The later Iron Age in north-west Europe is characterised by major changes such as the appearance of fortified oppida and new burial rites. This study examines the absolute chronology of the adoption of cremation burial in southern England through radiocarbon dating of human bone from the late Iron Age cremation cemetery at Westhampnett (West Sussex). The earliest and second largest of its type in Britain, the cemetery occupied a low but prominent hill in the coastal plain, some 9 km from the modern coast and 4 km east of the modern city of Chichester (West Sussex) (Fig. 1).

Some 161 graves, four shrines and numerous pyre sites were found when the cemetery was excavated in 1992 before a new road was built. In the early Bronze Age, a ring ditch had been constructed on the hill and this monument may have provided the focus for the Iron Age cemetery. The use of space was strongly defined: the shrines and pyres lay in discrete areas, and the graves were arranged around a circular space with later burials added to the periphery. Within this distribution, a minority of well-furnished burials appeared to have been the foci for small clusters of graves. As the graves rarely intercut it is likely that they were marked in some way.

The burials were un-urned, but most of the graves contained pottery, including some early wheel-made vessels, which were placed as grave goods, and about a quarter contained brooches or other metal objects that had accompanied the deceased on the pyre (Fig. 2). The number of burials suggested that the cemetery was used by a number of settlements. All the graves, pyres and pyre-related features (i.e. features that contained pyre-debris, but were not pyres) were whole-earth sampled in order to retrieve as much evidence as possible.

In addition to the Bronze Age ring ditch and the Iron Age cemetery, the low hill was also the site of a small Romano-British cremation cemetery (1st–2nd century AD) and a small Anglo-Saxon inhumation cemetery (5th–7th centuries AD). Both later cemeteries were also fully excavated but are not considered here. The excavations around the hill yielded evidence for occupation for all the periods between the Late Upper Palaeolithic and the Anglo-Saxon, and some flints of Neolithic date were found on the hill itself.
Changing chronologies: the 1997 report and subsequent changes to Late Iron Age chronologies

The monograph on the Westhampnett cemeteries was published in 1997. At that time it was not possible to radiocarbon date cremated human bone and the modest budget available for dating was applied to the Late Upper Palaeolithic-Early Bronze Age evidence from the road scheme, as it was considered that the scientific dates would be more helpful for these periods.

The dating of the Iron Age cemetery relied on the pyre and grave goods, especially the brooches. This was not without its difficulties as, whilst widely distributed in continental Europe, where they are typical of the La Tène D1 and D2 horizons, the brooches were relatively rare types in Britain. Three main categories are represented (Fig. 3). One-piece filiform brooches with external chords and short 2- or 4-coil springs predominate (Feugère Type 2a–b) but there were three brooches with internal chords belonging to the Nauheim family (Feugère Type 5a–b) and seven boss-on-bow brooches of the Almgren 65 series (Feugère Type 8b). No brooches definitely of La Tène C construction were present.

The cemetery dating consequently rested on the continental typo-chronologies for these brooches, which had very recently undergone a major revision, resulting in a significantly earlier start for La Tène D1. The fragmentation caused by the process of cremation, the transfer of the brittle objects to the grave, and subsequent post-depositional disturbance (mainly by ploughing) made it difficult to distinguish between earlier or later varieties of iron filiform brooches. However, the relatively curved bows of the more complete brooches were considered closer to examples attributed to La Tène D2a by Miron. While acknowledging the earlier appearance of Nauheim and filiform types on the continent, the Westhampnett brooches were attributed to a period straddling La Tène D1b–D2a and a date range for the cemetery of 100–40 BC was suggested, with a preferred range within that of 90–50 BC.

Few other metal objects from the cemetery were from well-defined groups with relatively secure typologies and chronologies. These were a winged belt-hook, an iron razor, and a British gold coin. The pottery assemblage was considered to occupy a transitional date between the local Middle Iron Age Saucepan pottery tradition (the St Catherine's Hill/Worthy Down style) and Late Iron Age pottery of the 'Aylesford-Swarling' tradition best known from cremation burials in south-east England. However, the typological affinities of the assemblage were considered to be as much with lower Normandy, and to a lesser extent...
Armorica, as within Britain. As the spatial organisation of the cemetery seemed to have been established, the site was regarded as only having a single phase. While cautious in relation to Miron’s chronology for the Saar-Moselle region, the preferred date range of 90–50 BC for Westhampnett represented a significantly earlier dating for the adoption of cremation burial in England, which had previously been dated to after c. 50 BC.

With its fine-grained and seemingly well-dated evidence, Westhampnett has become a reference site for late Iron Age mortuary rituals and chronology in southern Britain, but 20 years on, the time has come to revisit the dating.

Firstly, a series of studies using Bayesian modelling to develop independent radiocarbon chronologies for later Iron Age artefact typologies have yielded earlier than expected dates for insular metalwork previously dated by reference to the continent. Some of the dates obtained in these programmes are not without their difficulties, and will be discussed elsewhere, but others raise questions about the accepted chronologies. To give one example, modelled dates for two Arras-culture inhumation burials in East Yorkshire in northern England imply that one-piece filiform brooches of late Iron Age form appeared before the mid-2nd century BC. Although the brooches in question have solid rather than framed catch-plates like the Westhampnett examples, and would generally be considered to be typologically later, they pose questions about the accepted dating of the series that need to be addressed.

Secondly, the chronology of the presumed continental brooch prototypes is also open to question. The start of La Tène D1b west of the Rhine, for which Nauheim and one-piece filiform brooches are one of the principal markers, is usually set around 120 BC, but a date of 130 BC has been advocated in some areas. Independent evidence that would resolve the matter is not only in short supply but also, particularly where it takes the form of dendrochronological dates from loosely associated pieces of wood, it is sometimes open to question.

Moreover, dating the start of La Tène D1b establishes when these brooch types became widespread, not when they first appeared. In Lorraine, some contexts containing early varieties of Nauheim brooch are now thought to belong to an earlier phase of La Tène D1. One-piece iron filiform brooches with external chords and long springs occur regularly in La Tène D1a graves in eastern France and in the Bern region (CH) the type is suggested to have appeared between 160-125 BC. These brooches have longer springs than the examples from Westhampnett, but show that filiform brooches developed from La Tène C2
types rather than from the Nauheim \(^{15}\). Lastly, boss on bow brooches related to the Almgren 65 – the latest form at Westhampnett – are recorded in La Tène D1 contexts \(^{16}\), which may also have implications for the end date of the cemetery.

Thirdly, radiocarbon dating of calcined bone is now widely applied to prehistoric burials of all periods across north-west Europe \(^{17}\), including the Iron Age \(^{18}\). Allied to Bayesian modelling, which allows archaeologists to date events to margins of decades rather than centuries \(^{19}\), it should be possible to develop robust chronologies for cremation burial cemeteries that provide a similar level of precision to artefact typo-chronologies. Westhampnett provides a good test case; quite apart from the merits of revisiting any chronology that is now 20 years old in the light of current understanding, the presence of brooches in many of the graves allows us directly to confront the two forms of dating. Any addition to the limited corpus of independent dates for the brooch types that form a mainstay of late Iron Age chronologies on both sides of the Channel has to be of value. More widely, the study could open the way to the systematic dating of cremation burials across central and western Europe, which are widely seen as a diagnostic trait of the late La Tène.

It was clear, therefore, that successful radiocarbon dating of the Westhampnett cemetery could have a significance reaching far beyond southern England. The radiocarbon dating programme reported on here was undertaken with the aid of a grant from the UK Natural Environment Research Council (NERC) Radiocarbon Facility for Archaeology.

#1#Radiocarbon dating cremation burials

The method of pre-treating calcined bone to enable radiocarbon dating was first published by Lanting et al. \(^{20}\). Before this it was impossible to date calcined bone. An inter-laboratory study by Naysmith et al. \(^{21}\) showed good reproducibility of radiocarbon dates on cremated bone by six laboratories, demonstrating the technical method to be reliable. Unlike the radiocarbon age produced from extracted bone collagen (i.e. from an inhumation burial), which dates the death of the individual, the processes of cremation are such that the radiocarbon measurement on this material directly dates the cremation. A potential problem for interpretation is the possibility for carbon exchange between the bioapatite, the datable fraction of the cremated bone, and the carbon (CO and CO\(_2\)) in the pyre ‘atmosphere’ that is derived from the fuel source. This possibility for exchange has been demonstrated using both controlled laboratory cremation \(^{22}\) and small real-world experiments on joints of animal meat \(^{23}\). While the processes are not fully understood, for an offset to occur requires the pyre fuel to contain ‘old’ carbon (i.e. coal, old growth wood, or even peat).
Although the analysis of the charcoals found in the pyres at Westhampnett indicated a preponderance of roundwood from coppices that were managed to provide fuel \(^{24}\), the occurrence of iron nails and structural fittings in almost every pyre site and pyre-related feature strongly suggests that some wooden objects and/or seasoned timbers were re-used as fuel \(^{25}\). In practice, the need to sustain temperatures of over 700°C for several hours in order to cremate the corpse \(^{26}\) and for the pyre to maintain its shape in order to provide the heat to do this means that seasoned timbers, probably of oak, were almost certainly used \(^{27}\). The intense heat generated by the pyre when it is alight means that it is not possible to approach the pyre in order to add fuel once the whole pyre is alight. The rarity of charcoals from heartwood amongst the excavated charcoals at Westhampnett may be due to these timbers being reduced to ash (presumably because they were left to burn overnight and it was only possible to approach the pyre the following morning). The smaller, coppiced, timbers may have been placed both within and around the pyre and it may be that the only the smaller timbers that were placed around the pyre and fell away from it survived as identifiable charcoals. Therefore as a precaution, replicate measurements on charred seeds or roundwood charcoal from 10 graves were sought as a cross-check on the cremated bone results. This has been shown to demonstrate the reliability of the bone measurements for accurately dating cremation burials \(^{28}\).

Simulation models were run to estimate the number of samples needed to establish the date and duration of the cemetery, and to investigate whether there was discernible spatial and chronological patterning between the graves. As well as dating all graves with identifiable brooches, a representative sample of graves without brooches was also dated because brooches may not have featured in the funerary rites throughout the lifetime of the cemetery. Graves containing other typical late Iron Age objects such as locally-made copies of Armorican wheel-made pottery were also dated, as was the one grave with a funerary monument (grave 20566). To accommodate a longer timespan than the 40–60 years proposed in 1997, multiple simulations were created that allowed for the cemetery to have been used for up to 100–150 years. These models estimated that 50–55 dates were required, including replicate measurements on 10 graves.

#Methodology

A total of 54 samples from 44 of the 161 cremation graves (27%) were submitted to the Oxford Radiocarbon Accelerator Unit (ORAU) for dating by accelerator mass spectrometry (AMS). All the samples were single entities \(^{29}\). They consisted of a single fragment of
cremated bone from each of the 44 burials (Fig. 4) and ten samples of non-human material from nine burials to test for offsets in the dates of the cremated bone. Six of the replicate samples consisted of carbonized cereal remains, along with a charred hazelnut shell, fragments of hazel and ash charcoal and a piece of cremated sheep long bone. All of these samples were found amongst the cremated bone. Only a small minority of graves contained material suitable for replicate samples.

The samples were pre-treated following methods detailed in Brock et al. 30 and have been calibrated using the internationally agreed IntCal13 calibration curve of Reimer et al. 31. There was insufficient charred material for dating in one replicate sample (20601b), but three auto-replicate dates were generated as part of the ORAU internal Quality Assurance procedures, giving a total of 56 determinations (Table 1).

Five of the eight pairs of samples have radiocarbon measurements that fail a chi-square test (Table 2) 32. As the paired samples were of short-lived material, there was no reason to expect any offset in age. For three pairs, the result from the replicate is clearly too early. The hazel charcoal from grave 20095 dates from the Neolithic, whilst the charred cereal from graves 20089 and 20245 is of earlier Iron Age date. The charred hazelnut shell from grave 20170 dates to the late Iron Age, but fails the chi-square test and so appears to be residual in this grave. On the other hand, the late Iron Age cereal in grave 20018 would seem to be intrusive, as it is younger than its pair.

These discrepancies are not particularly surprising in view of the abundant evidence for earlier activity nearby. This includes Neolithic flints from the hill itself and in general there was a marked increase in settlement on the West Sussex Coastal Plain through the Late Bronze Age and Iron Age 33. Mention should also be made of a grain of bread wheat, submitted as a second replicate from grave 20170, which proved to be modern (OxA-32645, not listed in Table 2). Although rare in Britain during the Iron Age, bread wheat was widely cultivated in France 34, so its presence in a cemetery with strong continental links would have been of considerable interest had the seed proved to be of Iron Age date. Truncation by ploughing and the fact that the burials were un-urned made it comparatively easy for small materials like seeds to be intrusive amongst the cremated bone, as evidently happened in this case and with grave 20018 (above).
The three results among the paired dates that pre-date 500 cal. BC have been excluded from further analysis (OxA-32402, -32445, -32951), but the two that fall broadly within the expected range were both retained, giving a total of 52 dates for modelling the use of the cemetery 35.

These dates are very consistent, apart from OxA-32638 for grave 20566, which is significantly earlier than the others. This grave was the only one to be marked by a monument - a four-post structure set within a small ditched enclosure - and it stood 40 m to the east of the cemetery. The burial was also unusual in being urned rather than being unurned and the pot was the only one in the cemetery with a red slip. This type of funerary monument is well-known known in northern France 36 and this, in conjunction with the type of burial and the pot, led Fitzpatrick to suggest that the dead individual (who was probably female) might be from France. The burial was dated to the Late Iron Age 37.

OxA-32638 shows that the burial is in fact earlier. Although it calibrates across the ‘Hallstatt plateau’ to 745–400 cal. BC (95% probability), the bulk of the probability density is at 540–410 cal. BC (68% probability), but this still seems early compared to French monuments of this type, which lie more in the 4th to 3rd centuries BC. Given the discrepancy in date, it seems prudent to treat grave 20566 as a separate phase and so we have excluded it from the modelling but retained the calibrated probability (in outline) for visual reference in Figure 5. Rather than the larger early Bronze Age ring ditch, it could even have been the focus for the development of the cemetery; it lies due east of the centre of the circular space around which the late Iron Age cemetery seems to have been organised (see Fig. 4 above) 38.

In developing the dating models for the cemetery it is important to provide an explicit assumption regarding the distribution of the dates through time. Most models make use of the ‘Uniform Prior’, which effectively acts as a binary switch, where at one moment in time there is no activity and then there is, after which activity occurs relatively uniformly at a maximum level until it ceases, in the same binary manner as it began. Willis et al. have argued, however, that the Uniform Prior is not to be preferred where there is no archaeological information to suggest this abrupt increase in activity 39. In modelling the chronology of the 4th millennium BC cremation burials in the Aubrey Holes at Stonehenge (Wiltshire), Willis et al. chose a ‘Trapezium Prior’ model 40, which assumes a gradual increase in activity during the Neolithic, leading to a period of full and constant use, and then a gradual decline. This form of model also allows the tempo of activity to be estimated between the first or last uses of the cemetery and the middle period in which activity was at its peak 41.
The initial or Primary chronological model (Fig. 5) utilises all 51 dates for the principal phase of late Iron Age cremation burial. No stratigraphic relationships are modelled between results. This model has good agreement between the radiocarbon dates and the assumption that the material dated is from a 'trapezium' distribution, that is to say that it all belongs to a single phase of relatively continuous activity (Amodel=97). This Primary model estimates that cremation started at Westhampnett in 270–185 cal. BC (95% probability; Fig. 5; start: Westhampnett (Primary)), probably in 245–205 cal. BC (68% probability). Peak use began in 220–105 cal. BC (95% probability; Fig. 5; end start: Westhampnett (Primary)), probably in 210–145 cal. BC (68% probability). Cremation began to decline in 165–50 cal. BC (95% probability; Fig. 5; start end: Westhampnett (Primary)), probably in 140–80 cal. BC (68% probability). The activity ended in 130–20 cal. BC (95% probability; Fig. 5; end end: Westhampnett (Primary)), probably in 100–40 cal. BC (68% probability). The total span of dated activity was 85–225 years (95% probability; Fig. 6; Primary model span), and probably 120–190 years (68% probability). The main floruit of cremation activity took place over a period of 1–145 years (95% probability; Fig. 6; Primary model main floruit), and probably 20–110 years (68% probability).

The start date suggested by this model is a century earlier than the date of 100/90 BC proposed in 1997. More importantly it is several decades earlier that the current date of 130/120BC for the inception of La Tène D1b and the widespread appearance of Nauheim and one-piece filiform brooches west of the Rhine. A shift of several decades might seem relatively unimportant for earlier periods in prehistory, for example in the Early Bronze Age for which the dating of cremated bone has been used extensively in Britain and Ireland, but can alter the narrative quite dramatically when situated on the cusp on the Roman period.

As noted above, Hüls et al. and Snoeck et al. have shown that an age-offset in cremated bone can be induced during cremation. Moreover, as we have also seen, there are good grounds for thinking that seasoned timbers were used in the Westhampnett pyres. Accordingly an Outlier model was constructed that assumed an old-wood offset of unknown age was transferred from pyre material to the cremated bone. This model utilises the dataset from the Primary model and applies a 'Charcoal Outlier Model' to the dates on the carbonised charcoal and cremated bone to see what effect this has on the results. The single year samples (e.g. charred seeds and hazel nutshell) remain in the model as accurately dating the year of their respective deaths. It is assumed that they were burnt on the pyre, for example as tinder to start the fire.
This Outlier model also has good agreement between the dates (A\text{model}=91). It estimates that the start of cremation occurred in $250–100 \text{ cal. BC}$ (95\% probability; Fig. 7; start start: Westhampnett (Outlier)), probably in $235–130 \text{ cal. BC}$ (68\% probability). Peak use began in $210–90 \text{ cal. BC}$ (95\% probability; Fig. 7; end start: Westhampnett (Outlier)), probably in $175–105 \text{ cal. BC}$ (68\% probability). Cremation began to decline in $155–45 \text{ cal. BC}$ (95\% probability; Fig. 7; start end: Westhampnett (Outlier)), probably in $130–75 \text{ cal. BC}$ (68\% probability). The activity ended in $140–15 \text{ cal. BC}$ (95\% probability; Fig. 7; end end: Westhampnett (Outlier)), probably in $110–40 \text{ cal. BC}$ (68\% probability). The total span of dated activity was $1–205 \text{ years}$ (95\% probability; Fig. 8; Outlier model span), probably $50–160 \text{ years}$ (68\% probability). The main floruit of cremation activity took place over a period of $1–130 \text{ years}$ (95\% probability; Fig. 8; Outlier model main floruit), and probably $1–90 \text{ years}$ (68\% probability).

In both models, the probabilities for the end dates of the cemetery are near identical and a high degree of confidence can be placed in these values. Qualitatively, the results are similar, making it difficult to prefer one model over the other. The obvious discrepancy is between the start dates for the Primary and Outlier models, and especially the calculation of when cremation started (e.g. ‘start start’). The difference between start start: Westhampnett (Primary) and start start: Westhampnett (Outlier) is from $–35$ to $135 \text{ years}$ (95\% probability). The negative element stems from the overlap in probabilities, which could reflect the same actual date. On the other hand, these two modelled distributions may differ by as many as $135 \text{ years}$. Interrogating the posterior output for the charcoal outlier indicates there is an offset of $1–78 \text{ years}$ (95\% probability; Fig. 9), and probably $1–21 \text{ years}$ (68\% probability). This suggests that there was indeed sufficient ‘old wood’ in the funeral pyres to induce an offset in the radiocarbon ages of some samples.

Returning to the discrepant start dates it becomes clear that the Outlier model, whilst maintaining much of the probability in the Primary model, has lessened the overall precision in the probability density estimate for start start: Westhampnett (Outlier). This reduces the precision of the dating, but more realistically represents the increased errors in the model associated with the possible uptake of ‘old carbon’ during the cremation process, and so somewhat paradoxically, increases its overall accuracy. Along with the greater consistency with current typo-chronologies, this leads us to prefer the Outlier model and to employ it for exploring some possible chronological patterns within the cemetery.

# Internal chronological patterns
A number of questions about the internal chronology of the cemetery were examined by running queries. Much of this exploration entails the extraction of posterior density estimates from the preferred Outlier model and importing them into groups (e.g. in Query 1 the group is graves without brooches). The earliest and latest probability for the groups are calculated using the First and Last functions in OxCal, in conjunction with the Order function to provide a probability that one ‘event’ pre- or post-dates another. Brief commentaries on the results are given after each query.

#2# Query 1: Are the graves with brooches earlier than those without?

This query was run to investigate whether brooches were placed in graves throughout the life of the cemetery or there were phases at the start and/or end when brooches did not feature in the funerary rite. A plot of the First and Last dates for graves ‘with Brooches’ and ‘without Brooches’ shows no clear chronological distinction (Fig. 10, Query 1), but there is a 69% probability that the graves ‘with Brooches’ (last: with Brooches) ended before those ‘without Brooches’ (last: without Brooches).

#3# Comment: It is possible therefore that brooches were not placed in the latest graves.

#2# Query 2: Relationship of the ‘Inner Circle’ to the remainder of the cemetery

Fitzpatrick suggested that the graves around the edge of the circular space (the so-called 'Inner Circle') might be the earliest 46. His reasons were a) the spatial organisation of the cemetery appeared to have been determined from the start and b) the proportion of typologically early pots from 'Inner Circle graves (5 of 9 biconical bowls of Middle Iron Age tradition). Four ‘Inner Circle’ burials were dated (20087, 20208, 20255, 20274). However, the calculated probabilities for the ‘Inner Circle’ dates fall comfortably within those for the Remaining Dates and do not support the suggestion that these graves are the earliest in the cemetery (Fig. 10, Query 2).

#3# Comment: The location of a grave in the 'Inner Circle' may have been determined by other factors such as the age of the deceased. It is clear that older adults (i.e. individuals certainly or possibly over 45 years of age) were preferentially buried in the 'Inner Circle' 47.

#2# Query 3: Is there any chronological variation between the brooch groups?
The graves with brooches were divided according to the typological categories represented. Group 1 burials contained brooches of Nauheim form (Feugère Type 5a-b) (20169, 20170*, 20235). Group 2 burials contained one-piece filiform brooches with external chords (Feugère Type 2a-b) with either 4-coil (20021*, 20089, 20134, 20179*, 20191*, 20338*, 20368*, 20408*, 20573*) or 2-coil springs (20132, 20252, 20484, 20541, 20543*, 20571, 20610*). The brooches in another three graves are possibly of this type, but were missing their springs (20253*, 20453*, 20605*). Lastly, Group 3 graves contained boss-on-bow brooches (Feugère Type 8b) either in pairs (20601, 20629, 20675) or a singleton (20622). Where graves are asterisked, the brooches are too incomplete to be absolutely certain of the type.

This query was run twice, the first time using the above groups, the second time excluding graves with brooches not certainly identified to type. The results show why a large number of dates are required for robust analysis. Running the query with all the data suggests not only that the deposition of Feugère Type 2 brooches at Westhampnett began before Types 5 and 8b, but also suggests chronological patterning within the Group 2 graves (Fig. 11, Query 3a). There is an 84% probability that burials with Feugère Type 2 brooches with 4-coil springs (Group 2-4) began prior to Group 1 and an 83% probability that they started before Group 3 graves. Moreover, there is a 73% probability that some Group 2 graves with 4-coil spring brooches are earlier than those with 2-coil springs (Group 2-2). It should however be noted that much of the internal chronology is driven by the relatively early date for grave 20338. If this grave is excluded, the query suggests that Group 2 is still the earliest of the three groups, but further comparisons are inconclusive.

When the less certainly identified brooches are excluded, little internal chronology can be teased out, apart from a 74% probability that Group 2 graves began before the first Group 1 graves, and a 73% probability that Group 2 graves began prior to Group 3 (Fig. 11, Query 3b). From this, it would also appear that the start of Groups 1 and 3 was approximately contemporary and both belong to the later stages of the cemetery.

#3# Commentary: An earlier date for filiform brooches with 4-coils would be consistent with their derivation from La Tène C types with 4-coils, such as those from the Bern region 48. Boss-on-bow brooches are known from La Tène D1 contexts 49, but most examples of the Almgren 65 form seem to date to La Tène D2 50. The typologically developed examples from Westhampnett seem unlikely to be as early as the Nauheim brooches, although the Bayesian modelling provides no grounds for separating them.

#2# Query 4: Pottery of Middle Iron Age tradition
The pottery from the cemetery displays a range of typological influences. Some of these influences are from continental Europe but as already noted, a small number of pots are typologically earlier, some appearing to derive from the local Middle Iron Age ‘Saucepan’ pot tradition. Three graves were dated (20051, 20255, 20451), two of which contained biconical-shaped pots related to the Middle Iron Age tradition (20255, 20451). The results indicate that these graves lie early in the span of dated activity (Fig. 12 Query 4), with a start date of 200–95 cal. BC (95% probability; first: MIA pottery dates), and probably 180–115 cal. BC (68% probability). The latest of these deposits was in 155–55 cal. BC (95% probability; last: MIA pottery dates), probably in 135–80 cal. BC (68% probability).

#3#Comment: Some burials accompanied by Middle Iron Age vessels evidently post-date others with late Iron Age forms but there is a 94% probability that Middle Iron Age tradition vessels stopped being placed in graves before the cemetery went out of use. The modelling supports the view that they are one of the earlier types in the cemetery.

#2#Query 5: Copies of Armorican pottery

Four graves contained locally-made copies of Armorican pots (20018, 20471, 20601, 20637). There is an 82% probability that some of the other burials are earlier, but a 91% probability that Armorican copies stopped being placed in graves before the cemetery went out of use (Fig. 12, Query 5).

#3#Commentary: Imported Armorican vessels have been found at the nearby late Iron Age settlement of North Bersted (M. Lyne pers. comm.). There can be little doubt that the locally-made pots from the cemetery are direct copies of such imports. The largest assemblage of imported Armorican pottery in England was found at Hengistbury Head on the Dorset coast, c. 60 km to the west, where they were associated with Dressel 1A amphorae and attributed to the Late Iron Age 1 phase, which Cunliffe dated ‘roughly’ to c. 100–50 BC. The query is not inconsistent with this dating, but can also be taken as indicating that Armorican imports were arriving earlier in the Westhampnett area.

#2#Query 6: Wheel-made pottery

Two graves contained wheel-made pottery (20457, 20650), for which the modelled distributions fall in the 2nd century cal. BC, if not the very end of the 3rd century cal. BC (Fig. 12, Query 6).
Commentary: These graves containing wheel-made vessels were expected to date towards the end of the use of the cemetery, but the modelling does not support this. Wheel-made vessels are found in appreciable quantity at sites in northern France from the middle of the 2nd century BC, but the modelled date for Westhampnett would be exceptionally early for Britain.

Query 7: Coin dating
Burial 20493 contained an uninscribed British O quarter-stater, a rare example of an Iron Age gold coin from a secure archaeological context. The relationship of this grave to the Group 1 and 3 graves containing Nauheim and boss-on-bow brooches was queried (Fig. 12, Query 7).

Commentary: British O quarter-staters are derived from the so-called ‘au Bateau’ series which circulated widely on both sides of the Channel. On numismatic grounds, a date spanning the late 2nd century BC and the first half of the 1st century BC can be argued for the series, including the British derivatives, which copy an early biface variety of the «au bateau» type. The posterior density estimate for grave 20493 falls squarely within the period when Nauheim and Almgren 65 brooches were being deposited at Westhampnett. This supports the broad numismatic dating and additionally suggests that, like these brooches, the British O coin belongs to the later stages of the cemetery.

Lastly, attention may be drawn to the dating of grave 20252, which in addition to the pair of 2-coil filiform brooches, contained a winged belt hook. This is a relatively common object in France and was current in La Tène D1 and into D2.

Discussion

The radiocarbon dating programme for the Westhampnett cemetery is one of the first to date a European later prehistoric cremation burial cemetery. The results demonstrate that the method is valuable, but that further work is necessary.

At the site-specific level, the Bayesian modelling in general terms supports the published dating of the cemetery, which suggested that the cremation rite was adopted in southern England significantly earlier than previously thought. The results also support the view that the cemetery passed out of use around the mid-1st century BC. Although over 50 radiocarbon dates were obtained, the number available for specific types of objects is mostly
small, limiting the confidence that may be attached to the results of the queries, which
nevertheless support the conclusions reached in 1997. Perhaps the most significant
outcome is from Query 3. This suggests that filiform brooches with external chords and 4-coil
springs are earlier than the 2-coil varieties and the Nauheim brooches. This is consistent
with their derivation from La Tène C types.

The significance of the Westhampnett case study is, however, considerably wider and the
following observations may be made. First and most importantly, the results show that
radiocarbon dating of cremated bone provides a reliable independent dating method for the
Iron Age. Cremation was practised across north-west Europe in the later Iron Age and
existing chronologies are largely based on the brooches which are often found in the graves.
In consequence there is potential to develop a chronological framework that both links and
transcends existing regional chronologies. Second, as Query 3 showed, when there are no
stratigraphic controls within the archaeological features from which a set of radiocarbon
dates have been obtained, it may be necessary to obtain a large number of dates for
Bayesian modelling to be effective. The samples dated, whether cremated human bone or
another material, do not affect this observation.

Third, there is a significant difference between the start dates for the cemetery given by the
Primary and Outlier models. Both models are internally consistent so this requires
explanation. No definitive answer is possible on the basis of a single case study, but carbon
exchange between the bioapatite, the datable fraction of the cremated bone, and carbon
(CO and CO₂) derived from the fuel during cremation appears the most likely explanation.
We have suggested above that this may have been caused by the use of old and/or
seasoned timbers on the pyre. Old timbers could have been used for purely functional
reasons, i.e. the need for a slow burning fuel to transform the body, but it is also possible
that old timber, for example from buildings, was deliberately incorporated into the pyres.

The start date suggested by the Primary model is difficult to reconcile with current typo-
chronologies. The date range indicated by the Outlier model which allows for the old wood
effect is also somewhat earlier than expected, but we should not rush to dismiss the
possibility that use of the Westhampnett cemetery began a generation or so earlier than
proposed in 1997. A start date in the mid to late 2nd century BC would be consistent both
with the mounting Continental evidence for the use of one-piece filiform brooches with
external chords during La Tène D1a (c. 150–120 BC) and our results suggesting that 4-coil
brooches of this type were the earliest in the Westhampnett cemetery. Both models also
suggest that the cemetery could well have been used for somewhat longer than the half century originally proposed.

In conclusion, radiocarbon dating of cremated bone provides a valuable dating technique for the later Iron Age in north-west Europe. Further case studies and more methodological research are needed, but the technique has the potential to help develop a systematic and independent chronological framework with which to assess the dramatic changes that characterised the later Iron Age.

#1#Acknowledgements
The programme of radiocarbon dating reported here was undertaken with the aid of a generous grant (NF/2015/1/20) from the UK Natural Environment Research Council (NERC) Radiocarbon Facility for Archaeology. We are most grateful to Professor Tom Higham and his colleagues at University of Oxford Radiocarbon Accelerator Unit where the dating was carried out; to Amy Roberts, Collections Officer at the Novium, Chichester, for facilitating the research and the retrieval of samples from the excavation archive; to Malcolm Lyne for providing information about the pottery from the unpublished excavations at North Bersted; and to Dr Jo Appleby and Professor Marijke van der Veen of the School of Archaeology and Ancient History, University of Leicester, for confirming sample identifications.

Illustration captions

Fig. 1 Map showing the location of the Westhampnett cremation burial cemetery

Fig. 2 Two representative graves from the cemetery selected for dating (from Fitzpatrick 1997; metalwork 1:2; pottery 1:4). The modelled radiocarbon probabilities are also shown.

Fig. 3 Principal types of brooches from the cemetery. The brooches illustrated are all of iron apart from those from graves 20622 (silver) and 20484, 20609 and 20675 (all copper alloy)

Fig. 4 Plan of the Westhampnett cemetery showing the location of the dated graves. The first two digits (20) are omitted from the burial numbers.

Fig. 5 Primary chronological model for Westhampnett using the trapezium prior (Lee and Bronk Ramsey 2012). Each distribution represents the relative probability that an event occurred at some particular time. For each of the radiocarbon measurements two distributions have been plotted, one in outline, which is the result of simple radiocarbon
calibration, and a solid one, which is based on the chronological model used. The other distributions correspond to aspects of the model. For example, 'start start: Westhampnett (Primary)' is the estimated date that this phase of cremation burial activity began on the site, based on the radiocarbon dating results. The large square 'brackets' along with the OxCal keywords define the overall model exactly.

**Fig. 6** Probability distributions for the overall span of activity associated with the cremation cemetery *(end end: Westhampnett (Primary)–start start: Westhampnett Primary)* and for the span of the main floruit of activity *(end start: Westhampnett (Primary)–start end: Westhampnett (Primary))*, as derived from the modelling shown in Figure 5.

**Fig. 7** Alternative chronological model for Westhampnett, incorporating a 'Charcoal Outlier Model' to account for the uptake of 'old carbon' in the cremated remains. The structure is as given in Figure 5.

**Fig. 8** Probability distributions for the overall span of activity associated with the cremation cemetery *(end end: Westhampnett (Outlier)–start start: Westhampnett (Outlier)) and for the span of the main floruit of activity *(end start: Westhampnett (Outlier)–start end: Westhampnett (Outlier))*, as derived from the modelling shown in Figure 7.

**Fig. 9** Charcoal Outlier posterior showing the probability for the ‘old wood’ offset across these samples.

**Fig. 10** Probability distributions for the start and end dates for the graves identified in Queries 1–2.

**Fig. 11** Probability distributions for the start and end dates for the graves identified in Query 3.

**Fig. 12** Probability distributions for the start and end dates for the events and graves identified in Queries 4–7. The probabilities first: *Brooch Group 1* and last: *Brooch Group 3* are from the more conservative model that excludes those brooches that cannot be confidently placed into these two categories (see Query 3b).
Table 1 Radiocarbon results for the Westhampnett burials. Radiocarbon measurements denoted by an * are internal auto-replicates measured as part of the ORAU internal QA procedures.

Table 2 Chi-square test results for paired samples from eight of the 44 cremations. (A sample of bread wheat submitted as a second replicate from grave 20170 proved to be modern and is omitted; OxA-32645).

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Abstract
The work reported here is one of the first systematic radiocarbon dating studies of a Late Iron Age cremation burial cemetery. The Westhampnett cemetery in southern England was excavated before it was possible to date cremated bone. The 1st century BC date (La Tène
D1b-D2a) for the site proposed in the 1997 publication was based on brooches present in the graves and their continental parallels. 44 of the 161 cremation burials were radiocarbon dated (27%) and the results modelled using Bayesian statistics. Two models are presented, the ‘Primary Model’ and the ‘Charcoal Outlier Model.’ The latter model addresses the potential problem of carbon exchange between the bioapatite (the datable fraction of the cremated bone) and the carbon (CO and CO₂) from the fuel for the pyre, which could be earlier in date (i.e. an ‘old wood effect’). Both models are internally consistent and suggest the same end date for the use of the cemetery. However, the early start date suggested by the ‘Primary Model’ is difficult to reconcile with current typo-chronologies for the brooches. The start date indicated by the ‘Charcoal Outlier Model’ is also earlier than expected but not incompatible with recent continental dating for one-piece filiform brooches. Whilst further studies are needed, it is clear that radiocarbon dating of cremated bone has great potential to help develop a more rigorous independent chronological framework for the Late Iron Age across Europe.

Notes

1 Fitzpatrick 1997.
3 Fitzpatrick et al. 2008.
9 Garrow et al. 2009; Hamilton et al. 2015.
10 Jay et al. 2012, 184.
11 e.g. Barral et al. 2012, 13.
16 Haselgrove 1997; Edgar 2012.
17 Bradley et al. 2015.
e.g. De Mulder et al. 2007.

e.g. Hamilton et al. 2015.

Lanting et al. 2001.

Naysmith et al. 2007.

Hüls et al. 2010.

Snoeck et al. 2014.

Gale 1997.


Gale 1997, 82.

De Mulder et al. 2007; Olsen et al. 2008.

Ashmore 1999.

Brock et al. 2010.

Reimer et al. 2013.


Fitzpatrick et al. 2008, 140, 186.


Modelled dates are shown in italics along with their probability e.g. 1–145 years (95% probability).

e.g. Bradley et al. 2015, 317–318, fig 7.21.

Fitzpatrick 1997, 236.

Fitzpatrick 1997, 10–12, 234–237; fig. 37.

Willis et al. 2016.

Lee and Bronk Ramsey 2012.

Willis et al. 2016.

e.g. Brindley 2007; Sheridan 2007; Sheridan and Bayliss 2008.

Hüls et al. 2010; Snoeck et al. 2014.


Bronk Ramsey 2009.

Fitzpatrick 1997, 203–204, fig. 113

Fitzpatrick 1997, 234, fig. 123.


Haselgrove 1997; Edgar 2012.

e.g. Demetz 1999; Poux et al. 2007.
Cunliffe 1987, 75.

e.g. Gransar and Pommepuy 2005.

Scheers 1977, no. 13; Delestrée 1996.


e.g. Bataille 2001, his Type 4E2.
References


Stevenson 2013: J. Stevenson, Living by the Sword. The archaeology of Brisley Farm, Ashford, Kent. Spoilheap Monograph 6 (Portslade 2013).


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Figure 3

filiform F2a

20571

20132

20541

F2b

20089

20134

20484

Nauheim F5a

20169

20235

20170

F5b?

boss-on-bow F8b

20622

20629

20675

20601

1cm
Figure 4
Figure 11
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**Mean 20453**

| T’=0.5; ν=1; T'(5%)=3.8 |
| 2075 ±20 |

| OxA-32632 | 20457 | Cremated human bone | −26.29 | 2196 ±28 |
| OxA-32633 | 20471 | Cremated human bone | −20.91 | 2158 ±37 |

| Mean 20453 | |
| 2075 ±20 |

| OxA-32634 | 20479 | Cremated human bone | −21.07 | 2132 ±28 |
| OxA-32635 | 20484 | Feugère 2b 2-coil, copper alloy | Cremated human bone | −23.56 | 2116 ±28 |

| OxA-32636 | 20493 | British O gold quarter-stater | Cremated human bone | −19.74 | 2105 ±26 |

| OxA-32637 | 20541 | Feugère 2a 2-coil, iron | Cremated human bone | −16.71 | 2112 ±26 |
| OxA-32956 | 20543 | Feugère 2a? 2-coil, iron | Cremated human bone | −22.64 | 2082 ±32 |

| OxA-32638 | 20566 | Cremated human bone | −18.41 | 2422 ±27 |

| OxA-32639 | 20571 | Feugère 2a 2-coil; iron knife; iron latch lifter | Cremated human bone | −18.83 | 2034 ±32 |
| OxA-32640 | 20573 | Feugère 2a? 4-coil, iron | Cremated human bone | −20.06 | 2115 ±26 |

| OxA-32957 | 20637 | Cremated human bone | −25.12 | 2058 ±31 |

| OxA-32644 | 20675 | Cremated human bone | −19.44 | 2080 ±29 |

| British O gold quarter-stater | 2075 ±20 |

| 190–70 cal BC |

| 205–75 cal BC |

| 185–65 cal BC |

| 175–60 cal BC |

| 180–65 cal BC |

| 180–60 cal BC |

| 170–60 cal BC |

| 190–70 cal BC |

| 165–60 cal BC |

| 170–70 cal BC |

| 165–55 cal BC |

| 205–75 cal BC |

| 170–60 cal BC |