The massacre mass grave of Schöneck-Kilianstädten reveals new insights into collective violence in Early Neolithic Central Europe

Christian Meyer[a,1], Christian Lohr[b], Detlef Gronenborn[b,c], and Kurt W. Alt[d,e,f]

[a]Institute of Anthropology, University of Mainz, 55099 Mainz, Germany; [b]Römisch-Germanisches Zentralmuseum, 55116 Mainz, Germany; [c]School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Braamfontein 2000, Johannesburg, South Africa; [d]Center of Natural and Cultural History of Teeth, Danube Private University, 3500 Krems-Stein, Austria; [e]Integrative Prehistory and Archaeological Science, University of Basel, 4055 Basel, Switzerland; and [f]State Department for Heritage Management and Archaeology Saxony-Anhalt, State Museum of Prehistory, 06114 Halle (Saale), Germany

Edited by Melinda A. Zeder, National Museum of Natural History, Santa Fe, NM, and approved July 20, 2015 (received for review March 3, 2015)

Conflict and warfare are central but also disputed themes in discussions about the European Neolithic. Although a few recent population studies provide broad overviews, only a very limited number of currently known key sites provide precise insights into moments of extreme and mass violence and their impact on Neolithic societies. The massacre sites of Talheim, Germany, and Asparn/Schletz, Austria, have long been the focal points around which hypotheses concerning a final lethal crisis of the first Central European farmers of the Early Neolithic *Linearbandkeramik* Culture (LBK) have concentrated. With the recently examined LBK mass grave site of Schöneck-Kilianstädten, Germany, we present new conclusive and indisputable evidence for another massacre, adding new data to the discussion of LBK violence patterns. At least 26 individuals were violently killed by blunt force and arrow injuries before being deposited in a commingled mass grave. Although the absence and possible abduction of younger females has been suggested for other sites previously, a new violence-related pattern was identified here: the intentional and systematic breaking of lower limbs. The abundance of the identified perimortem fractures clearly indicates torture and/or mutilation of the victims. The new evidence presented here for unequivocal lethal violence on a large scale is put into perspective for the Early Neolithic of Central Europe and, in conjunction with previous results, indicates that massacres of entire communities were not isolated occurrences but rather were frequent features of the last phases of the LBK.

LBK | warfare | trauma | burial | osteoarchaeology

The Neolithic was a time of profound change in Central Europe. The appearance, spread, and subsequent development of the first farmers in this area in the Early Neolithic have attracted continuous attention (1–3). Those first agriculturists (5600–4900 cal BC) (4), whose pottery decoration style has given rise to their modern ascribed name of Linear Pottery culture (in German, *Linearbandkeramik*, LBK), left a very rich archaeological record including a large number of skeletal remains. In recent years the Early Neolithic also has been targeted by various bioarchaeometric analyses, including studies on ancient DNA (5, 6) and stable isotopes (3, 7–9). One of the key results has been an apparent genetic discontinuity between Mesolithic and Neolithic populations (10), the latter spreading west into Central Europe from the southeast, bringing with them the well-known "Neolithic package" consisting mainly of domesticated crops and cattle (11). The genetic makeup of these first farmers was different not only from their predecessors in this region but also from their successors, showing complex patterns of movements and migrations over time (5, 6). Strontium isotope analyses have revealed a virilocal residence pattern practiced within the LBK, which also is evident from some later Neolithic periods (12). Furthermore, the deposition of ground stone adzes, the typical weapon-tools of the LBK, in only some male burials seems to indicate the presence of social inequality at the onset of the settled agricultural lifestyle, probably related to inherited access to the most coveted loess soils (9, 13) in which considerable labor and effort was invested over time (14).

Built mainly on several enigmatic sites with clear osteological evidence for lethal mass violence and generalized patterns of increased differentiation and fortification from many others (15, 16), the disappearance of the LBK from the Neolithic landscape often has been portrayed as a result of strife and social unrest, culminating in a far-reaching apocalyptic nightmare of violence, warfare, and cannibalism (15–18). Although such a scenario appears somewhat exaggerated, the proposed "crisis" at the end of the LBK has attracted much attention, speculation, and debate (15–23). Foremost in this discussion is the evidence from the sites of Talheim, Germany, and Asparn/Schletz, Austria, of massacres of probably entire LBK communities (19, 24–26). The dead from these mass fatality events were either left unburied or thrown into a mass grave, lacking all indications of care or burial ritual.

To these two clear-cut conflict sites we can now add another with unequivocal osteoarchaeological evidence of indiscriminate lethal violence, torture and mutilation, and disposal of the corpses in a commingled and chaotic mass grave (Fig. 1). Although isolated cases of interpersonal violence are known from much older periods (27, 28), as are some pictorial representations of possible violent behavior (29), direct evidence for targeted collective violence is very rare in the preagricultural record of Central Europe. One of the most frequently discussed sites in this regard is the

Significance

The Early Neolithic massacre-related mass grave of Schöneck-Kilianstädten presented here provides new data and insights for the ongoing discussions of prehistoric warfare in Central Europe. Although several characteristics gleaned from the analysis of the human skeletal remains support and strengthen previous hypotheses based on the few known massacre sites of this time, a pattern of intentional mutilation of violence victims identified here is of special significance. Adding another key site to the evidence for Early Neolithic warfare generally allows more robust and reliable reconstructions of the possible reasons for the extent and frequency of outbreaks of lethal mass violence and the general impact these events had on shaping the further development of the Central European Neolithic.

Author contributions: C.M., D.G., and K.W.A. designed research; C.M. and C.L. performed research; C.M. and C.L. analyzed data; and C.M., C.L., D.G., and K.W.A. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

[1]To whom correspondence should be addressed. Email: Chr.Meyer@email.de.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1504365112/-/DCSupplemental.

Fig. 1. Composite image of the LBK mass grave of Schöneck-Kilianstädten, Germany (area 4, feature 139). Individual images were adjusted for visualization of the complete feature.

Ofnet Cave in Germany, which shows the deposition of selected human remains with clear evidence of perimortem injuries and cut marks in Mesolithic times (30, 31). At that site, however, only detached and ochre-covered heads with articulated vertebrae were deposited carefully along with animal teeth ornaments in a special location, indicating much more complex behavior than a massacre (32).

In the following Early Neolithic mass violence in Central Europe seems to reach unprecedented levels within the later phases of the LBK. Taken together, the reliable evidence now available indicates that mass killings of certain groups within the later LBK *oikumene* apparently were not isolated occurrences but clustered toward the end of the LBK sequence in widely separated localities (Fig. S1). We therefore suggest that massacres were an inherent phenomenon of the later LBK and that the destruction of complete communities as the result of collective lethal violence was indeed a relevant factor of Neolithic life, at least in some periods.

Disposal of the Dead in Early Neolithic Central Europe

The LBK is often described as one of the best-researched archaeological complexes in Central European prehistory (1, 33). Although overall variation is quite extensive chronologically and geographically (3), most of the deceased LBK individuals known thus far were interred as single inhumations or cremations in dedicated burial areas; multiple burials remain rare (34). Many individuals also were buried carefully within settlements; such burials are regarded as another variant within the commonly encountered array of possible burial practices (35). Bodies usually were deposited in a flexed position on their left side, oriented with the cephalic extremity roughly to the east, but supine positions and other orientations are quite common also. Nevertheless, a pattern of care and deliberation is readily apparent in the deposition of the dead. Grave goods, mainly pottery, shell ornaments, and lithic artifacts, are often present. In male burials polished stone adzes are often found, which have been identified as both woodworking tools and as lethal weapons used repeatedly against human targets (24, 36). Arrowheads occur in graves as well. Although these arrowheads could be used for hunting game, they also were weapons used against human foes (24, 37), and persons equipped with them have been characterized previously as hunters/warriors (38). Although arrow wounds remain rare in LBK skeletons, they do occur at the known mass violence sites, thereby demonstrating the repeated use of missile weapons against human targets in addition to close-quarter fighting using shock weapons. Usually, direct casualties of violent encounters of whatever extent seem not to have been included in the regular burial places, but survived traumata are sometimes found (39). The known casualties of perimortem violence are found mainly in "deviant" graves instead, i.e., in burials that lack the careful arrangement of the bodies. The Talheim mass grave and the bodies found in the ditches at Asparn/Schletz belong to this category, as well as the LBK mass grave of Wiederstedt, Germany, which lacks obvious signs of violence (35, 40). Other sites that initially were regarded as massacre-related by some, such as the enclosure ditch cemetery of Vaihingen/Enz or the supraregional ritual place of Herxheim (15, 16, 41), are now seen in another light (18, 20, 21).

The Mass Grave and Its Analysis

The chance discovery of another LBK mass grave in 2006, during road-building activity at the site of Schöneck-Kilianstädten (Hesse, Germany) (42, 43), provided a rare and much needed fresh insight into the matter of collective violence at the end of the LBK. Four ^{14}C-samples from different individuals date the mass grave to 5207–4849 cal BC (Table S1). The site is situated within a region of intense late LBK activity and very near a long-standing border between different flint-distribution systems that might indicate a profound divide between neighboring settlements in this region (44, 45).

The feature containing the commingled skeletal remains was a reused long V-shaped pit measuring *ca*. 7.5 m in length and 0.3–1.0 m in breadth that could have been part of a larger ditch system at the site (43). It was located within a larger settlement area including up to 18 successively built LBK houses. The southern end of the mass grave pit was trapezoidal in shape and

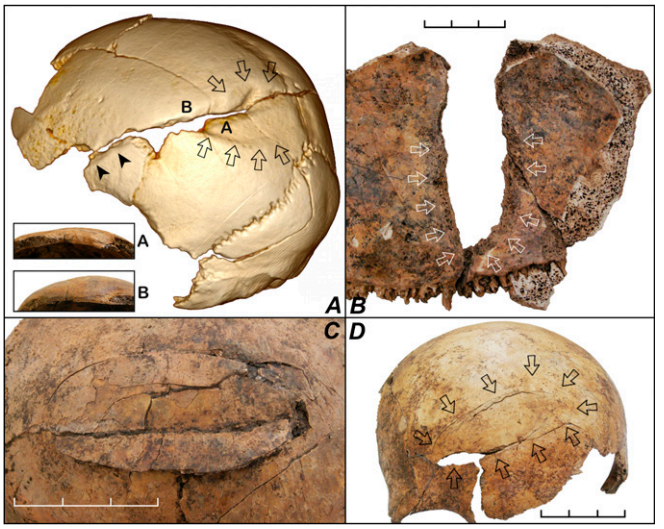

Fig. 2. Examples of cranial trauma identified in the mass grave. (*A*) CT reconstruction of cranial fragment no. 331, displaying a healed depressed fracture on the left parietal (open arrows) with evidence of nonunion of fracture edges (A and B) and surgical treatment (solid arrows). (*B*) Endocranial view of left adult parietal no. 79 showing a comminuted blunt-force injury with internal beveling. (*C*) Ectocranial view of skull fragment no. 233 (a child *ca*. 3–5 y old) showing a shaped, nonpenetrating blunt-force injury of the left parietal. (*D*) Ectocranial view of skull fragment no. 177 (a child *ca*. 8 y old) showing a shaped, nonpenetrating blunt-force injury across the frontal bone. (Scale bars, 3 cm each.)

Table 1. Extent of perimortem cranial injuries in adult individuals

Element	Side	*N*	PI A	%	PI B	%
Frontal	R	9	2	22.2	7	77.8
	L	8	1	12.5	6	75.0
Parietal	R	9	3	33.3	7	77.8
	L	8	3	37.5	7	87.5
Occipital	R	6	1	16.7	5	83.3
	L	6	1	16.7	4	66.7
Temporal	R	5	0	—	4	80.0
	L	7	0	—	5	71.4
Zygomatic	R	6	1	16.7	3	50.0
	L	6	0	—	1	16.7
Maxilla	R	5	0	—	3	60.0
	L	5	0	—	2	40.0
Mandibula	R	6	3	50.0	5	83.3
	L	8	2	25.0	6	75.0

PI A, clear perimortem injuries (minimum); PI B, = clear and/or probable perimortem injuries (maximum).

continued as a narrow trench to the north. The human bones were recovered under adverse conditions, and, unfortunately, only rather basic archaeological documentation is available. Bone preservation is poor in parts, taphonomic fragmentation is high, and the bones are very fragile and partly disintegrated. Nevertheless, using standardized and well-tested osteological methods, it was possible to gather reliable information from this assemblage including age and sex determinations (46, 47), calculations of the minimum number of individuals (MNI) represented, and the assessment of taphonomic and pathological changes present on the skeletal remains (48–50). The overall recovery conditions and the low level of detail of the available documentation precluded the reliable determination of individuals from all specimens, so osteological analyses and numerical calculations are based on a skeletal element count in a systematic and standardized way suitable for commingled remains (51, 52). Therefore the main aim is to provide reliable information on the group level, suitable for comparison with similar data from other sites.

In addition to the human bones, which are the most ubiquitous finds, the pit contained typical settlement refuse, consisting mainly of pottery sherds, pieces of burnt clay, animal bones, and various fragmented stone artifacts (43). All these artifacts show signs of wear, weathering, or other earlier damage; nothing was complete or largely undamaged. Their condition very much suggests that the recovered objects were not grave goods but were accidentally included waste material, as observed at other LBK mass burial sites (24, 40).

The only finds likely directly associated with the human remains are two bone arrowheads. These were discovered during the cleaning process in the laboratory within the soil previously adhering to the human bones (43). Their close proximity to the bones suggests that the arrowheads likely were inside the bodies when the bodies were deposited. Finds of arrowheads within body cavities are known from other Neolithic sites (29, 53) and can be taken as supporting evidence of conflict. When lodged in bone, they are widely regarded as the best indicator for armed conflict (54, 55).

Osteological Results

Based on the proximal left femur and the left femoral diaphysis, a postcranial MNI of 21 was determined (Table S2). The right side of both elements provided an MNI of only 19, as did the diaphysis of the left tibia. Of the major long bones, the proximal left tibia and humerus indicated a lower MNI of only 13. These results indicate quite well that, although the individuals were articulated upon deposition, taphonomic processes typical for the acidic soil of this region have destroyed a large part of the skeletal remains. The articulation of the skeletons can be observed from the top layers of the feature, and the presence of numerous small bone fragments demonstrates that this location is a primary deposition, because otherwise these fragments would have been lost. Detailed analyses of the crania and especially of the mostly still associated dentitions raised the final MNI to 26, which probably is close to the actual number of individuals originally present.

The age structure revealed a balanced ratio of 13 (50%) subadults and 13 (50%) adults (Tables S3 and S4). Of the 13 subadults 10 were less than 6 y old at death, the youngest being represented by two long bones of a maximum age of 6 mo. Only two individuals were children aged between *ca*. 6 and 8 y. The next youngest individual is a 16- to 21-y-old, classed as subadult biologically but who likely counted as a socially adult member of the LBK community (56). Individuals between the ages of 9 and 15 y seem not to be represented in the mass grave. This peculiar subadult demography pattern is significantly different from the overall 0- to 8-y-old and 8- to 17-y-old LBK samples currently available from both cemetery ($\chi^2 = 7.684$; $P = 0.006$) and settlement burials ($\chi^2 = 6.109$; $P = 0.013$) (57). Among the adults, younger adult individuals predominate; only two were more than 40 y old (Table S4). The sex of nine adult crania including mandibles could be determined as male or likely male; only those of the two oldest individuals are attributed to (likely) females, resulting in a male:female ratio of 1:4.5. Sex could not be determined reliably for two further crania. The postcranial elements also reflect this numerical deficit of females, albeit in lesser detail. Pelvic bones are largely destroyed, and the extant fragments represent only one male and one female individual. This skewed sex distribution is significantly different both from an equal number of male and female individuals ($\chi^2 = 4.455$; $P = 0.035$) and from the actual sex distributions observed in regular LBK burial places such as the large cemetery of Schwetzingen (Yates' $\chi^2 = 4.893$; $P = 0.027$) (58). In contrast, the male:female ratio at this site is not significantly different from that at the two other massacre sites ($\chi^2 = 1.909$; $P = 0.385$).

Assessing the overall antemortem disease load, we find lesions typical for the LBK: probable signs of tuberculosis in some ribs (50), traces of vitamin C deficiency (48), healed rib and long-bone fractures, a likely well-healed cranial surgery following trauma (Fig. 2*A*) (59), and osteomyelitis. Joint and dental diseases remain rare. The general health status therefore is as

Table 2. Extent of perimortem cranial injuries in subadult individuals

Element	Side	*N*	PI A	%	PI B	%
Frontal	Right	6	1	16.7	3	50.0
	Left	8	1	12.5	5	62.5
Parietal	Right	5	2	40.0	2	40.0
	Left	8	4	50.0	7	87.5
Occipital	Right	4	0	—	2	50.0
	Left	6	0	—	4	66.7
Temporal	Right	3	0	—	1	33.3
	Left	4	0	—	2	50.0
Zygomatic	Right	1	0	—	0	—
	Left	5	0	—	2	40.0
Maxilla	Right	3	0	—	0	—
	Left	5	0	—	2	40.0
Mandibula	Right	4	0	—	0	—
	Left	3	0	—	1	33.3

PI A, clear perimortem injuries (minimum); PI B, = clear and/or probable perimortem injuries (maximum).

Fig. 3. Examples of perimortem long-bone fractures identified in the mass grave, often showing the classic butterfly pattern (*A–C*). (*A*) Right tibia no. 289. (*B*) Left tibia no. 20–21. (*C*) Right tibia no. 374. (*D*) Right humerus no. 328 with parallel chop marks. (Scale bars, 2 cm each.)

expected for an LBK group from Central Europe, as previously determined from larger population samples.

The lesions that provide the most telling evidence for the interpretation of this mass grave feature are the very frequent perimortem cranial and postcranial fractures (49). These features characterize the assemblage in a way comparable to the other known LBK massacre sites of Talheim and Asparn/Schletz (24–26). Unequivocal perimortem blunt-force injuries affect most cranial bones and can be securely attributed in part to the known adze weapon-tools of the LBK (Fig. 2 *B–D*). Because most crania were only partly preserved, incomplete, and fragmentary, exact impact sites could not always be determined with confidence. Instead, the overall patterning of perimortem fracture zones was analyzed per cranial element for subadults and adults separately. The highest percentage of traumatized bone was found in the left parietal for both groups, a classic location for blows delivered in face-to-face confrontations during interpersonal violence (60, 61). Injuries to the other larger cranial elements are prevalent as well (Table 1). In the subadult sample, the left halves of the occipital and the frontal are the second and third most frequent cranial injuries (Table 2).

In addition to the extensive cranial trauma, a very high number of perimortem-fractured long bones were recorded (Fig. 3), but traces of carnivore activity could not be identified. Again, because of the high overall fragmentation, an element count based upon anatomically identified and isolated bone units was used for analysis (Table 3). The differences in fracture frequency between the major long bones are very apparent. On average, 19% of the fragments of the upper extremity bones show perimortem fracture [including at least one case of intended amputation of a humerus (Fig. 3*D*)], but the fracture frequency is much higher for the distal elements of the lower extremity. Some 31–42% of fibula units and a staggering 53–63% of tibia units show perimortem fractures, double to triple the percentage found in the upper limb bones. The lowest overall frequency was found in the femur, where a maximum of only 7% of identified units show perimortem fractures. This pattern clearly reveals a highly significant bias toward perimortem fragmentation of the distal segment of the lower limb and, especially, the tibia ($\chi^2 = 56.011$; $P < 0.001$). Suggestive but not definite lesions that could be attributed to arrow injuries were found in two vertebrae.

Osteoarchaeological Synthesis

Combining all evidence, the Kilianstädten mass grave is a clear example of an LBK massacre. Massive cranial traumata, affecting all cranial elements and including facial and tooth fractures and caused by the typical weapon-tools of the time, are accompanied by likely arrow injuries and subsequent commingled and careless deposition. In this regard, the Kilianstädten site is most similar to the Talheim massacre site (24), where a complete community of probably biologically related people was wiped out (8, 62, 63). The ratios of subadult to adult individuals are virtually identical at both sites (24), strongly indicating that the community at Kilianstädten was the target of an equally destructive lethal attack, almost annihilating a complete settlement. The significant absence of younger women in the Kilianstädten mass grave may indicate that these were taken captive by the attackers, as also has been suggested for the Asparn/Schletz site in Austria (19); ethnographic evidence attests to this practice (54, 55, 64). Likewise, the scarcity of teenagers among the victims could reflect their higher chances for escape in comparison with younger children or older adults (65), teenagers being possibly the most nimble demographic segment and unburdened by childcare or physical ailments (53). Alternatively, they could have been captured for forced integration into the attacker's community (60). Interestingly, the age gap in the Kilianstädten sample largely coincides with the proposed LBK middle-childhood period when children seem to have become much more active and recognized members of their communities (57) and thus might have been regarded, like the younger women of reproductive age, as a choice population segment for capture. When these likely missing individuals are taken into account, the overall sizes of the groups at Talheim and Kilianstädten would have been very similar as well, probably suggesting local communities of 30–40 people. Because attempts at unraveling the kinship structure of regular long-term LBK burial sites have been inconclusive so far (5, 66), the mass fatality samples also will play a key role in characterizing the composition of contemporaneous communities. Earlier studies already have indicated that kinship seems to have been one of the organizing principles of LBK life but that overall individual mobility was high over time (8, 63, 66). Therefore the complex interplay between biological and social factors that makes up the concept of prehistoric kinship is best approached via the actually contemporaneous population samples provided by the mass graves (35, 67).

The truly unique characteristic of the Kilianstädten mass grave, which previously was unknown for the LBK, is the clear pattern of targeted perimortem destruction of the distal segment of the lower limb. Chance damage can be dismissed; therefore an explanation must be sought in the violent events just before the deposition of the corpses (43). Specifically smashing the legs (tibiae and fibulae) certainly conveyed a message, which might be decoded with reference to other sites showing evidence of comparable levels of violence. In fact, torture and mutilation are often found as part of warfare (64, 68–70), and instances in which the lower limbs have been targeted specifically are known both from archaeological sites (71, 72) and recent history (69, 73). Restricting movement, practically and symbolically, may be the main reason for primarily targeting the legs, violently stressing the futility of resistance and escape and adding to the terror of the victims if they were still alive and acting as a subjugated audience (72). Because of the general nature of the

Table 3. Extent of perimortem-fractured long bones based on an identified unit count

Element	No of units	PI A	%	PI B	%
Humerus	52	6	11.5	10	19.2
Ulna	39	4	10.3	8	20.5
Radius	42	3	7.1	7	16.7
Femur	56	1	1.8	4	7.1
Tibia	57	30	52.6	36	63.2
Fibula	48	15	31.3	20	41.7

PI A, clear perimortem injuries (minimum); PI B, = clear and/or probable perimortem injuries (maximum).

osteological evidence for perimortem trauma, it is impossible to determine precisely whether living victims were tortured or their corpses mutilated systematically, or both. However, these possibilities may be understood in a similar manner, because both may convey hatred and contempt in an ostentatious way, as does the usual apparently careless disposal of violence victims in a commingled mass grave in times of lethal conflict (64, 74).

Early Neolithic Mass Graves as Evidence for Lethal Collective Violence

Building on both the evidence previously available for the LBK and the evidence presented here, we suggest that the repeated occurrence of almost indiscriminate massacres, the possible abduction of selected members, and the patterns of torture, mutilation, and careless disposal all fit into the concept of prehistoric warfare as currently understood within anthropology (54, 64, 75). Particular LBK groups were singled out for as yet unknown reasons, attacked with brute force, and annihilated by others, probably close neighbors and very likely other LBK groups of the wider region (25, 76). As has been shown, even within the overall quite homogenous-appearing LBK, recognizable boundaries did exist in many places (77–80). These borders most probably were a result of the spread of different groups without close social or biological kinship ties to one another who came in to close contact as a consequence of the LBK colonization pattern (4, 80). In fact, because the LBK was the first complete Neolithic culture in Central Europe (3), today all farmers of this time and region are classified as members of the LBK by default, regardless of how these people defined themselves and how they differentiated themselves from their contemporaries. Alternative cultural attributions, based almost exclusively on pottery styles, arise only with the decline of the LBK in its final phases (4). The suggested regional differentiation, the possible collapse of previous exchange systems, and increasing defensive architecture are all compatible with increasing levels of widespread social tensions and the looming threat of utmost violence (3). The massacres now known from three widely separated localities but dating to a rather short period give direct evidence that outbreaks of lethal collective violence unquestionably occurred repeatedly within the later LBK (19, 24–26). Although the particular triggers for each massacre might have been different, the overarching patterns of extreme violence and the atypical treatment of the dead are recognizably similar (35). In this context, it is especially telling that all three of the unequivocal massacre sites currently known date to the later phases of the LBK (17, 25), but there is no evidence for comparable levels of violence in the earlier periods.

The Kilianstädten massacre, which occurred within an archaeologically suggested border zone of different LBK subgroups (43, 80), with its high potential for intergroup conflict (54, 76), provides an illuminating example of characteristics of nonstate warfare identified earlier from the ethnographic record; the abduction of younger women and the torture, mutilation, and killing of enemies can be seen clearly in the osteological record of Early Neolithic Central Europe (54). Although some earlier works supporting the notion of widespread warfare during the later LBK were based, at least in part, on a premature interpretation of several LBK sites (15, 16, 41) that now are interpreted differently (20–23), the evidence has become more conclusive again with the Kilianstädten site. Importantly, more skeletal remains, the only direct evidence for collective lethal violence, are now available (16, 41, 49). Although the underlying supraregional causes for the recognized increase in mass violence in the late LBK undoubtedly were complex and multifactorial, a significant increase in population followed by adverse climatic conditions (drought), possibly coupled with the inability of long-settled farmers to practice the avoidance behavior by which hunter-gatherers typically evade conflict (75), seems to have been an important component of the overall picture (4). As previous research has shown, climatic changes, especially those leading to increasing unpredictability of or even significant decreases in agricultural production, have played major roles in the change and collapse of societies throughout human history (4, 81, 82). Ecological imbalance and perceived or actual resource stress were suggested previously as some of the main reasons for massacres and warfare in general (55, 64, 83), and at the end of the LBK aggression might have been aggravated further by patrilineally determined social inequality, especially with regard to access to coveted, high-quality farmland, food, and possibly prestige goods (9, 13, 14, 76, 84).

In conclusion, the concerted annihilation of entire social units, one of the hallmarks of early warfare, is now clearly evident from the analysis of human skeletal remains from three separate late LBK localities (19, 24–26). Massacres seem to have been the most powerful strategy in prehistoric warfare (54, 85, 86), and the osteoarchaeological evidence from Early Neolithic Central Europe clearly shows that such acts of mass violence were carried out repeatedly in the deep human past by groups living in pristine prestate conditions (83, 86, 87).

ACKNOWLEDGMENTS. We thank T. Eifler and the Radiology Unit of the University Hospital of Mainz for bone CT-scans, N. Nicklisch and L. Fibiger for help in the preparation of a figure and the manuscript, the anonymous reviewers for their valuable suggestions, and the Hessian State Office for Heritage Management for ongoing support. H.-C. Strien helped with the typological dating of the ceramics.

1. Modderman PJR (1988) The Linear Pottery Culture: Diversity in uniformity. *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 38:63–139.
2. Gronenborn D (1999) A variation on a basic theme: The transition to farming in Southern Central Europe. *J World Prehist* 13(2):123–210.
3. Bickle P, Whittle A (2013) *The First Farmers of Central Europe* (Oxbow, Oxford, UK).
4. Gronenborn D, Strien H-C, Dietrich S, Sirocko F (2014) 'Adaptive cycles' and climate fluctuations: A case study from Linear Pottery Culture in western Central Europe. *J Archaeol Sci* 51:73–83.
5. Haak W, et al.; Members of the Genographic Consortium (2010) Ancient DNA from European early Neolithic farmers reveals their Near Eastern affinities. *PLoS Biol* 8(11): e1000536.
6. Brandt G, et al.; Genographic Consortium (2013) Ancient DNA reveals key stages in the formation of central European mitochondrial genetic diversity. *Science* 342(6155): 257–261.
7. Oelze V, et al. (2011) Early Neolithic diet and animal husbandry: Stable isotope evidence from three Linearbandkeramik (LBK) sites in Central Germany. *J Archaeol Sci* 38(2):270–279.
8. Bentley RA, Wahl J, Price TD, Atkinson TC (2008) Isotopic signatures and hereditary traits: Snapshot of a Neolithic community in Germany. *Antiquity* 82(316):290–304.
9. Bentley RA, et al. (2012) Community differentiation and kinship among Europe's first farmers. *Proc Natl Acad Sci USA* 109(24):9326–9330.
10. Bramanti B, et al. (2009) Genetic discontinuity between local hunter-gatherers and central Europe's first farmers. *Science* 326(5949):137–140.
11. Edwards CJ, et al. (2007) Mitochondrial DNA analysis shows a Near Eastern Neolithic origin for domestic cattle and no indication of domestication of European aurochs. *Proc Biol Sci* 274(1616):1377–1385.
12. Haak W, et al. (2008) Ancient DNA, Strontium isotopes, and osteological analyses shed light on social and kinship organization of the Later Stone Age. *Proc Natl Acad Sci USA* 105(47):18226–18231.
13. Hedges R, et al. (2013) The supra-regional perspective. *The First Farmers of Central Europe*, eds Bickle P, Whittle A (Oxbow, Oxford, UK), pp 343–384.
14. Bogaard A, et al. (2013) Crop manuring and intensive land management by Europe's first farmers. *Proc Natl Acad Sci USA* 110(31):12589–12594.
15. Farruggia J-P (2002) Une crise majeure de la civilisation du Néolithique Danubien des années 5100 avant notre ère. *Archeologické Rozhledy* 54(1):44–98.
16. Golitko M, Keeley LH (2007) Beating ploughshares back into swords: Warfare in the Linearbandkeramik. *Antiquity* 81(312):332–342.
17. Wild EM, et al. (2004) Neolithic massacres: Local skirmishes or general warfare in Europe? *Radiocarbon* 46(1):377–385.
18. Boulestin B, et al. (2009) Mass cannibalism in the Linear Pottery Culture at Herxheim (Palatinate, Germany). *Antiquity* 83(322):968–982.
19. Teschler-Nicola M, et al. (1999) Evidence of genocide 7000 BP—Neolithic paradigm and geo-climatic reality. *Coll Antropol* 23(2):437–450.
20. Zeeb-Lanz A (2009) Gewaltszenarien oder Sinnkrise? Die Grubenanlage von Herxheim und das Ende der Bandkeramik. *Krisen–Kulturwandel–Kontinuitäten*, ed Zeeb-Lanz A (Marie Leidorf, Rahden, Germany), pp 87–101.

21. Stäuble H (2014) *Die Krise am Ende der Linienbandkeramik? Oder ist es am Ende eine Krise der Bandkeramik-Forschung?! No future?*, eds Link T, Schimmelpfennig D (Welt und Erde, Kerpen-Loogh, Germany), pp 11–49.
22. Zeeb-Lanz A (2014) Gewalt im Ritual – Gewalt an Toten. Die Krise am Ende der Bandkeramik im Spiegel außergewöhnlicher Befunde. *Gewalt und Gesellschaft*, eds Link T, Peter-Röcher H (Habelt, Bonn), pp 257–270.
23. Link T (2014) Gewaltphantasien? Kritische Bemerkungen zur Diskussion über Krieg und Krise am Ende der Bandkeramik. *Gewalt und Gesellschaft*, eds Link T, Peter-Röcher H (Habelt, Bonn), pp 271–286.
24. Wahl J, König HG (1987) Anthropologisch-traumatologische Untersuchung der menschlichen Skelettreste aus dem bandkeramischen Massengrab bei Talheim, Kreis Heilbronn. *Fundberichte aus Baden-Württemberg* 12:65–186.
25. Wahl J, Trautmann I (2012) The Neolithic massacre at Talheim: A pivotal find in conflict archaeology. *Sticks, Stones, and Broken Bones*, eds Schulting R, Fibiger L (Oxford Univ Press, Oxford, UK), pp 77–100.
26. Teschler-Nicola M (2012) The Early Neolithic site Asparn/Schletz (Lower Austria): Anthropological evidence of interpersonal violence. *Sticks, Stones, and Broken Bones*, eds Schulting R, Fibiger L (Oxford Univ Press, Oxford, UK), pp 101–120.
27. Zollikofer CPE, Ponce De Leon MS, Vandermeersch B, Lévêque F (2002) Evidence for interpersonal violence in the St. Cesaire Neanderthal. *Proc Natl Acad Sci USA* 99(9): 6444–6448.
28. Sala N, et al. (2015) Lethal interpersonal violence in the middle Pleistocene. *PLoS One* 10(5):e0126589.
29. Guilaine J, Zammit J (2005) *The Origins of War. Violence in Prehistory* (Blackwell, Oxford, UK).
30. Frayer DW (1997) Ofnet: Evidence for a Mesolithic massacre. *Troubled Times*, eds Martin DL, Frayer DW (Overseas Publishers Association, Amsterdam), pp 181–216.
31. Orschiedt J (2005) The head burials from Ofnet cave: An example of warlike conflict in the Mesolithic. *Warfare, Violence and Slavery in Prehistory*, eds Parker Pearson M, Thorpe IJN (Archaeopress, Oxford, UK), pp 67–73.
32. Schulting RJ (2015) Mesolithic skull cults? *Ancient Death Ways*, eds von Hackwitz K, Peyroteo-Stjerna R (Institutionen för arkeologi och antik historia, Uppsala, Sweden), pp 19–46.
33. Petrasch J (1999) Mord und Krieg in der Bandkeramik. *Archäologisches Korrespondenzblatt* 29(4):505–516.
34. Trautmann I (2006) *The Significance of Cremations in Early Neolithic Communities in Central Europe*. PhD thesis (University of Tübingen, Tübingen, Germany) Available at nbn-resolving.de/urn:nbn:de:bsz:21-opus-30056. Accessed June 30, 2015.
35. Meyer C, et al. (2014) Mass graves of the LBK: Patterns and peculiarities. *Early Farmers*, eds Whittle A, Bickle P (Oxford Univ Press, Oxford, UK), pp 307–325.
36. Villotte S, Knüsel CJ (2014) "I sing of arms and of a man …": Medial epicondylosis and the sexual division of labour in prehistoric Europe. *J Archaeol Sci* 43:168–174.
37. Jeunesse C, Barrand-Emam H, Denaire A, Chenal F (2014) Unusual funeral practices and violence in Early Neolithic Central Europe: New discoveries at the Mulhouse-Est Linearbandkeramik. *Antiquity* 342: Online Project Gallery. Available at journal.antiquity.ac.uk/projgall/jeunesse342. Accessed June 30, 2015.
38. Gronenborn D (2003) Der ‚Jäger/Krieger' aus Schwanfeld. Einige Aspekte der politisch-sozialen Geschichte des mitteleuropäischen Altneolithikums. *Archäologische Perspektiven*, eds Eckert J, Eisenhauer U, Zimmermann A (Marie Leidorf, Rahden, Germany), pp 35–48. German.
39. Petrasch J (2006) Gewalttätigkeiten in der Steinzeit – Archäologisch-kulturgeschichtliche Analysen zur Ermittlung ihrer Häufigkeiten. *Frühe Spuren der Gewalt*, eds Piek J, Terberger T (Landesamt für Kultur und Denkmalpflege, Schwerin, Germany), pp 155–162.
40. Meyer C, Kürbis O, Alt KW (2004) Das Massengrab von Wiederstedt, Ldkr. Mansfelder Land. Auswertung und Gedanken zur Deutung im Kontext der Linienbandkeramik. *Jahresschrift für mitteldeutsche Vorgeschichte* 88:31–66.
41. Christensen J (2004) Warfare in the European Neolithic. *Acta Archaeologica* 75(2): 129–156.
42. Schwitalla G, Schmitt KM (2006) Ein Massengrab aus der Umgehungsstraße oder "Aus der Linearbandkeramik ist alles bekannt." *hessenArchäologie* 2006:31–32.
43. Lohr C (2013) Archäologische und anthropologische Untersuchungen des Massengrabes von Schöneck-Kilianstädten (Main-Kinzig-Kreis, Hessen). Masters thesis (University of Mainz, Mainz, Germany).
44. Ramminger B (2003) *Zur bandkeramischen Besiedlung im unteren Niddertal* (Habelt, Bonn).
45. Kerig T (2008) *Hanau-Mittelbuchen. Siedlung und Erdwerk der bandkeramischen Kultur* (Habelt, Bonn).
46. White TD, Folkens PA (2005) *The Human Bone Manual* (Elsevier, Amsterdam).
47. Szilvássy J (1988) Altersdiagnose am Skelett. *Anthropologie. Handbuch der vergleichenden Biologie des Menschen II/1*, ed Knußmann R (Fischer, Stuttgart), pp 421–443.
48. Carli-Thiele P (1996) *Spuren von Mangelerkrankungen an steinzeitlichen Kinderskeleten* (Erich Goltze, Göttingen, Germany).
49. Knüsel CJ (2005) The physical evidence of warfare – subtle stigmata? *Warfare, Violence and Slavery in Prehistory*, eds Parker Pearson M, Thorpe IJN (Archaeopress, Oxford, UK), pp 49–65.
50. Nicklisch N, et al. (2012) Rib lesions in skeletons from early Neolithic sites in Central Germany: On the trail of tuberculosis at the onset of agriculture. *Am J Phys Anthropol* 149(3):391–404.
51. Schmitt S (2002) Mass graves and the collection of forensic evidence: Genocide, war crimes, and crimes against humanity. *Advances in Forensic Taphonomy*, eds Haglund WD, Sorg MH (CRC, Boca Raton, FL), pp 277–292.
52. Byrd J, Adams BJ (2009) Analysis of commingled human remains. *Handbook of Forensic Archaeology and Anthropology*, eds Blau S, Ubelaker DH (Left Coast, Walnut Creek, CA), pp 174–186.
53. Meyer C, et al. (2009) The Eulau eulogy: Bioarchaeological interpretation of lethal violence in Corded Ware multiple burials from Saxony-Anhalt, Germany. *J Anthropol Archaeol* 28(4):412–423.
54. Keeley LH (1996) *War Before Civilization* (Oxford Univ Press, New York).
55. Maschner HDG, Reedy-Maschner KL (1998) Raid, retreat, defend (repeat): The archaeology and ethnohistory of warfare on the North Pacific Rim. *J Anthropol Archaeol* 17(1):19–51.
56. Fibiger L (2014) Misplaced childhood? Interpersonal violence and children in Neolithic Europe. *The Routledge Handbook of the Bioarchaeology of Human Conflict*, eds Knüsel C, Smith MJ (Routledge, London), pp 127–145.
57. Bickle P, Fibiger L (2014) Ageing, childhood and social identity in the Early Neolithic of Central Europe. *Eur J Archaeol* 17(2):208–228.
58. Gerling C (2007) Der Tod in der jüngeren Bandkeramik. Das Gräberfeld von Schwetzingen. *Denkmalpflege in Baden-Württemberg* 36(3):159–163.
59. Alt KW, et al. (1997) Evidence for Stone Age cranial surgery. *Nature* 387(6631):360.
60. Schulting RJ, Fibiger L (2014) Violence in Neolithic North-west Europe. A population perspective. *Early Farmers*, eds Whittle A, Bickle P (Oxford Univ Press, Oxford, UK), pp 281–306.
61. Fibiger L, Ahlström T, Bennike P, Schulting RJ (2013) Patterns of violence-related skull trauma in Neolithic Southern Scandinavia. *Am J Phys Anthropol* 150(2):190–202.
62. Alt KW, Vach W, Wahl J (1995) Verwandtschaftsanalyse der Skelettreste aus dem bandkeramischen Massengrab von Talheim, Kreis Heilbronn. *Fundberichte aus Baden-Württemberg* 20:195–217.
63. Duering A, Wahl J (2014) A massacred village community? Agent-based modelling sheds new light on the demography of the Neolithic mass grave of Talheim. *Anthropol Anz* 71(4):447–468.
64. LeBlanc SA, Register KE (2003) *Constant Battles. Why We Fight* (St. Martin's, New York).
65. Verwimp P (2004) Death and survival during the 1994 genocide in Rwanda. *Popul Stud (Camb)* 58(2):233–245.
66. Brandt G, et al. (2014) Settlement burials at the Karsdorf LBK site, Saxony-Anhalt, Germany. *Early Farmers*, eds Whittle A, Bickle P (Oxford Univ Press, Oxford, UK), pp 95–114.
67. Meyer C, Ganslmeier R, Dresely V, Alt KW (2012) New approaches to the reconstruction of kinship and social structure based on bioarchaeological analysis of Neolithic multiple and collective graves. *Theoretical and Methodological Considerations in Central European Neolithic Archaeology*, eds Kolár J, Trampota F (Archaeopress, Oxford, UK), pp 11–23.
68. Knüsel C, Smith MJ (2014) Introduction. The bioarchaeology of conflict. *The Routledge Handbook of the Bioarchaeology of Human Conflict*, eds Knüsel C, Smith MJ (Routledge, London), pp 3–24.
69. Ferllini R (2014) Recent conflicts, deaths and simple technologies. The Rwandan case. *The Routledge Handbook of the Bioarchaeology of Human Conflict*, eds Knüsel C, Smith MJ (Routledge, London), pp 641–655.
70. Gronenborn D (2007) Climate change and socio-political crises: Some cases from Neolithic Central Europe. *War and Sacrifice. Studies in the Archaeology of Conflict*, eds Pollard T, Banks I (Brill, Leiden, The Netherlands), pp 13–32.
71. Potter JM, Chuipka JP (2010) Perimortem mutilation of human remains in an early village in the American Southwest: A case for ethnic violence. *J Anthropol Archaeol* 29(4):507–523.
72. Osterholtz AJ (2012) The social role of hobbling and torture: Violence in the prehistoric Southwest. *Int J Paleopathol* 2(2-3):148–155.
73. Kimmerle EH, Baraybar JP (2008) *Skeletal Trauma. Identification of Injuries Resulting from Human Rights Abuse and Armed Conflict* (CRC, Boca Raton, FL).
74. Komar D (2008) Patterns of mortuary practice associated with genocide. Implications for archaeological research. *Curr Anthropol* 49(1):123–133.
75. Fry DP (2013) War, peace, and human nature. The challenge of achieving scientific objectivity. *War, Peace, and Human Nature*, ed Fry DP (Oxford Univ Press, New York), pp 1–21.
76. Golitko ML (2010) Warfare and Alliance Building during the Belgian Early Neolithic, Late Sixth Millennium BC. PhD thesis (University of Illinois, Chicago).
77. Zimmermann A (1995) *Austauschsysteme von Silexartefakten in der Bandkeramik Mitteleuropas* (Habelt, Bonn).
78. Kneipp J (1998) *Bandkeramik zwischen Rhein, Weser und Main* (Habelt, Bonn).
79. Lefranc P (2007) *La Céramique du Rubané en Alsace* (Université Marc-Bloch, Strasbourg, France).
80. Kerig T (2010) Grenzen ziehen: Zur Chronologie regionaler und sozialer Unterschiede im hessischen Altneolithikum. *The Spread of the Neolithic to Central Europe*, eds Gronenborn D, Petrasch J (Römisch-Germanisches Zentralmuseum, Mainz, Germany), pp 475–486.
81. Zhang DD, Brecke P, Lee HF, He YQ, Zhang J (2007) Global climate change, war, and population decline in recent human history. *Proc Natl Acad Sci USA* 104(49):19214–19219.
82. Douglas PMJ, et al. (2015) Drought, agricultural adaptation, and sociopolitical collapse in the Maya Lowlands. *Proc Natl Acad Sci USA* 112(18):5607–5612.
83. Ember CR, Ember M (1997) Violence in the ethnographic record: Results of cross-cultural research on war and aggression. *Troubled Times*, eds Martin DL, Frayer DW (Overseas Publishers Association, Amsterdam), pp 1–20.
84. Knüsel C, Smith MJ (2014) The osteology of conflict. What does it all mean? *The Routledge Handbook of the Bioarchaeology of Human Conflict*, eds Knüsel C, Smith MJ (Routledge, London), pp 656–694.
85. Willey P (1990) *Prehistoric Warfare on the Great Plains. Skeletal Analysis of the Crow Creek Massacre Victims* (Garland Publishing, New York).
86. Armit I (2011) Violence and society in the deep human past. *Br J Criminol* 51(3): 499–517.
87. Ferguson RB, Whitehead NL (1992) The violent edge of empire. *War in the Tribal Zone*, eds Ferguson RB, Whitehead NL (SAR, Santa Fe, NM), pp 1–30.