterogeneous material.	Settlement waste; pottery, animal bones, charcoal, stone, building material.	Kenward et al., 1986, p. 259; Robinson, 2011, p. 281.
Organic dump	Dumps of organic material.	Deep contexts with sloping boundaries, peaty material, visible plant remains.	Wood, charcoal, animal bones.	Kenward et al., 1986, p. 259.

4. Results

4.1. Summary of taxa and ecological groups

A total of 43 samples were analysed from 31 contexts, 40 of which were fully quantified and three semi-quantified. No variation was observed from samples from the same contexts; hence samples from the same context were combined for purposes of analysis. The density at which plant remains were present varied widely, from 0.1 seeds/L (sample 759, context 4851, well 3171) to 946 seeds/L (sample 3219, context 9309, well 8328) (Table 4). 12,698 seeds were identified from fully quantified samples (excluding *Juncus* spp. and Poaceae indet.) representing 161 taxa.

grassland plants, were *Filipendula ulmaria*, *Ranunculus repens* and *Rhinanthus minor*. The next group, wet ground taxa, contained 18 taxa, including abundant *Juncus* spp. (*J. articulatus* gp., *J. bufonius* gp., *J. effusus* gp.), *Eleocharis palustris*, *Mentha aquatica* and *Ranunculus flammula*. Woodland habitats were represented by common occurrences of *Betula pendula/pubescens* seeds, *Corylus avellana* nutshells, *Prunus spinosa* stones and *Rubus fruticosus* seeds, as well as other rarer taxa. *Prunus spinosa* (sloe), *Corylus avellana* (hazelnut shell) and *Rubus fruticosus* agg. (bramble) could have been collected for food. Finally, numerous taxa (43) were placed in the various group. These represent seeds which could not be identified beyond genus or family (*Carex* spp., *Rumex* spp.) and those which occur in a broad range of habitats.

Table 4
Summary of statistics for waterlogged samples from Insula IX. GA = gradual accumulation, ND = non-organic deposit, OD = organic deposit, PF = primary fill, as classified in Table 3.

Period	Well	Samples	Context	Fill type	Number of taxa (seeds)	∑ (seeds)	Density (seeds/L)
0	10421	4068	10438	ND	5	69	4.3
0	10421	4085	10439	ND	12	21	6.0
0	10421	4141	10441	ND	42	917	131
0	10421	4165	10442	PF	38	593	64.2
0	8328	3191	9152	ND	19	186	14.3
0	8328	3216	9257	OD	25	433	108.3
0	8328	3195, 3198	9258	ND	33	355	355.0
0	8328	3217, 3219, 3293	9309	OD	69	804	268.0
0	8328	3322, 3335, 3341, 3380	9663	OD	24	267	31.4
1	1586	612	3932	GA	41	174	19.3
1	1586	615	3981	GA	40	230	28.8
1	3171	738	4837	GA	5	17	3.4
1	3171	739	4838	GA	17	219	8.1

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Table 4 (*continued*)

Period	Well	Samples	Context	Fill type	Number of taxa (seeds)	∑ (seeds)	Density (seeds/L)
1	3171	741	4845	GA	4	13	0.4
1	3171	749	4846	GA	9	47	1.2
1	3171	754, 755	4850	OD	65	3595	51.7
1	3171	758, 759	4851	GA	23	63	1.9
1	3171	761	4866	PF	12	43	1.8
1	5100	2799	7828	PF	9	22	1.5
1	5791	1284	6482	OD	70	583	36.4
1	5791	1320	6484	OD	92	936	93.6
1	5791	1216, 1328	6485	OD	89	1305	40.8
1	5791	1554, 1555	6487	ND	53	141	9.4
1	5791	1296	6504	ND	45	216	14.4
1	5791	1584	6897	ND	31	73	12.2
1	5791	1594	6905	ND	25	66	3.7
1	5791	1656	6917	ND	76	935	55.0
1	5791	1662	6921	ND	33	81	5.4
1	5791	1682	6923	PF	15	42	7.0

Table 5
Summary of the sum and frequency of taxa by well and period. All taxa are seeds unless otherwise stated. Wells 1586 and 5100 have been excluded due to the low number of contexts.

	Well								Period			
	10421		8328		3171		5791		0		1	
	Sum	% Frequency (4)	Sum	% Frequency (5)	Sum	% Frequency (7)	Sum	% Frequency (10)	Sum	% Frequency (9)	Sum	% Frequency (20)
Food plants												
Anethum graveolens			6	20	62	29	3	20			1	5
Apium graveolens	9	50	2	40	2	14	39	90	11	44	44	60
Brassica cultivar					1	14					8	15
Coriandrum sativum	1	25	3	20	17	43	18	70	6	11	65	20
Foeniculum vulgare							2	20			2	10
Hordeum sp. (rachis)							5	50			5	25
Linum usitatissimum			61	20	73	43	11	60	61	11	84	45
Linum usitatissimum (capsules)			46	40	3	14	4	30	46	22	7	20
Olea europaea	1	25							1	11		
Prunus avium					1	14	1	10			2	10
Triticum spelta (glume base)			19	40			7	30	19	22	16	25
Triticum spelta/dicoccum (glume base)			8	40			17	70	8	22	18	40
Triticum sp.							1	10			1	5
Cereal indet. (culm node)							1	10			1	5
Cereal indet. (bran)				20				30		11		25
Cereal indet. (grain)							8	30	4	22	36	55
Wild plants												
Disturbed ground												
Atropa belladonna	3	25	13	60	13	57	2	20	16	44	15	30
Ballota nigra	6	50	4	40	159	43	21	70	10	44	180	50
Chelidonium majus							1	10			1	5
Hyoscyamus niger	1	25	2	20	13	14	4	30	3	22	17	20
Lapsana communis					1	14	2	20			3	15
Malva sylvestris			6	20					6	11		
Sagina sp.	69	75	59	40			18	20	109	55	22	15
Urtica dioica	17	75	92	60	378	43	211	90		66	611	75
Disturbed (arable) ground												
Aethusa cynapium					39	14	1	10			40	10
Agrostemma githago			5	60			7	50	5	33	8	30
Anisantha sterilis											1	5
Anthemis arvensis							2	10			2	5
Anthriscus caucalis	1	25	10	40	28	14	1	10	11	33	31	15
Aphanes arvensis	5	50	5	40	3	29	10	50	10	44	14	40
Aphanes australis	5	25	18	40	10	14	59	60	23	33	76	45
Atriplex sp.			5	20	10	14	14	80	5	11	25	50
Avena sp.							2	20			2	10
Bromus secalinus			9	40	1	14	31	70	9	22	33	45
Capsella bursa-pastoris	531	50	61	20	1	14	46	80	592	33	61	55
Chenopodium album	73	50	25	60	37	14	29	90	98	55	77	60
Chenopodium ficifolium	1	25			28	29			1	11	28	10
Chenopodium polyspermum			6	40	21	14	1	10	6	22	22	10
Fallopia convolvulus	1	25							1	11		

Table 5 (*continued*)

	Well								Period			
	10421		8328		3171		5791		0		1	
	Sum	% Frequency (4)	Sum	% Frequency (5)	Sum	% Frequency (7)	Sum	% Frequency (10)	Sum	% Frequency (9)	Sum	% Frequency (20)
Fumaria sp.	22	50	2	40	17	43			24	44	17	15
Galeopsis tetrahit							2	20			2	10
Galium aparine							16	10			16	5
Lamium sp.	6	50			24	14	9	50	6	22	33	30
Legousia hybrida			5	20			2	10	5	11	2	5
Odontites vernus							37	60			37	30
Papaver argemone			5	40			171	70	5	22	173	45
Papaver rhoeas	5	50	14	60			46	40	19	56	47	25
Papaver somniferum	6	75	12	60			11	40	18	67	12	25
Persicaria lapathifolia			3	20	1	14			3	11	1	5
Plantago major	3	50	2	40			13	50	5	44	17	35
Polygonum aviculare agg.	267	50	236	80	274	43	102	90	503	67	426	70
Potentilla reptans			1	20					1	11		
Ranunculus sardous			2	20	43	43	55	90	2	11	108	70
Raphanus raphanistrum					7	14					7	5
Rumex crispus							3	10			3	5
Rumex obtusifolius							2	20			2	10
Scleranthus annuus							1	10			1	5
Silene vulgaris							1	10			1	5
Sisymbrium sp.	11	50							11	22		
Solanum nigrum	1	25	6	40	173	14	13	50	7	33	193	40
Sonchus asper	2	50			22	29	9	50	2	22	32	40
Sonchus oleraceus					64	29	1	10			65	15
Spergula arvensis	2	25	2	20			7	40	4	22	7	20
Stellaria media gp.	217	50	18	60	401	43	247	100	235	56	663	80
Thlaspi arvense	1	25	3	40	4	43	1	10	4	33	5	20
Torilis sp.			2	20			7	50	2	11	7	25
Tripleurospermum inodorum	2	50	1	20			12	40	3	33	12	20
Urtica urens	111	50	132	80	1234	57	154	100	243	67	1408	80
Valerianella locusta							8	30			8	15
Valerianella rimosa							1	10			1	5
Valerianella dentata			1	20			5	30	1	11	5	15
Viola S. Melanium	3	50			1	14	11	40	3	22	12	25
Grassland												
Achillea millefolium							1	10			1	5
Centaurea nigra			1	20			18	30	1	11	18	15
Centaurea nigra (flower head)								10				5
Filipendula ulmaria			6	20	5	29	280	90	6	11	289	70
Hypochaeris sp.	4	25					13	50	4	11	13	25
Lathyrus pratensis								10			1	5
Leontodon saxatilis			1	20					1	11		
Leontodon sp.			7	20	1	14	58	50	7	11	60	35
Leucanthemum vulgare							3	30			3	15
Linum catharticum			7	20	1	14	23	70	7	11	30	50
Medicago lupulina							1	10			1	5
Medicago sp.							3	20			3	10
Medicago sp. (pod)								30				15
Oenanthe pimpinelloides							4	30			5	20
Ornithopus sp.			2	20					2	11		
Picris hieracioides							3	20			3	10
Plantago sp.							5	20			5	10
Poaceae indet. (culm base)								10				5
Poaceae indet.	1512	100	1427	80	152	57	3473	100	2939	89	3965	85
Potentilla anserina					2	14	1	10			4	15
Potentilla erecta			9	40	3	29	8	50	9	22	12	40
Prunella vulgaris	6	50	26	60	24	29	61	90	32	56	89	65
Ranunculus acris			5	20	6	14	59	60	5	11	68	40
Ranunculus bulbosus							2	10			2	5
Ranunculus repens	16	50	13	60	69	57	89	80	29	56	163	70
Rhinanthus minor			11	40	3	14	80	80	11	22	83	45
Scabiosa columbaria							1	10			1	5
Stellaria graminea	3	25	2	20	2	14	14	50	5	22	17	35
Trifolium sp.					1	14					1	5
Trifolium sp. (flower)				40				40		22		20
Trifolium sp. (calix)				40				70		11		35
Asteraceae indet. (flower head)								20				5
Fabaceae indet. (pod fragment)								20				10
Vicia/Lathyrus (pod fragment)								40				20
Vicia/Lathyrus (tendril)								20				10
Vicia/Lathyrus (flower)								10				5

(*continued on next page*)

Table 5 (*continued*)

	Well								Period			
	10421		8328		3171		5791		0		1	
	Sum	% Frequency (4)	Sum	% Frequency (5)	Sum	% Frequency (7)	Sum	% Frequency (10)	Sum	% Frequency (9)	Sum	% Frequency (20)
Viola sp. (capsule fragment)				20				10				5
Heathland												
Calluna vulgaris			8	40					8	22		
Calluna vulgaris (shoots)				20						11		
Calluna vulgaris (seed capsule)				20						11		
Danthonia decumbens			1	20			13	50	1	11	14	30
Erica sp.			15	20					15	11		
Ericaceae indet. (seed capsule)				20				10		11		5
Ericaceae indet. (leaf)				20						11		
Pteridium aquilinium (fronds)				40				50		22		25
Sphagnum (buds)		25		20						22		5
Sphagnum (leaf)		25		40				10		33		15
Ulex europaeus (spine)		25		60						44		
Wet ground												
Alisma plantago-aquatica			1	20					1	11		
Alisma sp.			1	20			1	10	1	11	1	5
Apium nodiflorum	1	25	3	40			11	50	4	33	12	30
Caltha palustris							12	30			12	15
Eleocharis palustris	20	75	461	100	272	86	497	90	481	89	873	90
Glyceria type					1	14					1	5
Hydrocotyle vulgaris							7	50			7	25
Isolepis setacea	4	25							4	11	1	5
Juncus effusus gp.	895	100	513	80	756	57	2646	100	1408	89	3491	80
Lychnis flos-cuculi			1	20			1	10	1	11	1	5
Lycopus europaeus					3	14	2	20			5	15
Lythrum salicaria							1	10			1	5
Mentha aquatica	1	25	104	60			41	70	105	44	42	40
Oenanthe fistulosa							4	10			4	5
Pulicaria sp.			1	20			5	20	1	11	5	10
Ranunculus flammula	1	25	16	60	21	29	64	90	17	44	128	65
Ranunculus S. *Batrachium*	1	25			1	14			1	11	1	5
Thalictrum flavum							5	40			6	25
Veronica beccabunga							3	20			3	10
Woodland												
Alnus glutinosa							1	10			1	5
Betula pendula/pubescens	3	25	5	20			40	90	8	22	41	50
Corylus avellana (nutshell)	7	50	5	40	7	29	2	20	12	4	11	30
Crataegus sp.							1	10			1	5
Fragaria vesca							1	10			1	5
Fraxinus excelsior							1	10			2	10
Ilex aquifolium (leaf)								20	11	12	3	15
Luzula sp.							5	30			5	15
Malus sp.			1	20					1	11		
Prunus spinosa	1	25	3	40	5	29			4	33	5	10
Rubus fruticosus	6	50	28	100	57	43	9	60	34	78	73	60
Rubus sp. (thorn)						14						10
Salix sp. (bud)								10				5
Viola S. *Viola*					1	14	2	10			3	10
Bark								10		11		5
Deciduous tree leaf								50		11		35
Various												
Arctium sp.			2	20	1	14	4	30	2	11	5	20
Arenaria sp.							4	10			4	5
Carduus sp.							1	10			2	10
Carduus/Cirsium					8	14	8	10			16	10
Carex sp.	13	75	75	80	66	86	194	100	88	78	282	95
Cerastium fontanum			7	20	1	14	27	60	7	11	29	40
Cirsium sp.							4	30			6	25
Conium maculatum			1	20			1	10	1	11	2	10
Crepis capillaris			1	20					1	11	1	5
Daucus carota			1	20	5	29	5	30	1	11	10	25
Epilobium sp.							4	20			4	10
Galium sp.							5	20			6	15
Hypericum sp.			5	20			2	20	5	11	6	15
Juncus articulatus gp.	307	100	2040	60	3606	43	10002	100	2347	78	14099	75
Juncus bufonius gp.	393	100	240	60	2592	14	2412	100	633	78	5175	65
Mentha sp.			16	60			3	20	16	33	3	10
Montia fontana ssp.	73	50	15	40	8	14	67	40	88	43	75	25
Myosotis sp.							7	30			7	15
Ranunculus parviflorus	1	25	1	20	5	14	19	90	2	22	25	55
Ranunculus S. *Ranunculus*	2	50	4	40	1	14	172	90	6	44	174	55

Table 5 (*continued*)

	Well								Period			
	10421		8328		3171		5791		0		1	
	Sum	% Frequency (4)	Sum	% Frequency (5)	Sum	% Frequency (7)	Sum	% Frequency (10)	Sum	% Frequency (9)	Sum	% Frequency (20)
Rumex acetosella agg.	3	50	97	60	37	29	519	90	100	56	564	65
Rumex conglomeratus			1	20			45	50	1	11	45	25
Rumex sp.	2	50	30	60	5	29	180	70	32	56	185	45
Sambucus nigra	2	25	49	80	126	100	8	40	51	56	135	60
Senecio sp.							6	50			6	25
Silene sp.							1	10			1	5
Solanum dulcamara	1	25			2	14	1	10	1	11	3	10
Taraxacum sp.	2	50	1	20	1	14	1	10	3	33	5	15

4.2. Well deposition groups

The wide range of taxa identified from the six Late Iron Age and Early Roman wells at Insula IX is reflected in the different depositional histories of each well. Here, a brief summary of the sequence of deposits within each well is summarised, drawing on the well deposition types presented above (Table 3), in order to aid the interpretation of archaeobotanical remains. The earliest deposit in well 10421 was the primary fill (10442), followed by the placing of a complete coarse ware cooking pot and a partially complete Silchester ware beaker in the well shaft. Context 10442 was described as redeposited natural during excavation, and contained very few archaeological inclusions, with horizontal context boundaries. In reference to the established criteria, identification as a primary deposit seems secure (Fig. 5). These were followed by the first non-organic dump (10441), before the well shaft partially collapsed (10440) and was backfilled with further non-organic deposits (10439), and (10438), containing poorly preserved waterlogged plant remains. In contrast, well 8328 was backfilled with a series of organic dumps. A primary fill accumulated of gravel and clay sediment (9680-unsampled), before three complete pots were placed in the well shaft, and covered with an organic dump (9663) containing visible plant remains, silty clay sediment, animal bone and pottery. This was followed by a further dump of stable flooring from south-east, containing the same material as well as burnt fragments of quern stone and a small, complete pierced pot, alongside a further intact pot. More midden-type material was then placed into the well (9258), followed by a small deposit of probable sewage (9257).

The four period one wells varied in the type of material deposited into them. The primary fill of well 1586 consisted of silty gravel (unsampled), followed by two contexts consisting of lenses of organic material and gravel (3981, 3932), and separated by a deposit of several intact pots and flagons. A similar gravelly primary fill accumulated in well 3171(4866) with few archaeological inclusions and horizontal context boundaries, followed by further gravelly accumulations (4851), and a dump of organic material (4850). The well then appears to have filled up with a series of gradual accumulations with low densities of

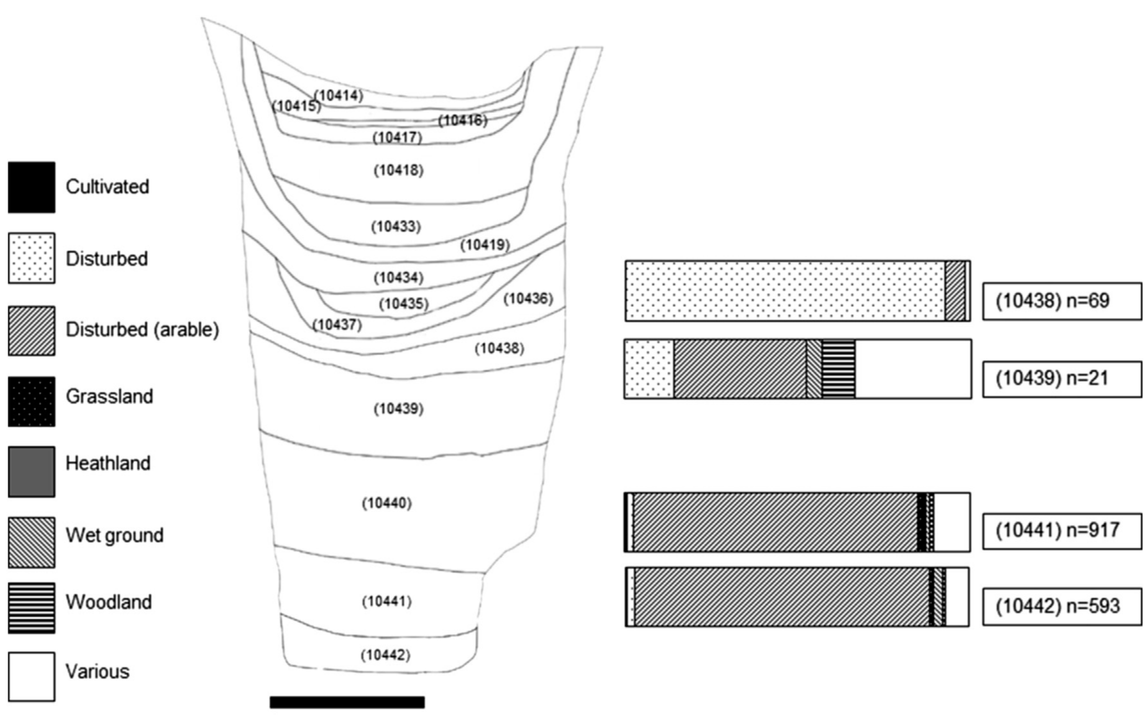

Fig. 5. Proportion of seeds classified by habitat group per context in well 10421.

waterlogged plant remains (4846, 4845, 4838, 4837). In contrast, the only context in well 5100 to contain waterlogged plant remains was the silty primary fill which accumulated within the timber barrel lining (7828). The most productive well in terms of waterlogged plant remains was well 5791. A primary fill of clay sediment (6923) was overlain by a sequence of organic dumps interspersed with non-organic dumps containing building material. The lower sequence was covered with a clay capping (6486). Overall, the majority of the well fills represent dumps of material, where plant remains are more likely to derive from a single source. The primary well fills and gradual accumulations are more likely to contain seeds from plants growing in the vicinity of the well.

4.3. Univariate analysis

The waterlogged plant remains identified are now discussed per well in terms of the taxa identified, and the representation of broad habitat groups. The two basal contexts of well 10421 were dominated by a similar range of disturbed-arable taxa (Fig. 5). The most abundant species were *Capsella bursa pastoris*, *Chenopodium album*, *Polygonum aviculare*, *Stellaria media* and *Urtica urens*. *Fallopia convolvulus* and *Sisymbrium* sp., both annuals of waste and rough ground, were only recorded from this well. Small proportions of disturbed ground and grassland (*Hypochaeris* sp. and *Ranunculus repens*) and wet ground plants (*Eleocharis palustris* and *Isolepis setacea*) were present. The lowest two contexts contained evidence for cultivated plant foods. From context (10442), two endocarp fragments of *Olea europaea* were identified along with one seed of *Apium graveolens*. Eight seeds of *A. graveolens* were also present in (10441), along with one seed of *Coriandrum sativum*. Contexts 10439 and 10438 both contained a low density of seeds, with large numbers of Poaceae indet. and *Juncus* spp., and lower quantities of plants of disturbed ground, wet ground and woodland. Overall, there was a low presence of heathland and grassland taxa.

The plant remains from well 8328 contrast strongly with the earlier well 10421. A more diverse range of taxa were identified. The lowest fill was dominated by annuals of disturbed ground, mainly *Capsella bursa-pastoris* (n = 61) and *Polygonum aviculare* (n = 152) (Fig. 6). Some seeds of heathland plants were present, including *Calluna vulgaris* (n = 7), as well as vegetative fragments of Ericaceae indet. capsules, *Pteridium aquilinum* fronds and *Ulex europaeus* spines, alongside woodland, wet ground and grassland taxa. The overlying fill, (9309) was visibly rich in organic material, and the samples consisted almost entirely of laminated vegetative material and cereal bran. Whilst seeds of disturbed (arable) habitats still make up the highest proportion of this sample, there is a higher proportion and more diverse range of grassland plants (*Prunella vulgaris*, *Ranunculus repens*, *Rhinanthus minor*) and wet ground taxa (*Eleocharis palustris*, *Ranunculus flammula*). *Calluna vulgaris* shoots and seeds, *Erica* sp. seeds, *Ericaceae* capsules and leafs, *Pteridium aquilinum* fronds, *Ulex europaeaus* spines and *Sphagnum* sp. buds and leaves make up the range of heathland material. Context 9258 has a higher proportion of wet ground (*Eleocharis palustris*) and disturbed ground (*Urtica dioica*) plants, a trend continuing with overlying context 9257 which was dominated by wet ground taxa *Eleocharis palustris* and *Mentha aquatica*. The uppermost context from which waterlogged plant remains were recovered contained a low density of poorly preserved seeds. Considering all contexts, the most frequent plants were wet ground taxa *Eleocharis palustris* (100%) and *Juncus effusus* gp. (80%), disturbed (arable) taxa such as *Polygonum aviculare* (80%), *Stellaria media* (80%), *Urtica urens* (80%), and the decay resistant seeds of *Carex* sp. (80%), *Rubus fruticosus* agg. (100%) and *Sambucus nigra* (80%). Cultivated plant foods were present in the two lowest well fills. One seed of *Apium graveolens*, eight *Linum usitatissimum* (flax) capsule fragments and three *Triticum spelta* and *spelta/dicoccum*

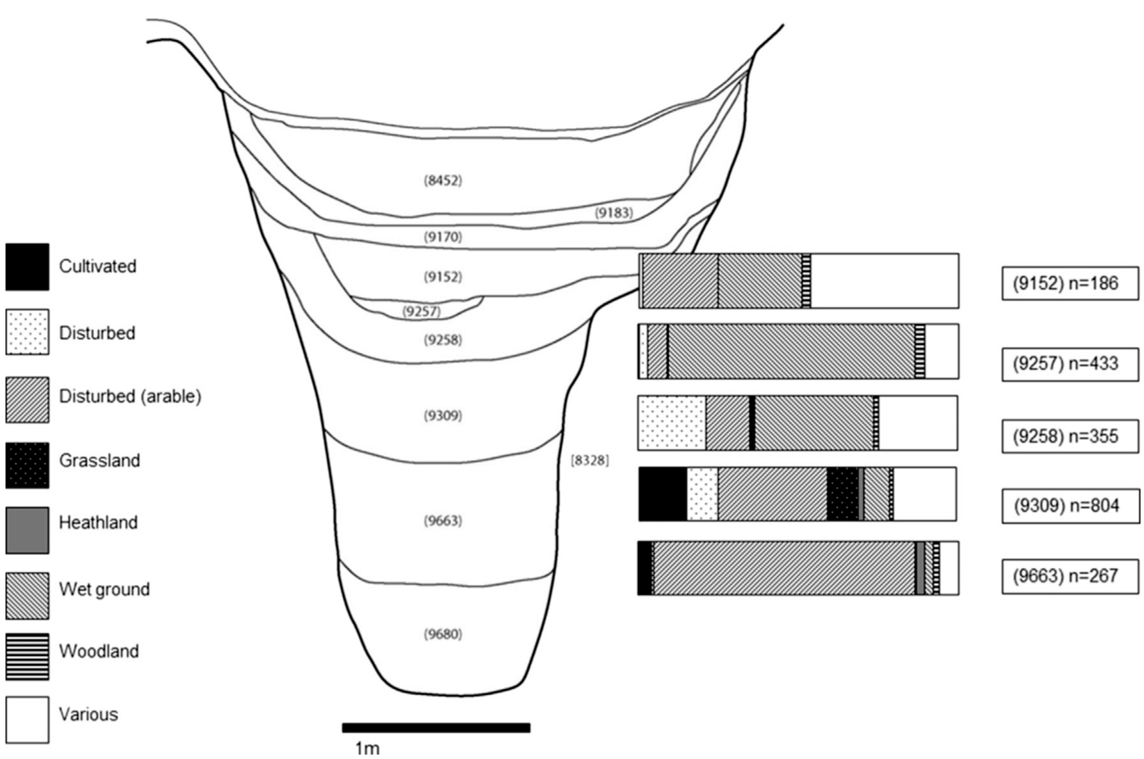

Fig. 6. Proportion of seeds classified by habitat group per context in well 8328.

glume bases were recovered from samples from context 9663. The first record of *Anethum graveolens* came from context 9309, where six seeds were recorded along with three seeds of *Coriandrum sativum*, and 61 flax seeds. Crop by-products were represented by 38 flax capsule fragments, 17 spelt and seven spelt/emmer glume bases, along with abundant cereal bran.

Some of these cultivated plant foods were also identified from Early Roman well 1586. From context (3981), two *Apium graveolens* seeds and two *T. spelta* glume bases were identified, and one *Apium graveolens* and one *Coriandrum sativum* seed, plus further *T. spelta* glume bases from context (3932). Both well fills also had a similar range of wild taxa, with similar quantities of disturbed (arable), wet ground and grassland plants. These contexts contained a relativity low density (average 24.8 seeds/L), but a wide diversity of seeds, including grassland (*Filipendula ulmaria*, *Prunella vulgaris*, *Ranunculus repens*) and disturbed (arable) plants (*Aphanes arvensis*, *Solanum nigrum*, *Stellaria media*). The most abundant taxa continued to be plants of disturbed (arable) ground, *Polygonum aviculare* (n = 50), *Urtica urens* (n = 20) and *Capsella bursa-pastoris* (n = 14). Only a small assemblage of plant remains was recovered from well 5100, but showed the same mix of wet ground (*Eleocharis palustris*), disturbed ground (*Urtica dioica*) and grassland plants (*Taraxacum* sp.).

The assemblage retrieved from well 3171 was most similar to 1586. The lowest three contexts (4866, 4851, 4850) were mainly composed of disturbed (arable) taxa, with smaller quantities of wet ground, grassland, and cultivated plant foods (Fig. 7). *L. usitatissimum* seeds were present in all three of these contexts alongside *Anethum graveolens* (n = 15), *Apium graveolens* (n = 2), *Brassica* cultivar (n = 1), *C. sativum* (n = 12) and *Prunus avium* (n = 1) from context 4850. The most abundant disturbed (arable) taxa were *Urtica urens*, *Stellaria media* and *Polygonum aviculare*, whilst *Ranunculus repens* and *Eleocharis palustris* were also abundant. In the upper four contexts (4846, 4845, 4838, 4837), there was a low density of plant remains (0.4–8.1 seeds/L). The higher proportions of various and wet ground taxa is due to the preferential preservation of taxa in these groups such as *Carex* sp., *Sambucus nigra* and *Eleocharis palustris*. The high proportion of cultivated taxa in (4838) is due to 47 cf. *Anethum graveolens* seeds. The poor preservation of plant remains from these contexts limited interpretation. Considering all contexts, the most frequent taxa from this well were *Eleocharis palustris* (86%), disturbed ground taxa *Atropa belladonna* (57%), *Ballota nigra* (43%) and *Urtica dioica* (43%), disturbed (arable) taxa *Fumaria* sp. (43%), *Polygonum aviculare* (43%), *Ranunculus sardous* (43%) and *Urtica urens* (57%), and the decay resistant taxa *Carex* sp. (86%) and *Sambucus nigra* (100%).

Finally, well 5791 contained the most abundant and diverse assemblage of waterlogged plant remains. The composition of all contexts was similar, with the best represented habit groups being disturbed (arable), various, grassland, wet ground and cultivated (Fig. 8). The range of disturbed (arable) plants was the most diverse of all the wells and, alongside the common plants *Stellaria media* (n = 247, 100% frequency) and *Urtica urens* (n = 154, 100%), several taxa were unique to this well, including *Odontites vernus* (60%) and *Valerianella locusta* (30%). There was a consistent presence of grassland taxa, the most frequent of which were *Filipendula ulmaria* (90%), *Prunella vulgaris* (90%), *Ranunculus repens* (80%) and *Rhinanthus minor* (80%). The highest diversity of grassland taxa was recorded from contexts in this well, (6482), (6485) and (6917), which were also the only contexts to contain *Centaurea nigra*, *Leucanthemum vulgare* and *Picris hieracioides*. The wet ground group was also most diverse in these contexts: (6484), (6485) and (6917), including *Caltha palustris*, *Pulicaria* sp., *Ranunculus flammula* and *Thalictrum flavum*. There was also a unique range of vegetative parts of grassland plants: a *Centaurea nigra* seed head, Asteraceae

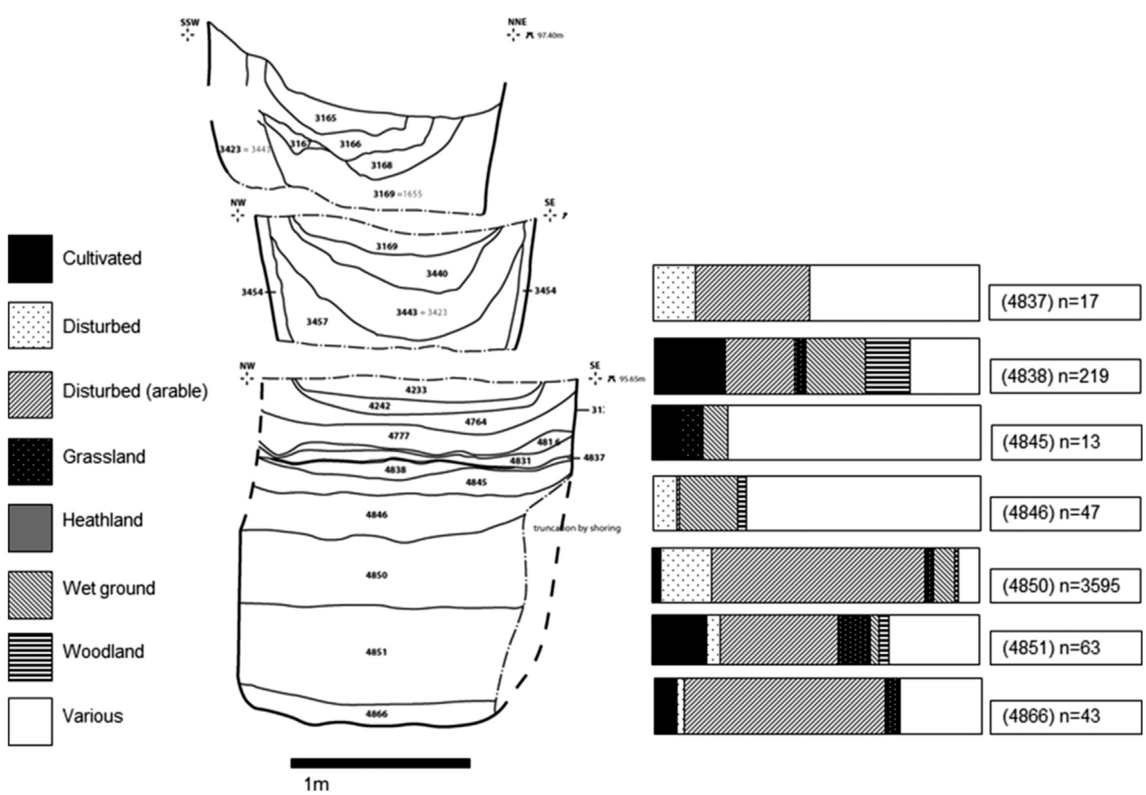

Fig. 7. Proportion of seeds classified by habitat group per context in well 3171.

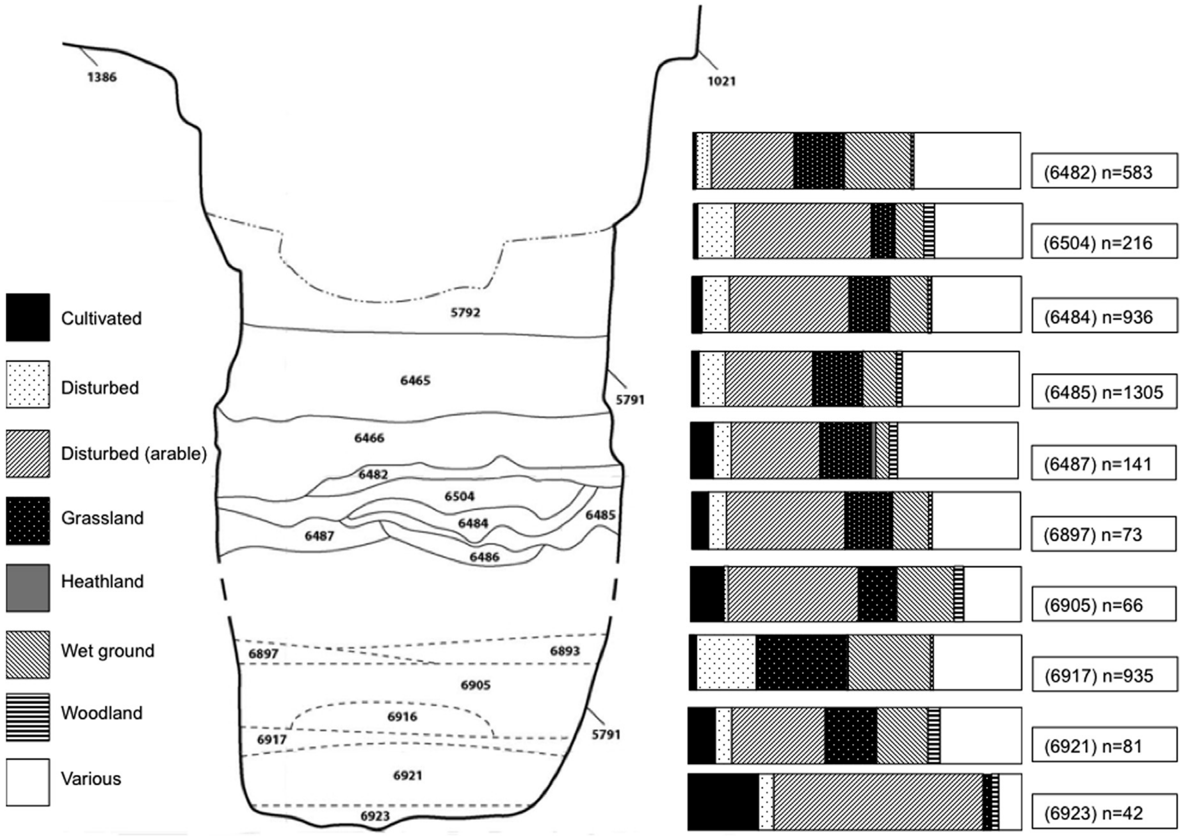

Fig. 8. Proportion of seeds classified by habitat group per context in well 5791.

seed and flower head and *Vicia/Lathyrus* seed pods and tendrils. A limited range of heathland plants was also present: bracken fronds, *Danthonia decumbens* seeds and Ericaceae capsules. Cultivated plant foods were present throughout the well. *Apium graveolens* (90%) and *C. sativum* (70%) were particularly frequent, and *Anethum graveolens*, *L. usitatissimum* (seeds and capsules), *Hordeum* rachis, *T. spelta* glume bases and cereal bran were present in various contexts. *Foeniculum vulgare* (fennel), was only found from this well in contexts (6484) and (6917). There was also a high frequency of *Betula* sp. seeds and hazelnut shell.

Overall, the wells contained low concentrations of waterlogged plant remains, other than numerous contexts in wells 8328 and 5791, and context (10441) of well 10421 (Table 4). These contexts contained both high densities of plant remains (>50 seeds/L) and abundant vegetative plant remains. Some taxa were common across all periods: *Carex* sp., *Eleocharis palustris*, and *Stellaria media*, but there are key variations between periods. The Late Iron Age Period 0 samples are characterised by disturbed (arable) taxa and heathland plants (Table 5). The Early Roman Period one wells show a marked diversity of grassland and wet ground taxa alongside the disturbed (arable) plants present in Period 0. Much of this diversity was, however, contained within well 5791, and to a lesser extent, well 1586. Numerous grassland, wet ground and likely arable weeds were only present in well 5791.

5. Discussion

5.1. Agricultural crops

A key issue of debate over the agricultural basis of oppida is what type, and how, crops were cultivated. The Insula IX well assemblages show that *Triticum spelta* and *spelta/dicoccum* glume bases and *Hordeum* sp. rachis were present at the settlement. No *T. dicoccum* (emmer) glume bases were identified. Spelt wheat and barley are both the staple cereal crops of Iron Age southern Britain (Van der Veen and O'Connor, 1998). One cereal culm node was recovered from (6485) well 5791. The presence of cereal chaff at a settlement makes it more likely that the residents of Insula IX were involved in the later stage of crop-processing, yet the crop residues may also have been used as resources such as fodder. Either way, it shows no change in the staple crops consumed at Late Iron Age and Early Roman Insula IX. Some of the taxa in the D(a) group probably entered the wells with cereal processing by-products; *Agrostemma githago* and *Anthemis arvensis* were particularly associated with arable fields before modern agricultural developments (Stace, 1997). Cereal chaff was most frequent amongst organic dumps (Table 6), indicating it was deposited amongst dense and diverse assemblages of plant remains.

The oil crop, flax, is much more frequent in the waterlogged assemblage than cereals. Seeds and capsules were both frequent in period 0 (11 and 22%) and period one (45 and 20%), especially abundant in context (9309) well 8328 and (4850) well 3171. Flax is an annual herbaceous plant used for linen textiles, linseed oil and linseeds across the old world (Zohary et al., 2012). Flax seeds occur in all deposit types (Table 6), suggesting they were regularly being processed and/or used within Insula IX. Furthermore seeds and capsules usually co-occur within contexts, suggesting that they represent by-products being utilised rather than food consumption waste. Morphometric analysis has been used to separate oil and fibre varieties of flax (Herbig and Maier, 2011; Larsson, 2013). A comparison of the published measurements of flax seeds from sites in north-western Europe with those of Insula IX examples (ESM 2) shows that the Silchester seeds have a large size range, with width

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Table 6
Summary of the presence of key taxa by deposit types.

	Primary fill (n = 4)	Gradual accumulation (n = 7)	Organic dump (n = 7)	Non-organic dump (n = 11)
Crops				
Barley rachis			2	3
Spelt/emmer glume bases		2	4	6
Flax seeds	2	1	5	2
Flax capsules			5	1
Flavourings				
Celery	2	2	6	6
Coriander		3	4	6
Dill		1	4	
Fennel			1	1

ranging from 1.2 to 2.9 cm, and length ranging from 2.2 to 4.1 cm (Fig. 9). This size range encompasses average measurements from seeds identified as a textile crop from Wrześnica, Poland (Latalowa, 1998) and seeds thought to be from food consumption, as at Cups Hotel, Colchester (Murphy, 1992). This large range indicates that flax was probably a multi-use crop, cultivated for oil seeds and fibres at Silchester.

After a Neolithic introduction (Campbell and Straker, 2003), flax is considered to be absent from the Iron Age Thames Valley region (Lambrick and Robinson, 2009, p. 254). This questions whether the cultivation of flax continued at all through the Iron Age, or whether flax seeds had to be accessed through trade. Flax is an intensive crop, requiring fertile and moist soils due to its small root run (Valamoti, 2011), and it is often grown in rotation by modern farmers (Bond and Hunter, 1987). The processing of flax for oil seeds and/or fibre requires multiple stages and specialist knowledge (Andresen and Karg, 2011). Hence, the cultivation of flax at the oppidum at Silchester is evidence for the undertaking of a labour-intensive, agricultural practice. Whether this represents an innovation in the re-adoption of a crop, or evidence of the wider continuation of flax cultivation through the Iron Age requires detailed synthesis of the available data, and the continued analysis of Iron Age waterlogged plant remains in the region.

5.2. Hay

A further potential agricultural innovation is represented by the presence of a diverse assemblage of grassland and wet ground taxa at Late Iron Age and Early Roman Insula IX. These can be interpreted as hay due to the presence of specific vegetative plant remains and the co-occurrence of taxa of wet grassland. In several contexts intact pieces of grassland vegetation were identified; a *Centaurea nigra* seed head, numerous *Trifolium* sp. calyx, a Fabaceae indet. pod and *Medicago* capsules (Fig. 10), showing that cut grassland material was being brought into the settlement. Based on a comparison with British NVC groups (Rodwell, 1993), the co-occurrence of *Centaurea nigra*, *Filipendula ulmaria*, *Leucanthemum vulgare*, *Lychnis flos-cuculi* and *Rhinanthus minor* has been previously identified as a hay meadow community (Table 7) (Greig, 1984, 1988b; Robinson, 2007). The NVC community, MG4 *Alopecurus pratensis–Sanguisorba officinalis*, occurs today when areas of grassland on seasonally flooded alluvial soil are closed to grazing animals in spring, cut for hay in July, and then grazed from early August. It is characterised by a species-rich community including many tall dicotyledonous plants. The NVC community MG5 *Centaureo-Cynosuretum cristati* is managed very similarly, with the addition of light manure in April. It is found on deep brown clayey or loamy soils (Rodwell, 1993). Many of the other plants identified at Silchester could also have also come from hay meadows, such as *Caltha palustris*, *Juncus* spp., *Luzula* sp. and *Thalictrum flavum*.

The limitations of such a phytosociological approach are that the range of seeds identified has been affected by the facts that some seeds could have been released before the grass was harvested, digestive taphonomy could have affected the range of taxa preserved, and plant communities could have changed through time. These issues have been approached through an application of the Functional Integrated Botanical Surveys approach by Hodgson et al. (1999) to the archaeobotanical dataset collated by Greig (1988b).

Table 7
National Vegetation Classification communities and functional attributes of potential hay taxa in mesotrophic grassland communities 4 and 5. A = annual, B = biennial, P = perennial. Constancy measured on a scale from 1 to 5.

Taxa	Mesotrophic grassland community 4 constant species	Mesotrophic grassland community 5 constant species	Flowering onset and duration/months	Canopy height (mm)	Life history	Stress index
Centaurea nigra	+3	+5	Jun-04	301–600	P	−1.4
Cerastium fontanum	+4	+3	Aug-06	<300	P	−0.3
Danthonia decumbens		+5	Jul-01	101–299	P	
Eleocharis palustris			May-03	300–599	P	
Filipendula ulmaria	+5	+1	Jun-03	>600	P	1.2
Hypochaeris sp.	+1	+3	Jun-04	<300	P	
Leontodon sp.	+4	+4	Jun-04	<100–299	P	
Leucanthemum vulgare	+2	+3	Jun-03	301–600	P	−1.4
Linum catharticum			Jun-04	<300	B/A	1.5
Potentilla erecta		+5	Jun-04	201–299	P	
Prunella vulgaris	+2	+4	Jun-04	<300	P	−0.2
Ranunculus acris	+5	+4	May-03	<300	P	−0.5
Ranunculus bulbosus	+1	+3	May-02	<300	P	0.0
Ranunculus repens	+3	+2	May-02	<300	P	−1.0
Rhinanthus minor	+3	+2	May-04	301–600	A/B	−0.2
Scabiosa columbaria			Jul-02	<300	B/P	−0.2

Sources: Rodwell, 1993; Fitter and Peat, 1994; Hodgson et al., 1999.

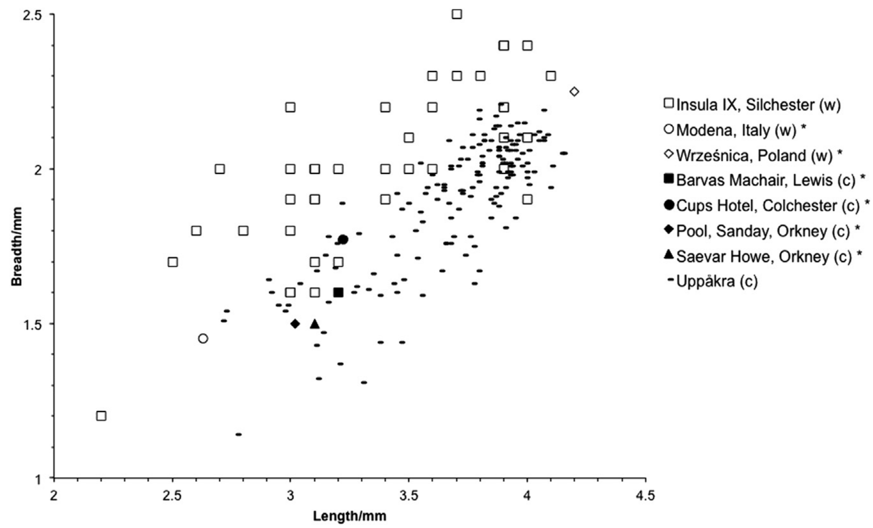

Fig. 9. Measurements of flax seeds from Insula IX compared to other published sites. * = average value. Barvas Machair, Pool, Saevar Hower (Bond and Hunter, 1987), Modena (Bosi et al., 2011), Cups Hotel (Murphy, 1992), Uppåkra (Larsson, 2013) and Wrześnica (Latalowa, 1998). W = waterlogged. C = charred.

This analysis showed that modern hay communities were successfully reclassified based on the presence of biennials, an intermediate to tall canopy height and low stress index. Table 7 summarises these attributes for the main taxa in the Insula IX samples which contained a diverse grassland taxa with similarities to modern hay communities. Based on flowering time, the vegetation was probably cut in July, in agreement with medieval and early modern hay management (Stuart, 1995; Williamson, 2003). Some tall growing taxa were present, including *Centaurea nigra*, *Leucanthemum vulgare* and *Rhinanthus minor*. Most of the taxa are perennials, but some biennials were present such as *Rhinanthus minor* and *Scabiosa columbaria*. The stress index of most taxa is low, although some species such as *Filipendula ulmaria* do cope well with stress. Furthermore, the presence of low-growing plants, such as *Eleocharis palustris* and *Linum catharticum*, which are not listed components of MG4 or MG5 today (Rodwell, 1993), suggests either management practices were different, or that these taxa entered the deposits from other sources.

The contexts containing hay date to c. AD30–55 (well 8328) and AD43–70/80 (well 5791). There is no evidence for a similar hay meadow flora from the large number of Iron Age waterlogged assemblages studied in the Thames Valley, the earliest current evidence for hay coming from early Roman Claydon Pike and Farmoor in the Upper Thames Valley (Booth et al., 2007, p. 280). Hence, these waterlogged assemblages represent the earliest evidence for hay meadow management in Britain. Furthermore, experimental cultivation has shown that it takes 20+ years of hay meadow management for plant succession from weed and wasteland to hay meadow to take place, or quicker from grazed pasture (McDonald, 2007). Thus, this innovative new grassland management technique was most likely being practised at pre-conquest Insula IX.

5.3. Stable flooring material

The well fills which contained hay and flax, also produced other materials such as bracken, gorse, cereal bran, wet ground plants and cereal chaff (Table 8). Various uses can be suggested for these materials. For instance historical evidence shows that bracken can be used for packaging, fuel, potash and litter (Rymer, 1976; Mabey, 1977). Young gorse shoots can be used for fodder (Rymer, 1979), or animal and human bedding (Mabey, 1977). Also present in these contexts were numerous wet ground plants. The most common wet ground plants are mainly low growing (*Eleocharis palustris*, *Juncus articulatus*), making it unlikely that these seeds originated from thatching or flooring material. Instead, the highest diversity of wet ground plants is in contexts which also contain much cereal bran, suggesting a shared origin in animal dung. Plants such as *Apium nodiflorum*, *Hydrocotyle vulgaris*, *Lycopaeus europaeus* and *Ranunculus* subg. *Batrachium* grow on banksides and wet meadows, areas where animals likely to have grazed. Horses can graze very close to the ground (Pilliner, 1992), and many seeds can survive the digestive process (Wallace and Charles, 2013). The abundance of cereal bran in wells 8328 and 5791 indicate the presence of digested plant material. However a more secure identification of dung requires the study of parasite eggs (Jones, 1982), phytoliths, faecal spherulites (Lanceolotti and Madella, 2012) as well as biomolecular and micromorphological analysis (Shillito et al., 2011). Microbotanical and micromorphological techniques have been applied to well 8328, and will be contrasted in future publications with the archaeobotanical evidence (Fulford et al., forthcoming).

Table 8
Contexts containing the stable manure indicator group (Kenward and Hall, 1997; Hall and Kenward, 1998) from Late Iron Age and Early Roman Insula IX.

Well	Context	Period	Dung	Fodder					Litter	
			Cereal bran	Flax seeds and capsules	Spelt/emmer grains/glume bases	Barley grains/rachis	Grassland plants	Holly leaves	Bracken/gorse	Leaves/buds
8328	9309	0	+	+	+		+	+	+	+
1586	3932	1	+		+		+	+		
5791	6485	1	+	+	+	+	+		+	+
5791	6897	1	+		+		+		+	+

Fig. 10. Components of the stable-manure package identified at Periods 0–1 Insula IX. A–C Heathland material. A: *Sphagnum* sp., B: *Ulex europaeus* spine, C: *Pteridium aquilinium* frond. D–I: Crop-processing material D: Cereal culm, E: *Agrostemma githago* fragment, F: *Triticum spelta* spikelet, G: *Hordeum* rachis, H: *Linum usitatissimum* seed, I: *Linum usitatissimum* capsule. J–R: Hay meadow taxa J: *Centaurea nigra* bract, K: *Medicago* sp. capsule, L: *Trifolium* calyx, M; Fabaceae indet. pod fragment, N: *Rhinanthus minor*, O: *Lychnis flos-cuculi*, P: *Linum catharticum*, Q: *Prunella vulgaris*, R: *Filipendula ulmaria*. S–V Marshy grassland components. S: *Eleocharis palustris*, T: *Caltha palustris*, U: *Pulicaria* sp., V: *Myosotis* sp. All scale bars = 2 mm.

The contexts in which these materials co-occur is summarised in Table 8, in which a range of materials (bracken, cereal bran, flax, wet ground plants, cereal chaff), are present which can be interpreted as bedding, fodder, hay and dung. This strongly suggests these assemblages match the indicator group of stable-manure, referring to coarse-texture material which has accumulated in a byre or stable (Kenward and Hall, 1997; Hall and Kenward, 1998). The presence of fragmented *Agrostemma githago* seeds and Fabaceae pods is also indicative of digested material (Kenward and Hall, 2012, p. 8), and the cereal chaff and flax capsules and seeds can be interpreted as fodder. The high abundance of nitrophilous weeds in these contexts, such as *Chenopodium album* and *Stellaria media*, are likely to have been growing on middens accumulated from this stable flooring material within the Insula IX area, which were then used to backfill the well shafts once they had gone out of use. For instance, context (9309) within well 8328 was recorded during excavation as having been dumped from the south-east due to the sloping context boundary, and contained a heterogeneous mix of plant remains, animal bones, quern stone fragments and pottery. When combined with other finds present in these contexts (nails, vivianite, animal bones), they allow the identification of the indicator package of stable manure.

To date, this is amongst the earliest evidence of stable flooring material in Britain (Kenward and Hall, 2012), comparable to the assemblages dated to the AD50s at 1 Poultry, London (Davis, 2011). The presence of this stable manure means that animals were being stabled within Insula IX, from c. AD30 to 70/80, most likely for reasons of access to land. If the area within the Inner Earthwork was entirely populated, the nearest pasture would have been 0.5 km or more away. However, the stabling of animals close to houses would have also improved access to secondary products, perhaps enabling households to have independent food supplies, in addition to facilitating long distance transport of people and/or goods. The evidence for animal stabling corresponds with suggestions that oppida, and Silchester in particular, were orientated towards the management of horses (Creighton, 2000, p. 18; Mattingly, 2007, p. 59).

5.4. New plant foods and horticulture

Wells 10421 and 8328 produced the earliest bioarchaeological evidence for the import of new plant foods to Late Iron Age Britain in the form of celery, coriander and olive (Lodwick, 2014). The additional evidence from the earliest phase of Early Roman occupation, AD43–70/80, sees largely a continuation of the same consumption patterns as in the Late Iron Age. Celery (60%) and coriander (55%) are very frequent in the period one wells. Two additional new plant foods are present: fennel and sweet cherry. Fennel is a perennial herb, and its absence from pre-Roman deposits in Britain shows it to be a Roman introduction. Overall, fennel is rare in Roman Britain, associated mainly with major towns, and it decreases in frequency from the Early Roman period (Van der Veen et al., 2008). The status of sweet cherry is debated, but it is most likely to be a Roman introduction (Moffett et al., 1989). Cherries are found at all site types in Roman Britain, and increase in frequency over time (Van der Veen et al., 2008).

The presence of these plant foods alongside much larger quantities of stable flooring material and hay disposed of in the wells hinders the interpretation of the higher frequencies of celery and coriander, as opposed to fennel, olive and sweet cherry. The plant foods may have originated from human faecal material, food preparation waste or from horticultural plots within the Insula IX area. Considering only the flavourings which would have been subject to similar methods of food preparation, it is clear that celery and coriander were much more frequent occurrences in the refuse material dumped into the wells than fennel. This pattern may be interpreted as evidence that horticulture was being undertaken. These flavourings are recorded across a range of deposit types (Table 6), showing they were present in the background settlement noise, and not just as components of refuse dumped into wells. In contrast, dill and fennel seeds are only found in dumped well-contexts (Table 6). When primary fills were sampled, as in the case of context (6923) from well 5791, 15% of the identified seeds were celery, indicating that there was a consistent source of celery seeds in the near vicinity throughout the period that the well was in use. Alternatively, this pattern may indicate that celery and coriander were being used more frequently in food preparation, hence more common occurrences in refuse deposits.

The substantial assemblage of Early Roman waterlogged samples from Insula IX has shown a strong continuity in plant food diet before and after the Roman conquest. Rather than a ‘Romanising’ diet, this shows that plant foods were selectively chosen c. 20BC–AD20 for a range of reasons (Lodwick, 2014) and continued to be popular post-conquest. When compared to the evidence for the presence of imported plant foods across Roman Britain in the first century AD, the range of foods consumed at Silchester appears restricted. At the administrative and trading centre of London, numerous Roman exotics were being consumed in the Early Roman period including fig and mulberry (Livarda and Orengo, 2015). Military populations also had access to exotics such as dates as seen at the colonia at Colchester c. AD60/61 (Murphy, 1984). Given that waterlogged preservation is the best form of preservation for preserving non-cereal plant foods (Jacomet, 2013) and considering the large number of seeds and samples studied, the absence of certain exotic plant foods in the Claudio-Neronian period at Silchester appears genuine. This relative conservatism in the selection of the range of new plant foods available following the Roman invasion parallels the ceramic evidence at British oppida, which indicates a continuation in Late Iron Age consumption patterns, as Gallo-Belgic ceramics continued to arrive at oppida post-conquest through traders, independent of the military supply to forts and emerging urban centres (Pitts, 2010, p. 45).

5.5. Agricultural innovations at Silchester and beyond

The detailed analysis of waterlogged plant remains from Late Iron Age and Early Roman occupation within the Insula IX area of the oppidum at Silchester have shown that agricultural practices included the production of hay and flax. Of the models presented in section 1, these support the model of agricultural innovations, albeit with a focus on animal foddering. Considering the development of the oppidum at Silchester, flax cultivation, hay meadow management and animal stabling are not evidenced from the earliest well, 10421 (Table 5). Neither did the small waterlogged assemblages studied from two contemporary wells at the forum-basilica site (Jones, 2000) show any evidence for these activities, although spatial variation in settlement activity is a possible explanation for this absence. Furthermore, no evidence for hay management and animal stabling is present in the surrounding region, with very limited evidence for flax cultivation (Lambrick and Robinson, 2009, p. 254). This implies that the change in agricultural practices was a response to, rather than a driver of, the urbanisation process. The dense settlement and presence of non-agriculturalists (craft specialists and elites) would have required novel methods of food production. Whilst these practices may have been a reaction of the occupants of Silchester to settlement nucleation, they may also have been introduced by new arrivals at the settlement, such as immigrants from northern France (Fulford and Timby, 2000, p. 64), obsides (Creighton, 2006) or the Roman military. The intensification of fodder management, with increased labour inputs per area, may have freed up areas of land for the expansion of cereal cultivation (cf. Williamson, 2003, p. 169), a hypothesis which the ongoing analysis of charred plant remains will inform upon. There is currently no evidence for surplus cereal production at Insula IX, such as storage pits or high density deposits of charred cereal grain. The ongoing analysis of charred plant remains will provide further insights, and quantitative regional synthesis is required to confirm whether these practices were indeed absent in the Iron Age Thames Valley (Lambrick and Robinson, 2009) and do indeed represent agricultural innovations taking place at Silchester.

Beyond providing insights into the process of settlement nucleation, the agricultural practices identified at Silchester also provide tentative evidence for the social organisation of the community resident at the oppidum (Hill, 2011, p. 253). The consumption of imported plant foods during the Late Iron Age supports the common argument that elites or kings were drawing on imported material culture to assert their status (Van der Veen, 2007). However, celery and coriander become so common in the Early Roman period that they suggest a wider portion of society was adopting these new flavours, although the presence of these plant foods in refuse deposits hinders further interpretation. In contrast, hay meadow management and flax cultivation both point towards a level of social organisation beyond the household level. The successful management of hay meadows relies on enclosing an area of alluvial meadow in April/May to prohibit grazing of the grassland (Greig, 1984, 1988b). Rapid labour mobilisation is required to harvest the hay in the short time-window in July when hay ripens, and the transport and drying of cut grassland material to the oppidum would have potentially drawn on labour resources beyond the household level. The limited distribution of waterlogged samples within chronological phases at Insula IX hinders an exploration of how many households were engaged in hay meadow and flax cultivation.

Whilst the analysis of waterlogged plant remains from Insula IX has informed upon the relationship between agricultural practice and urbanisation, a wider comparison is limited by the archaeobotanical datasets available. Within Britain, the only oppidum with well studied archaeobotanical remains is Stanwick, Yorkshire. Charred plant remains indicate the onsite processing of spelt wheat, grown under an extension cultivation regime with low levels of soil disturbance and fertility (Van der Veen, forthcoming). Regarding the archaeobotanical record available from European oppida, there is a general lack of waterlogged plant remains with which to compare evidence of foddering and oil crops. Charred plant remains indicate the cultivation of cereals consistent with those of the surrounding Iron Age settlements, as at Boviolles (Bonaventure et al., 2014), Kelheim, Bavaria (Küster, 1993), Bibracte (Durand and Wiethold, 2014) and Staré Hradisko (Danielisová and Hajnalová, 2014). Yet, the spread of new plant foods before Roman expansion has also been evidenced in the Aisne valley, where celery has been identified at Damary and Villeneuve St Germain (Bakels, 1999). The identification of charred crop-processing residues further confirms that crops were being processed on site, as at Manching (Küster, 1998). Evidence for large-scale crop storage appears to be restricted to the Augustan phases of oppida in France, evidenced by large charred storage deposits of cereal grains at Boviolles (Bonaventure et al., 2014) and Bibracte (Durand and Wiethold, 2014).

The development of oppida is a broad and variable process, yet following the site specific case study of Silchester and this brief European comparison, a number of trends can be identified. First, this phase of urbanisation is not associated with any changes in the range of staple crops cultivated, or a separation of cereal-processing from oppida settlements. Rather, the spread of new flavourings is evidenced at several sites. Second, the activities of animal-focussed, plant-management strategies were evidenced at Silchester, but the implications for the broader understanding of oppida urbanisation requires the sampling and analysis of further settlements with the preservation of waterlogged plant remains. In order to fully investigate the relationship between agricultural changes and urbanisation in the later 1st millennium BC, it is crucial to evaluate each site on an individual basis and with multiple lines of palaeoenvironmental and bioarchaeological evidence. The incorporation of further lines of archaeological and environmental datasets with those presented in this paper will allow the interpretations made here to be evaluated. Despite the large-scale excavations within the Insula IX area, the low number of wells producing waterlogged plant remains and the dominance of dumped midden material as opposed to gradual accumulations, limits the inferences that can be made concerning the spatial distribution of activities within the Late Iron Age and Early Roman settlement. The continued application of bulk sampling to Silchester itself and other oppida will ensure the models proposed here can be investigated more fully.

6. Conclusion

This paper has reviewed the models of agricultural practices at oppida, and presented the first detailed analysis of waterlogged plant remains from an occupation area within a British oppidum spanning the Late Iron Age—Early Roman transition. Whilst previous considerations of the relationship between agricultural change and late first millennium BC urbanisation have lacked any rigorous archaeobotanical analysis, this research has produced evidence for flax cultivation, hay meadow management, the stabling of animals, and the consumption of new plant foods. This archaeobotanical evidence indicates that the production of fodder for animals stabled within Silchester was an aspect of agriculture, potentially as a reaction to the settlement nucleation taking place from c. 20BC onwards. The evidence available currently fits best with models of agricultural innovation, in reaction to, rather than a driver of, urbanisation. Quantitative regional synthesis of archaeobotanical data is required to establish to what extent these agricultural practices were restricted to the oppidum at Silchester.

The identification of stable flooring material has only been possible through the detailed contextual analysis of anthropogenic waterlogged plant remains. These findings of the practice of foddering at Silchester, must be evaluated further by ongoing analysis of charred plant remains from Insula IX, and by a number of archaeological (ceramics, zooarchaeological data) and multiproxy palaeoenvironmental methods at the site and landscape level (Fulford et al., forthcoming). The plausibility of evaluating these results against British oppida and more broadly across Europe is reliant on the continued systematic study and analysis of plant macrofossils, alongside further bioarchaeological and geoarchaeological techniques, and comparison of these results with those from sites in the environs of oppida (Moore et al., 2013).

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.quaint.2016.02.058.

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