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Research Article

New temporal dimensions of the Linearbandkeramik cemetery horizon in Schwetzingen (Germany)

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Cemeteries of the Early Neolithic Linearbandkeramik culture (LBK, 5500–4900 BC) evoke a sense of emerging permanence of place as agricultural subsistence spread westward through Central Europe. Yet assumptions about the sequence of senescence and longevity of cemetery use are based on limited data. Here, the authors challenge the view that cemetery burial was a long-lasting Neolithic practice, modelling 50 new radiocarbon dates from the cemetery of Schwetzingen alongside published dates from eight other LBK mortuary contexts. The results, they argue, indicate a short-lived, largely contemporaneous cemetery horizon across Central Europe, forcing a re-evaluation of Early Neolithic social history.

Keywords: Central Europe, Early Neolithic, Linearbandkeramik, radiocarbon dating, Bayesian modelling, cemeteries

The temporality of cemetery burial during the Neolithic

Cemeteries are often modelled as stable sites, receiving burials at a constant rate over an extended period of time. They have generally been regarded as not easily subject to change and, to a certain extent, representing the 'norm' in a given social context (cf. Sayer 2020). While some scholars have challenged this assumption, suggesting that

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Neolithic cemeteries may have developed more dynamically (e.g. Nieszery 1995; Jeunesse 1997; Bentley & Knipper 2005), the lack of precise chronological data has limited independent testing of this hypothesis. However, advances in radiocarbon dating and the increasing availability of dated sites are revealing that some Neolithic funerary practices had shorter durations than previously thought (Whittle *et al.* 2011; Chambon *et al.* 2018; Pons *et al.* 2018).

This article contributes to this discussion by presenting new radiocarbon dates from the Early Neolithic cemetery of Schwetzingen (south-western Germany) and drawing wider comparisons to other dated Linearbandkeramik (LBK) cemeteries and funerary contexts across Central Europe (*c.* 5500–4900 cal BC). Using Bayesian modelling, we explore the timing and duration of LBK cemetery use, questioning whether these sites developed gradually or were instead short-lived and simultaneous across different regions of Central Europe.

The Linearbandkeramik cemeteries

The LBK represents the first farming society across Central Europe, occupying an area of more than 2000km, stretching from east of the Vistula in Poland to the River Seine in the Paris Basin. Single inhumations in large cemeteries account for the largest percentage of burials attributed to this archaeological culture, and are the basis for the main LBK social models, including those addressing social hierarchies (Jeunesse 1997), gender inequalities (Bickle 2020; Augereau 2022), sexual division of labour (Masclans *et al.* 2021) and kinship (Childebayeva *et al.* 2022; Gelabert *et al.* 2024). These models often assume that cemeteries represented the norm or the dominant burial rite in the LBK. Although several scholars have questioned the representativity of the single inhumation rite, notably by pointing to the absence of cemeteries in certain LBK regions (Frirdich 1994; Hofmann 2009), the chronological character of this practice has rarely been questioned (see van de Velde *et al.* 1979: 44).

Cemetery burial is thought to begin after 5300 cal BC, as part of a trend to greater variability in the contexts in which human remains from the LBK are found (Müller-Scheeßel *et al.* 2021). While intramural burials are found within settlements across the geographic and temporal distribution of the LBK, the use of cemeteries as dedicated areas for the dead is considered to begin with Vedrovice–Široká u lesa in south-eastern Czechia, *c.* 5300–5200 cal BC (Zvelebil & Pettitt 2013), spreading progressively westwards thereafter and clustering before the culture disappears from the archaeological record around 4900 cal BC (Farruggia 2002).

In many cases, the duration of cemetery use is estimated from ceramic chronologies or a few radiocarbon dates; formal statistical modelling is not often attempted. A growing number of radiocarbon dates are, however, available from several cemeteries, including Nitra-Horné Krškany (Slovakia; Griffiths 2013), Vedrovice-Široká u lesa (Czech Republic; Pettitt & Hedges 2008), Kleinhadersdorf (Austria; Stadler 2015) and Stuttgart-Mühlhausen (south-west Germany; Rivollat *et al.* 2020). With the new dates presented here from Schwetzingen, we can begin to reliably model the chronological history of these cemeteries.

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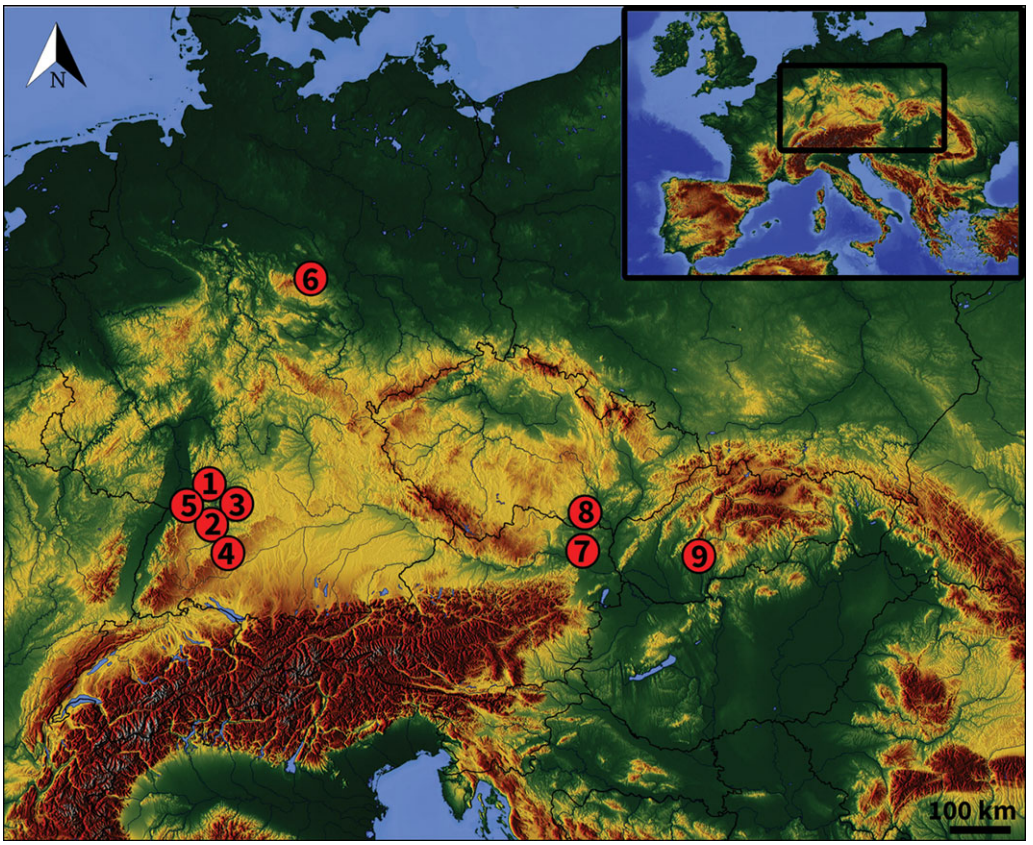

Figure 1. Location of the study's sites in south-western Germany: 1) Schwetzingen; 2) Stuttgart-Mühlhausen; 3) Talheim; 4) Lüsse; 5) Herxheim (figure by authors; base map: OpenStreetMap, Open Database Licence).

An accurate and precise understanding of the start and end of cemetery burial, as well as of the internal chronology of any given cemetery, is essential for evaluating the temporal relationships between mortuary practices and thus for validating the wider application of social models inferred from cemetery data. Here, we present 50 new radiocarbon dates from Schwetzingen, from which we can reconstruct a site chronology. In combination with published data, these dates allow us to further assess both the temporal dynamics of mortuary practices in the south-western German region and the wider 'cemetery horizon' of the LBK—the spatial and temporal framework of cemetery use on a macro-regional scale.

The Schwetzingen cemetery

Schwetzingen is one of the largest cemeteries of the European Early Neolithic (Figure 1). A total of 178 individual inhumation graves have been identified, forming three spatial clusters (Figure 2), together with three double inhumation graves, a further

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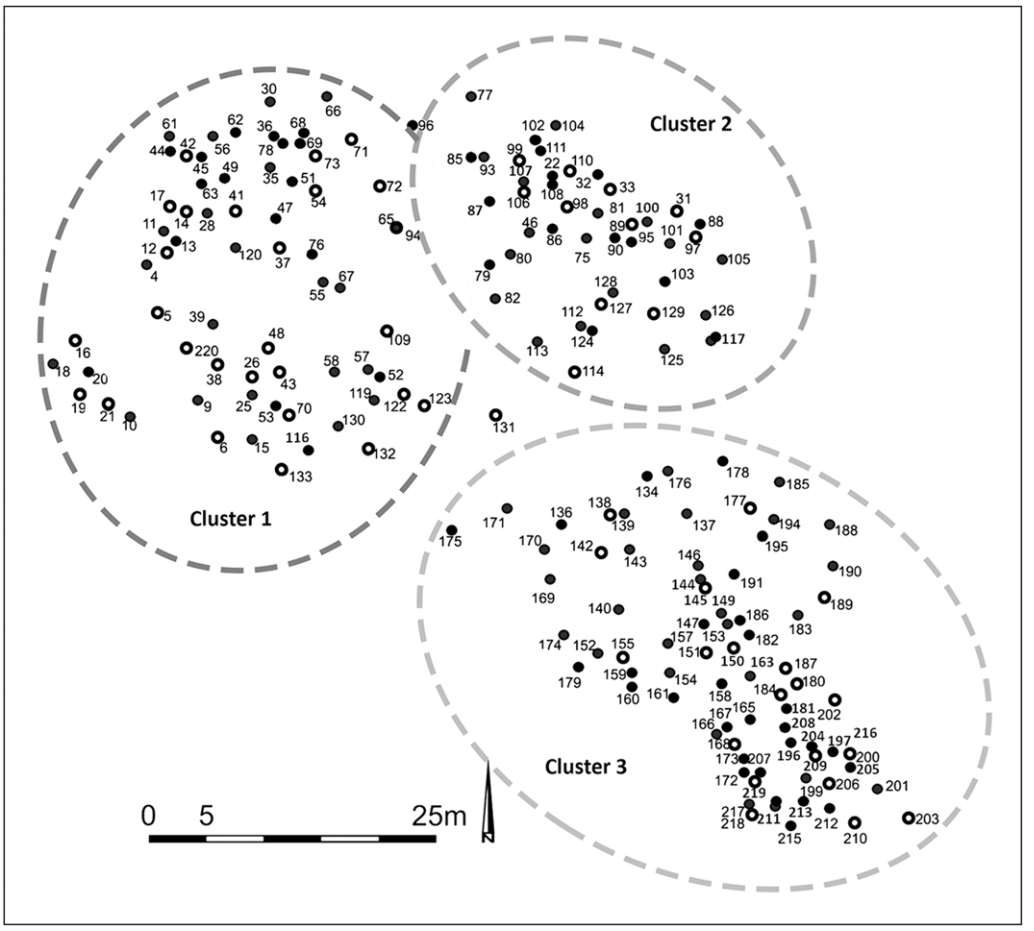

Figure 2. Plan of the Schwetzingen cemetery. Black dots: non-dated burials; white dots: dated burials (figure by authors).

two possible double graves and 15 cremations (Trautmann 2006). Though possibly a later phenomenon (Trautmann & Wahl 2005), we include five cremation burials as reliably LBK (see discussion in online supplementary material (OSM) 2.1). Discovered in 1988 and covering approximately 100 × 50m, the site has been intermittently excavated (Behrends 1989; Gerling & Francken 2007; Francken 2016; for further contextual information and excavation history, see OSM 2.2).

The pottery typology places the cemetery toward the end of the LBK (Strien 2000; Gerling 2012). Twelve previously available radiocarbon dates (sampling 6.1% of the individuals) suggest cemetery use began *5250–5080 cal BC* and ended *5170–5010 cal BC* (*95.4% probability*), with a duration of *0–160 years* (*95.4%*) (Griffiths 2013). Addition of the dates published here means that 62 dates are now available from Schwetzingen, sampling 30.89 per cent of individuals.

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Figure 3. Left) grave 106 from Schwetzingen (after Francken 2016); right) typical grave goods found in the Schwetzingen cemetery (figure by authors).

During burial, bodies were generally interred on their left side, with arms and legs flexed, and oriented either north-east to south-west or north-west to south-east, typically with the head towards the south-west.

Individuals were accompanied by typical LBK grave goods, including personal ornaments (*Spondylus* beads and medallions and various shells), stone adzes, flint blades and fragments, bone and antler tools, pottery vessels, pebbles possibly used as utensils, and grinding tools (Gerling 2012; Masclans *et al.* 2021) (Figure 3).

The Schwetzingen human remains have been the object of several interdisciplinary research approaches, including anthropological, isotopic and grave goods analyses (Behrends 1989; Bickle & Whittle 2013; Francken 2016; Masclans *et al.* 2021). Strontium isotope analysis ($^{87}Sr/^{86}Sr$) of dental enamel reveals substantial lifetime mobility for some males, which is interpreted as the result of the use of nearby uplands for animal husbandry (Bentley & Knipper 2005; Knipper 2009). In terms of diet, nitrogen ($\delta^{15}N$) values indicate that while males and females typically consumed animal protein from similar trophic levels, females showed more isotopic variability than males, suggesting that their dietary protein came from a wider range of trophic levels (Masclans *et al.* 2021).

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Materials and methods

Materials

Chronological assessment of the Schwetzingen cemetery is based on 50 new radiocarbon dates (Table S1) from 48 individuals (five cremations and 43 inhumations, with two replicates), along with 12 published dates from 11 inhumations (including one replicate; Table S2). Details of sampling are available in OSM2.1. Dates were calibrated using OxCal v.4.4.4 (Bronk Ramsey 2021) and the IntCal20 calibration curve (Reimer *et al.* 2020). Pre-treatment, target preparation and accelerator mass spectrometry (AMS) measurement follow standard protocol (Bronk Ramsey *et al.* 2004; Brock *et al.* 2010). Only AMS-measured human bones with standard deviations below ±40 are included in subsequent analyses.

To assess burial variability and chronology in the LBK of south-west Germany, the dates from Schwetzingen are compared with 54 published radiocarbon dates from four other sites in the region: the dual cemeteries of Stuttgart-Mühlhausen (Stuttgart; Rivollat *et al.* 2020), the mass burial of Talheim (Heilbronn; Wild *et al.* 2004), the settlement graves of Lüsse (Ammer Valley; Krauss *et al.* 2020) and the dead from the enclosure ditches at Herxheim (Riedhammer 2019; Turck 2019) (Figure 1, Table S3). These sites were chosen to reflect the diversity of mortuary practices and depositional scenarios in the region. Although Talheim and Herxheim represent exceptional cases, their inclusion allows for a broader assessment of temporal variation and diversity in the deposition of human remains within the LBK.

Further modelling was undertaken to better understand the temporal dynamics of cemeteries across the LBK. This model uses 94 published radiocarbon dates from five Central European cemeteries (Table S4): Nitra-Horné Krškany (Slovakia; Griffiths 2013), Vedrovice-Široká u lesa (Czechia; Pettitt & Hedges 2008), Kleinhadersdorf (Austria; Stadler 2015), Derenburg-Meerenstieg II (north-east Germany; Fritsch *et al.* 2010) and Stuttgart-Mühlhausen (south-west Germany; Rivollat *et al.* 2020) (Figure 1).

Methods

A single bounded-phase Bayesian model was used to understand burial chronology in Schwetzingen (Hamilton & Kenney 2015) due to the lack of stratigraphy, kinship or pottery data (see OSM 2.3). Radiocarbon biases on cremated bone are addressed (after Rose *et al.* 2020; see OSM 2.4 & 2.5) and typological priors, which are often based on limited diagnostic material, are excluded (see OSM 2.3 for justification).

As the radiocarbon measurements from Schwetzingen fall in a period on the IntCal20 calibration curve where a wiggle, at approximately 5300–5200 cal BC, is followed by a plateau, at 5200–5000 cal BC (Weninger 2020), the modelled radiocarbon dates may be strongly affected by the shape of the calibration curve. To mitigate bias, we ran a series of replicated Bayesian chronological simulations across all analysed sites (see OSM 2.6).

To assess temporal changes in LBK funerary practices and in the mobility and diet of buried individuals, we ran 36 Bayesian models using the Schwetzingen dates (OSM4).

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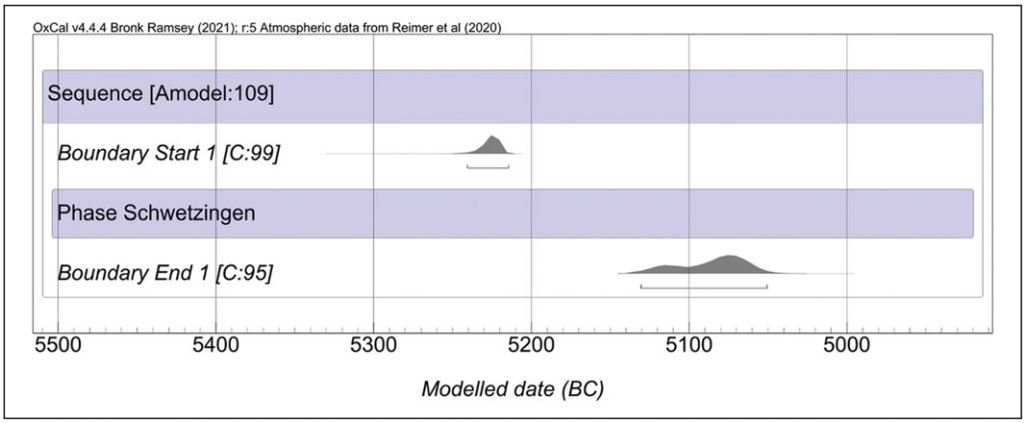

Figure 4. Single bounded-phase Bayesian model of the radiocarbon dates from the Schwetzingen cemetery (figure by authors).

When trends emerged, the OxCal order parameter tested event sequencing (OSM2.7). Dates from LBK sites and cemeteries in south-western Germany and Central Europe were also analysed using this method (OSM4).

Radiocarbon dating and chronological modelling of the Schwetzingen cemetery

General results

The single bounded-phase Bayesian model of the radiocarbon dates (which estimates both the start and end boundaries of activity at the site) from Schwetzingen cemetery agrees well (Figure 4 and OSM4; *Amode* = 119; *Aoverall* = 117; for an explanation of the agreement indices, refer to OSM2.8). The model estimates that burial activity began in *5240–5215 cal BC* (*95% probability*; *start: Schwetzingen*) or *5230–5220 cal BC* (*68% probability*) and ended in *5135–5050 cal BC* (*95% probability*; *end: Schwetzingen*) or either *5125–5105 cal BC* (*12% probability*) or *5095–5060 cal BC* (*56% probability*). The overall span of burial activity was *75–185 years* (*95% probability;* for span function refer to OSM2.9) or either *100–120 years* (*12% probability*) or *125–170 years* (*56% probability*). This suggests that the cemetery was in use for no more than six or seven generations, and possibly as few as four (based on a 25-year generation; Whittle & Bayliss 2007).

Chronological phase simulations

Simulations based on a chronological span of 130 years of burial activity at Schwetzingen (5225–5095 cal BC) consistently show very similar posterior probabilities for the start and end of burial activity, as well as its overall temporal span. When the chronological span of activity is reduced to 70 years, starting in 5225 cal BC, the posterior probabilities for the end of burial activity show a high degree of variability, while

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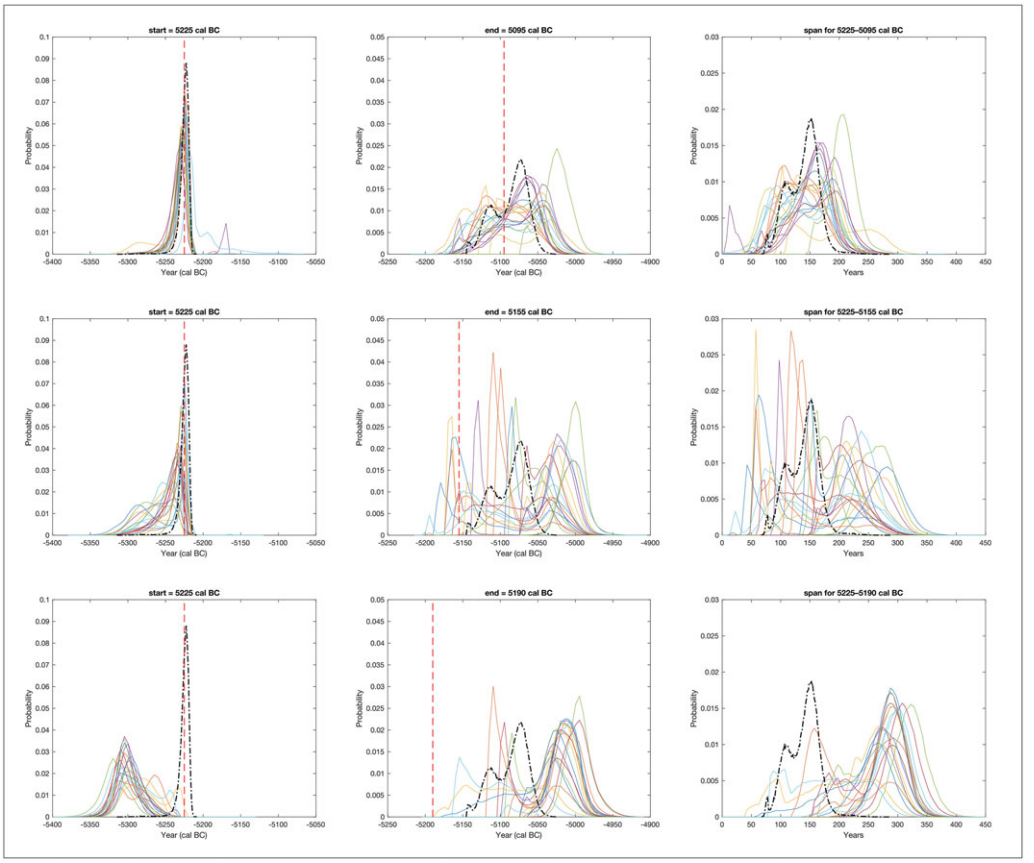

Figure 5. Single bounded-phase Bayesian model of the Schwetzingen cemetery, along with its corresponding simulations. The black dashed line represents the probability based on the model; coloured lines depict the outcomes from 20 different runs of the simulation with 58 dates spaced uniformly between three chronologies: long (top) = 5225–5095 cal BC; short (middle) = 5225–5155 cal BC; and very short (bottom) = 5225–5190 cal BC chronologies (figure by authors).

further reduction to a 35-year chronological span (5225–5190 cal BC) produced simulations that fell across three centuries.

The posterior probabilities obtained from our Bayesian model based on the actual radiocarbon dates closely match those produced by the simulation (5225–5095 cal BC), increasing our confidence that the duration of cemetery use did, in fact, span approximately 130 years. Visual assessment does not, however, rule out the possibility that the true chronology is slightly shorter than estimated by our model (full results are given in OSM3, but summarised in Figure 5).

Variability in funerary practices and lifeways

No statistically significant chronological differences are apparent between male and female burials, furnished and unfurnished burials, and burials displaying bone and stone arrow points. Furthermore, the position of the skeletons, the mobility groups (local/non-

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local) and the funerary rituals (inhumation/cremation) were continuously distributed throughout the same chronological phase (see Tables S8, S11, S14–18 & S21 for a more detailed discussion).

Our results do, however, suggest the presence of temporal-based discontinuities. First, burial in spatial cluster 2 (5330–5085 cal BC) started a bit earlier than in cluster 1 (5215–5130 cal BC) and cluster 3 (5200–5080 cal BC) (Table S6), indicating a chronological change in the use of the funerary space. This is consistent with the probabilities proposed by the order parameter, which indicates a 62% probability that burial started in cluster 2 before cluster 1, and a 69% probability that burial started in cluster 2 before cluster 3 (Table S7).

Second, the inclusion of stone adzes in graves appears to start earlier (5340–5140 cal BC versus 5215–5130 cal BC) and last longer (until 5160–5005 cal BC) than the practice of burying individuals without stone adzes. Again, this result is consistent with the order parameter, which suggests a 98% probability that the earliest graves in the cemetery contained stone adzes and an 86% probability that the latest graves contain stone adzes (Tables S9 & S10). Of the 20 stone adzes found at Schwetzingen, most are associated with males; just two were found with females, two with non-adults, and one with an individual of indeterminate sex. This suggests a strong but not exclusive link between adzes and male burials. This association may reflect broader patterns in burial selection during the earliest phases of the cemetery's use. Notably, the earliest burials in the cemetery are of young adults (20–35 years) and juveniles (12–20 years), appearing earlier (5320–5130 cal BC) than burials of older adults(>50) (70% probability), non-adults (1–11 years) (77% probability) and mature adult individuals (35–50 years) (70% probability) according to the order parameter (Tables S19 & S20).

Finally, the earliest dated burials, which also have a broader chronological range—beginning between 5335 and 5150 cal BC—despite being fewer in number, have 'non-normative' orientations. In contrast, the normative burial orientations of north-east to south-west and south-east to north-east started to be used slightly later, between 5190–5085 cal BC and 5220–5080 cal BC, respectively. Furthermore, the model proposes that the south-west to north-east and north-east to south-west orientations were most commonly associated with the last burials at the cemetery (75% and 83% probability, respectively; Tables S12 & S13). This shift in orientation over time may reflect cultural or ritual changes towards the end of the cemetery use.

Dating LBK bodies in south-western Germany

According to the single bounded-phase Bayesian model, the temporal distribution of all LBK-associated funerary practices or burial events in south-west Germany (Figure 1) was continuous in time, belonging to the same chronological phase between *5300–5210* and *5110–5040* cal BC with a span of *110–245 years* (*95.4%*) (Figure 6 *Amodel 84.5* and *Aoverall 84.3*). Not all contexts are distributed identically within the phase, as shown by the estimated chronology for each, calculated using a single bounded-phase model and tested through 20 simulations (OSM5). The order parameter determined that

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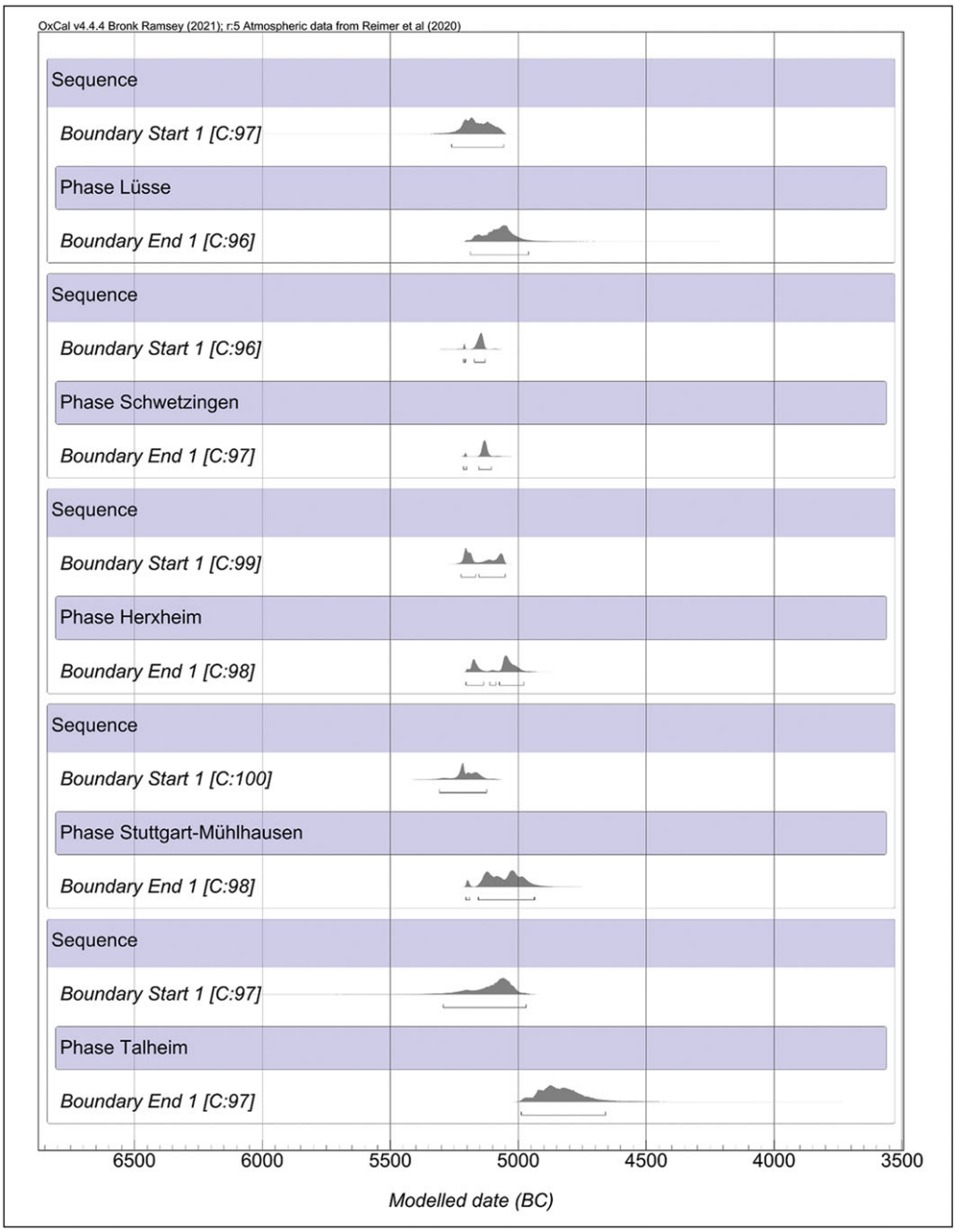

Figure 6. Modelled start and end boundaries of LBK funerary practices in south-western Germany (figure by authors).

Schwetzingen cemetery was the first in use, while the mass burial at Talheim is the latest event in the area. Moreover, the chronologies of all the studied sites end before the final use of Talheim (70% probability) (see Tables S22 & S23 for more details).

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Table 1. The temporal dynamics of modelled LBK mortuary contexts.

Site	Mortuary context	Beginning/end of activity (cal BC)	Span (years)
Lüsse	Settlement burials	5260–5055/5200–4960	0–150
Schwetzingen	Cemetery	5240–5215/5215–5055	95–185
Herxheim	Enclosure ditch	5240–5215/5135–5050	0–190
Stuttgart-Mühlhausen	Cemetery	5220–5085/5215–5055	0–95
Talheim	Mass burial	5230–4995/5200–4865	0–210
Nitra-Horné Krškany	Cemetery	5355–5210/5225–5030	0–250
Vedrovice-Široká u lesa	Cemetery	5330–5210/5215–5040	15–185
Derenburg-Meerenstieg II	Cemetery	5325–5040/5040–4800	0–330
Kleinhadersdorf	Cemetery	5315–5095/4975–4705	160–465

The models also indicate that the cemetery of Stuttgart-Mühlhausen displays the shortest span of use (Table 1), ending before Lüsse (65% probability), Schwetzingen (68%), Herxheim (63%) and Talheim (83%) (Tables S22 & S23). Our results place Schwetzingen earlier than sites like Stuttgart-Mühlhausen, despite previous typological assumptions, highlighting broader data limitations and the need for integrative modelling to resolve inter-site chronological discrepancies.

Modelling the temporal dynamics of LBK cemeteries

Modelling of temporal dynamics of LBK cemeteries shows that the chronological order of these sites (Figure 1) does not align with an east-to-west geographical gradient. Instead, the results suggest a more simultaneous start for the cemetery horizon across the LBK area. Our models indicate that Nitra-Horné Krškany (the easternmost cemetery) is one of the last to receive burials, with only Stuttgart-Mühlhausen (south-western Germany) starting later (Tables S24 & S25 and OSM5 for simulated results). Specifically, the order parameter suggests that the use of Nitra-Horné Krškany starts later than that of Vedrovice-Široká u lesa (85% probability), Derenburg-Meerenstieg II (63%), Kleinhadersdorf (76%) and Schwetzingen (77%) (Tables S24 & S25). Stuttgart-Mühlhausen is the last context to appear, as its use begins later than Nitra-Horné Krškany (69%), Vedrovice-Široká u lesa (>99%), Derenburg-Meerenstieg II (71%), Kleinhadersdorf (83%) and Schwetzingen (80%). According to the model, activity at Derenburg-Meerenstieg II, Kleinhadersdorf and Schwetzingen starts after Vedrovice-Široká u lesa but prior to Stuttgart-Mühlhausen and Nitra-Horné Krškany (Table S25). However, the determinations within probability ranges do not allow us to specify which of these three cemeteries was used first.

Much as we see at the beginning of the horizon, the end of cemetery use also does not align with a geographical east-west expansion pattern. Burial at Nitra-Horné Krškany ends first, followed by Stuttgart-Mühlhausen, Schwetzingen, Vedrovice-Široká u

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lesa and Derenburg-Meerenstieg II (Table S25). The cemetery of Kleinhadersdorf is the last to receive burials.

Discussion

Funerary practices at Schwetzingen

Bayesian modelling determined a narrow timeframe for the use of the Schwetzingen cemetery, with burial activity beginning in the north-eastern part of the cemetery (*5330–5085 cal BC*) before gradually extending west (*5215–5130 cal BC*) and then south (*5200–5080 cal BC*). The cemetery also shows a substantial shift in burial orientations over time, moving from earlier diversity to later standardisation. In its earliest phases (*5330–5150 cal BC*), a wide range of 'non-normative' orientations is observed, suggesting flexibility in burial practices and potentially reflecting diverse ritual expressions or cultural affiliations within the early community. This diversity persisted for some time but gradually gave way to more standardised north-east to south-west and south-east to north-east orientations (from *5190–5085* and *5220–5080 cal BC*, respectively), which became dominant in later burials, suggesting a trend towards ritual standardisation. While Hedges and colleagues (2013) link variation in body positioning to foraging communities—implying that greater diversity might be expected in earlier burials—our analysis shows no significant chronological patterning in body position at Schwetzingen (Table S18). This indicates that, unlike orientation, the variety of body positions remained consistent over time and likely responded to other factors such as social identity or local tradition.

Stone adzes are the only grave goods that display a clear chronological trend, appearing primarily in earlier burials (*5340–5140 cal BC*) and less frequently in later ones (*5215–5130 cal BC*). While many of the initial burials at Schwetzingen were of young adults and juveniles, individuals buried with stone adzes typically fall into the mature or older adults adult age categories. This pattern matches Pavúk's (1972) gerontocratic model at the Nitra-Horné Krškany cemetery, where older males were consistently buried with polished stone tools.

The continuous presence of these elderly males throughout the cemetery's use, despite the predominance of young individuals in the earliest burials, suggests a distinct status group of senior males. Stone adzes are linked to activities like woodworking, butchering and interpersonal violence (Masclans *et al.* 2021), though they may also have symbolised the status of certain male individuals or lineages within LBK society (Masclans *et al.* 2021; Augereau 2022). Persistence of the elderly-male/stone-adze link aligns with Bentley's (2013) interpretation of polished stone tools as indicators of inherited status, reinforcing the prevailing notion that LBK society was organised around patrilineal clans. Jeunesse (1997) also suggests that such grave goods were status-related and that access to them would become increasingly restricted over time, resulting in fewer individuals being buried with them. The local $^{87}Sr/^{86}Sr$ ratios of these elderly males further suggests that they were likely not involved in transhumance or other mobile

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activities, such as using unsettled uplands for animal husbandry (Bentley & Knipper 2005; Masclans *et al.* 2021).

Cremation burials appear intermittently across the temporal span of the site. It is unlikely, therefore, that cremation was practised only in the later phases of the LBK. The full social implications of this practice, as well as its representativity for the whole LBK area, will need to be explored in future research. Recent proposals that individuals could be returned to their natal communities for burial (e.g. Ensor 2021) add another potential dimension to the variability in mortuary practices—cremations being more easily transported than bodies—alongside regional beliefs, personal preference or cause of death.

Finally, no chronological differences are observed relating to the sex of the individuals, their dietary and mobility determinations or their associated grave goods (except stone adzes, see above), reinforcing the hypothesis that isotopic variability and artefact diversity may be linked to social factors, such as gender or age (Knipper 2009; Hedges *et al.* 2013; Masclans *et al.* 2021). Such patterns likely reflect complex social identities and roles within the community that transcended temporal boundaries.

Regional patterns in mortuary depositions in south-west Germany

Our results facilitate a re-evaluation of the temporal distribution of different forms of mortuary deposition in south-west Germany during the LBK. On a regional scale, the modelled results indicate that while all five sites fall within the same chronological phase, not all of the funerary rites are identically distributed within this phase. The cemetery of Schwetzingen was the earliest site in use, while the mass burial of Talheim represents the last event. The exceptionally brief use-span for Talheim indicated in our models is consistent with the mass burial of the 34 individuals following a single, violent event (Wahl & König 1987; Wild *et al.* 2004; Duering & Wahl 2014).

The temporal span of all contexts is shorter than previously assumed (between *110 and 245 years*), suggesting that either the LBK occupation in the area was shorter than traditionally considered, or that a substantial proportion of the dead remain missing from the archaeological record, perhaps having received alternate, non-visible mortuary treatment. Such hypotheses can be answered only by the development of a systematic and extensive radiocarbon-dating project selecting short-life samples from settlement contexts.

Despite the expectation that the cemeteries of Schwetzingen and Stuttgart-Mühlhausen would be the longest-lived contexts, these sites actually have the shortest durations, each potentially around 100 years (Table 1). The cemetery of Stuttgart-Mühlhausen evinces the shortest span of use, with burial activity ending earlier than Lüsse, Schwetzingen, Herxheim and Talheim. In contrast, the Herxheim enclosure—where bodies predominantly subject to secondary burial, deliberate fragmentation and possibly even cannibalism were amassed (Orschiedt & Haidle 2007)—has a chronological interval between *5225–5050* and *5200–4980 cal BC* (*95.4%*), with a maximum duration of *160 years*. However, ceramic typology and stratigraphy suggest a brief use of the site, possibly just a few decades (Riedhammer 2019). Currently, only 21 radiocarbon dates are available for Herxheim, covering just 4.2% of the estimated 500 individuals

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recovered. As nearly half the enclosure remains unexcavated, the total number of deposited individuals may exceed 1000 (Boulestin *et al.* 2009). Further dating is therefore needed to tighten up the radiocarbon chronology and assess whether the shorter relative chronology is supported independently.

The LBK cemetery horizon

Modelling of radiocarbon dates from six Central European LBK cemeteries indicates that neither the start nor the end of burial activity at these sites followed an east–west chronological dispersion. Instead, the cemeteries have a common timeline, with contemporaneous sites situated in widespread regions during a calculated span of *0–300 years*. The rapid adoption of varied Early Neolithic funerary practices across south-western Germany aligns with the perspective that the LBK was a dynamic and interactive community from its earliest to its latest phases (Jakucs *et al.* 2016).

The greater resolution offered by wider programmes of radiocarbon dating is thus challenging current models of cemeteries as long-lived phenomena. The more recently measured and more abundant radiocarbon dates from Schwetzingen, Stuttgart-Mühlhausen, Vedrovice-Široká u lesa and Herxheim (59, 2139 & 21 radiocarbon dates, respectively), provide both a more accurate and a shorter span of use (around *0–100* and *0–85 years*, respectively, at *95.4% probability*). By contrast, Kleinhadersdorf (15 radiocarbon dates), Derenburg-Meerenstieg II (9) and Nitra-Horné Krškany (11) present similar spans of use, in the order of *0–260 years* (*95.4% probability*).

The availability of data presents a further problem for the wider assessment of an LBK cemetery horizon; at present, well-dated LBK cemeteries are missing from Alsace, the Netherlands, the Rhineland, central and eastern Germany, Bohemia, western Austria and Hungary. Furthermore, the chronological relationship between the cemetery horizon and mortuary practices in regions where the bone is well preserved but cemeteries do not appear remains unexplored, especially in the westernmost reaches of the LBK (Thevenet 2009).

Increasing the number of radiocarbon dates available from cemeteries with poor chronological controls will improve internal site chronologies and facilitate clearer inter-site comparisons. If such programmes of dating mirror our results for Schwetzingen, the Early Neolithic cemetery horizon in Central Europe was likely shorter and more geographically simultaneous than traditionally believed. In which case, questions may be raised about the social drivers behind burial in cemeteries in the fifty-third century BC. Genome analysis indicates that only a quarter of individuals from Derenburg-Meerenstieg II and Stuttgart-Mühlhausen had biological relatives buried nearby (Childebayeva *et al.* 2022). These findings, along with new radiocarbon dating, suggest LBK cemeteries were not solely kin burial grounds, implying use by multiple communities.

Conclusions

The Schwetzingen cemetery illustrates the dynamic and evolving nature of LBK funerary practices, albeit over a relatively brief period. The gradual standardisation of specific elements of mortuary behaviour at the site suggests social changes and shifts in values

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within LBK communities, while the continued diversity in other practices indicates that the cemetery accommodated a range of identities and traditions. Our results indicate that cemeteries were not merely static markers of settled life but reflections of continuous social adaptation and interaction, challenging rigid cultural boundaries and revealing a more complex Early Neolithic landscape. Future research may further explore how status, age and identity shaped this burial ground's role in the broader LBK cultural landscape.

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Online supplementary material (OSM)

To view supplementary material for this article, please visit https://doi.org/10.15184/aqy.2025.10169 and select the supplementary materials tab.

References

AUGEREAU, A. 2022. In search of the origin of inequalities: gender study and variability of social organization in the first farmers societies of western Europe (Linearbandkeramik culture). *Journal of Anthropological Archaeology* 66. https://doi.org/10.1016/j.jaa.2022.101413

BEHRENDS, R.H. 1989. Ein Gräberfeld der Linienbandkeramik in Schwetzingen, Rhein-Neckar-Kreis. *Archäologie in Deutschland* 3/1989: 39.

BENTLEY, R.A. 2013. Mobility and the diversity of Early Neolithic lives: isotopic evidence from skeletons. *Journal of Anthropological Archaeology* 32: 303–12. https://doi.org/10.1016/j.jaa.2012.01.009

BENTLEY, R.A. & C. KNIPPER. 2005. Geographical patterns in biologically available strontium, carbon and oxygen isotope signatures in prehistoric SW Germany. *Archaeometry* 47: 629–44. https://doi.org/10.1111/j.1475-4754.2005.00223.x

BICKLE, P. 2020. Thinking gender differently: new approaches to identity difference in the Central European Neolithic. *Cambridge Archaeological Journal* 30: 201–18. https://doi.org/10.1017/S0959774319000453

BICKLE, P. & A. WHITTLE (ed.). 2013. *The first farmers of Central Europe: diversity in LBK lifeways*. Oxford: Oxbow.

BOULESTIN, B., A. ZEEB-LANZ, C. JEUNESSE, F. HAACK, R.M. ARBOGAST & A. DENAIRE. 2009. Mass cannibalism in the Linear Pottery Culture at Herxheim (Palatinate, Germany). *Antiquity* 83: 968–82. https://doi.org/10.1017/S0003598X00099282

BROCK, F., T. HIGHAM, P. DITCHFIELD & C. BRONK RAMSEY. 2010. Current pretreatment methods for AMS radiocarbon dating at the Oxford Radiocarbon Accelerator Unit (ORAU). *Radiocarbon* 52: 103–12. https://doi.org/10.1017/S0033822200045069

BRONK RAMSEY, C. 2021. OxCal, version 4.4.4 [software]. Oxford: Oxford Radiocarbon Accelerator Unit. Available at: https://c14.arch.ox.ac.uk/oxcal.html

BRONK RAMSEY, C., T. HIGHAM, A. BOWLES & R. HEDGES. 2004. Improvements to the pretreatment of bone at Oxford. *Radiocarbon* 46: 155–63. https://doi.org/10.1017/S0033822200039473

CHAMBON, P. *et al.* 2018. Collecting the dead: temporality and disposal in the Neolithic hypogée of Les Mournouards II (Marne, France). *Germania* 95: 93–143. https://doi.org/10.11588/ger.2017.49475

CHILDEBAYEVA, A. *et al.* 2022. Population genetics and signatures of selection in Early Neolithic European farmers. *Molecular Biology and Evolution* 39. https://doi.org/10.1093/molbev/msac108

DUERING, A. & J.A. WAHL. 2014. Massacred village community? Agent-based modelling sheds new light on the demography of the Neolithic mass grave of Talheim. *Anthropologischer Anzeiger* 71: 447–68. https://doi.org/10.1127/anthranz/2014/0450

ENSOR, B.E. 2021. Making aDNA useful for kinship analysis. *Antiquity* 95: 241–43. https://doi.org/10.15184/aqy.2020.234

FARRUGGIA, J.P. 2002. Le cimetière de la Céramique Linéaire d'Aiterhofen (Bavière orientale) dans le contexte de l'Europe centrale. Une crise majeure de la civilisation du Néolithique danubien des années 5100 avant notre ère. *Bulletin de la Societé Préhistoire Luxembourgeoise* 23/24: 75–127.

FRANCKEN, M. 2016. Familien- und Sozialstrukturen – Anthropologische Ansätze zur Binnengliederung linearbandkeramischer Populationen in Südwestdeutschland. Unpublished PhD Dissertation, University of Tübingen.

FRIRDICH, C. 1994. Kulturgeschichtliche Betrachtungen zur Bandkeramik im Merzbachtal, in J. Lüning and P. Stehli (ed.) *Die Bandkeramik im Merzbachtal auf der Aldenhovener Platte*: 207–393. Bonn: Habelt.

FRITSCH, B., E. CLASSEN, U. MÜLLER & V. DRESELEY. 2010. Die linienbandkeramischen Gräberfelder von Derenburg "Meerenstieg II" und Halberstadt "Sonntagsfeld", Lkr. Harz. *Jahresschrift für Mitteldeutsche Vorgeschichte* 92: 25–229. https://doi.org/10.11588/jsmv.2008.1.88665

GELABERT, P. *et al.* 2024. Social and genetic diversity among the first farmers of Central Europe. *Nature Human Behaviour* 9: 53–64. https://doi.org/10.1038/s41562-024-02034-z

GERLING, C. 2012. Das linearbandkeramische Gräberfeld von Schwetzingen, Rhein-Neckar-Kreis. *Fundberichte aus Baden-Württemberg* 32(1): 7–263. https://doi.org/10.11588/fbbw.2012.1.33774

GERLING, C. & M. FRANCKEN. 2007. Das linearbandkeramische Gräberfeld von Schwetzingen. *Archäologische Informationen* 30(1): 43–50. https://doi.org/10.11588/ai.2007.1.11153

GRIFFITHS, S. 2013. Appendix B1: radiocarbon dates from Nitra, Schwetzingen and Vedrovice, in P. Bickle & A. Whittle (ed.) *The first farmers of central Europe: diversity in LBK lifeways*: 443–58. Oxford: Oxbow.

HAMILTON, W.D. & J. KENNEY. 2015. Multiple Bayesian modelling approaches to a suite of radiocarbon dates from ovens excavated at Ysgol yr Hendre, Caernarfon, North Wales. *Quaternary Geochronology* 25: 72–82. https://doi.org/10.1016/j.quageo.2014.10.001

HEDGES, R. *et al.* 2013. The supra-regional perspective, in P. Bickle & A. Whittle (ed.) *The first farmers of central Europe: diversity in LBK lifeways*: 343–84. Oxford: Oxbow.

HOFMANN, D. 2009. Cemetery and settlement burial in the Lower Bavarian LBK, in D. Hofmann & P. Bickle (ed.) *Creating communities: new advances in Central European Neolithic research*: 220–34. Oxford: Oxbow.

JAKUCS, J., E. BÁNFFY & K. OROSS. 2016. Between the Vinča and Linearbandkeramik worlds: the diversity of practices and identities in the 54th–53rd centuries cal BC in southwest Hungary and beyond. *Journal of World Prehistory* 29: 267–336. https://doi.org/10.1007/s10963-016-9096-x

JEUNESSE, C. 1997. *Pratiques funéraires au néolithique ancien. Sépultures nécropoles Danubiennes 5500–4900 av. J.-C.* Paris: Errance.

KNIPPER, C. 2009. Mobility in a sedentary society: insights from isotope analysis of LBK human and animal teeth, in D. Hofmann & P. Bickle (ed.) *Creating communities: new advances in Central European Neolithic research*: 142–58. Oxford: Oxbow.

KRAUSS, R., J. BOFINGER & B. WENINGER. 2020. Chronology of Early Neolithic sites in the Ammer Valley, west of Tübingen (SW-Germany). *Quaternary International* 560–61: 273–85. https://doi.org/10.1016/j.quaint.2020.04.004

MASCLANS, A., C. HAMON, C. JEUNESSE & P. BICKLE. 2021. A sexual division of labour at the start of agriculture? A multi-proxy comparison through grave good stone tool technological and use-wear analysis. *PLoS ONE* 16. http://doi.org/10.1371/journal.pone.0249130

MÜLLER-SCHEEßEL, N., Z. HUKEĽOVÁ, J. MEADOWS, I. CHEBEN, L. MÜLLER & M. FURHOLT. 2021. New burial rites at the end of the Linearbandkeramik in south-west Slovakia. *Antiquity* 95: 65–84. https://doi.org/10.15184/aqy.2020.103

NIESZERY, N. 1995. *Linearbandkeramische gräberfelder in Bayern*. Rahden/Westf.: Leidorf.

ORSCHIEDT, J. & M.N. HAIDLE. 2007. The LBK enclosure at Herxheim: theatre of war or ritual centre? References from osteoarchaeological investigations. *Journal of Conflict Archaeology* 2: 152–67. https://doi.org/10.1163/157407706778942330

PAVÚK, J. 1972. Neolithisches Gräberfeld in Nitra. *Slovenská archeológia* 20: 5–105.

PETTITT, P. & R. HEDGES. 2008. The age of the Vedrovice cemetery: the AMS radiocarbon dating programme. *Anthropologie* 46(2–3): 125–34.

PONS, F. *et al.* 2018. *Le rempart chasséen de Château-Percin à Seilh (Haute-Garonne): une architecture monumentale de terre et de bois* (Recherches Archéologiques 14). Paris: CNRS.

REIMER, P.J. *et al.* 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). *Radiocarbon* 62: 725–57. https://doi.org/10.1017/RDC.2020.41

RIEDHAMMER, K. 2019. The radiocarbon dates from Herxheim and their archaeological interpretation, in A. Zeeb-Lanz (ed.) *Ritualised destruction in the Early Neolithic: the exceptional site of Herxheim (Palatinate, Germany)*: 285–303. Speyer: GDKE, Direktion Landesarchäologie.

RIVOLLAT, M. *et al.* 2020. Ancient genome-wide DNA from France highlights the complexity of interactions between Mesolithic hunter-gatherers and Neolithic farmers. *Science Advances* 6. https://doi.org/10.1126/sciadv.aaz5344

ROSE, H.A., J. MEADOWS & M.B. HENRIKSEN. 2020. Bayesian modeling of wood-age offsets in cremated bone. *Radiocarbon* 62: 379–401. https://doi.org/10.1017/RDC.2020.3

SAYER, D. 2020. *Early Anglo-Saxon cemeteries: kinship, community and identity*. Manchester: Manchester University Press.

STADLER, P. 2015. Statistische und Naturwissenschaftliche Untersuchungen, in C. Neugebauer-Maresch & E. Lenneis (ed.) *Das linearbandkeramische Gräberfeld von Kleinhadersdorf*: 149–52. Vienna: Verlag der Österreichischen Akademie der Wissenschaften.

STRIEN, H.C. 2000. *Untersuchungen zur Bandkeramik in Württemberg*. Bonn: Habelt.

THEVENET, C. 2009. Les sépultures rubanées du Bassin parisien: composition de l'échantillon funéraire et implantation sépulcrale, in A. Zeeb-Lanz (ed.) *Krisen-Kulturwan del-Kontinuitäten. Internationale Tagung Herxheim bei Landau (Pfalz) 2007. Internationale Archäologie Arbeitsemeinschaft, Symposium, Tagung, Kongress 10*: 111–28. Rahden: Marie Leidorf.

TRAUTMANN, I. 2006. The significance of cremations in Early Neolithic communities in Central Europe. Unpublished PhD dissertation, University of Tübingen.

TRAUTMANN, I. & J. WAHL. 2005. Leichenbrände aus linearbandkeramischen Gräberfeldern Südwestdeutschlands – Zum Bestattungsbrauch in Schwetzingen und Fellbach-Oeffmgen. *Fundberichte aus Baden-Württemberg* 28: 7–18.

TURCK, R. 2019. Where did the Herxheim dead come from? Isotopic analysis of human individuals, in A. Zeeb-Lanz (ed.) *Ritualised destruction in the Early Neolithic – the exceptional site of Herxheim (Palatinate,*

Germany): 313–421. Speyer: GDKE, Direktion Landesarchäologie.

VAN DE VELDE, P. *et al.* 1979. The social anthropology of a Neolithic cemetery in the Netherlands. *Current Anthropology* 20(1): 37–58. https://doi.org/10.1086/202202

WAHL, J. & H.G. KÖNIG. 1987. Anthropologisch-traumatologische Untersuchung der menschlichen Skelettreste aus dem bandkeramischen Massengrab bei Talheim, Kreis Heilbronn (mit einem Anhang von Jörg Biel). *Fundberichte aus Baden-Württemberg* 12: 56–193.

WENINGER, B. 2020. Barcode seriation and concepts of Gauge Theory: the ^{14}C-Chronology of Starčevo, LBK, and early Vinča. *Quaternary International* 560–61: 20–37. https://doi.org/10.1016/j.quaint.2020.04.031

WHITTLE, A. & A. BAYLISS. 2007. The times of their lives: from chronological precision to kinds of history and change. *Cambridge Archaeological Journal* 17: 21–28. https://doi.org/10.1017/S0959774307000030

WHITTLE, A., F. HEALY & A. BAYLISS. 2011. *Gathering time: dating the Early Neolithic enclosures of southern Britain and Ireland*. Oxford: Oxbow.

WILD, E.M. *et al.* 2004. Neolithic massacres: local skirmishes or general warfare in Europe? *Radiocarbon* 46: 377–85. https://doi.org/10.1017/S0033822200039680

ZVELEBIL, M. & P. PETTITT. 2013. Biosocial archaeology of the Early Neolithic: synthetic analyses of a human skeletal population from the LBK cemetery of Vedrovice, Czech Republic. *Journal of Anthropological Archaeology* 32: 313–29. https://doi.org/10.1016/j.jaa.2012.01.011