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# Recognizing plague epidemics in the archaeological record of West Africa

*Identifier des épidémies de peste par leur empreinte archéologique en Afrique de l'Ouest*

Daphne E. Gallagher and Stephen A. Dueppen

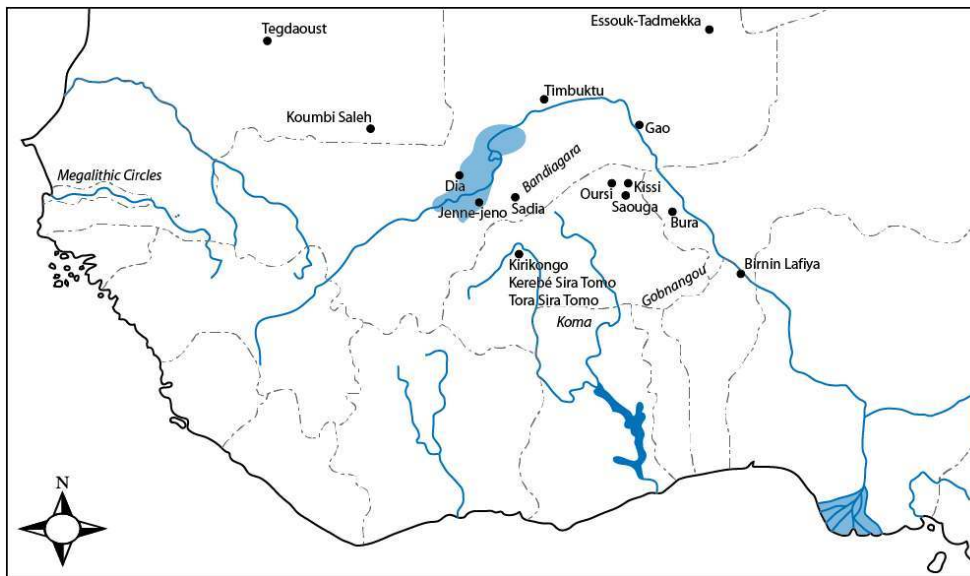
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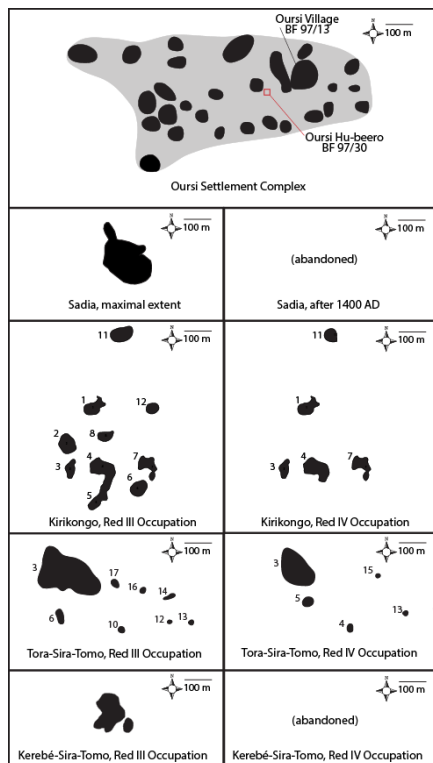
- 1 West Africa was never isolated. Scholars have long recognized that the early second millennium CE was a dynamic time in the West African savanna, marked by dramatic transformations in settlement patterns, economies, interregional connections, and changing material culture traditions.<sup>1</sup> In the archaeological record from the first millennium CE through the early second millennium CE, both the numbers of new communities and the size of sites generally grew, suggesting a region-wide trajectory of increasing population densities. However, by 1400 CE, this clear pattern of growth had

halted, and many regions have evidence of site abandonment, site size reduction, and reorganizations in population in the second quarter of the second millennium CE.

- 2 The reasons for these changes are poorly understood. While, as has been demonstrated in other regions, it is important to see each abandonment or reorganization as the result of the particular historical circumstances affecting that location—given the scale of the events, region-wide processes likely contributed. The paleoenvironmental record does suggest increasing aridity in many regions of the savanna at this time, which could have affected the ability to reliably produce enough food to support dense populations in some areas. Politically, the decline of the Mali empire and increasing Islamicization may have spurred population movements and settlement changes. Drawing on a growing trend in the literature,<sup>2</sup> we argue that the effects of the Second Plague Pandemic, better known as the Black Death, must also be considered as a possible contributing factor.
- 3 Caused by *Yersinia pestis*, the second plague pandemic is thought to have begun in East Asia in the early 1300s, then spread west through Eurasia, reaching the Middle East and sweeping through Europe and North Africa from 1347 to 1353 CE.<sup>3</sup> While the first wave of the Black Death was particularly devastating, historians have now established that plague outbreaks occurred regularly in Europe and North Africa for several hundred years.<sup>4</sup> The Second Pandemic was notable for its particularly high mortality rates, which are thought to have decreased the population of Europe, the Middle East, and North Africa by up to 50% over the latter half of the 14th century.<sup>5</sup> With the exception of a few scholars,<sup>6</sup> most researchers have implicitly assumed that the Sahara desert acted as an effective buffer against the spread of plague to Sub-Saharan West Africa, and consequently the region has rarely figured in analyses of the Black Death. As this special issue and the workshop in which it originated demonstrate, this is an assumption that requires re-evaluation, particularly in light of the significant advances in global studies of plague over the past two decades.
- 4 Determining whether and to what extent plague affected Sub-Saharan Africa is a large-scale, long-term project requiring a mixed methods approach that considers evidence from the documentary record, oral histories, archaeology, art history, historical linguistics, and genetics.<sup>7</sup> Here, we focus on the potential contributions of the archaeological record to these debates by examining the data from four well-published, well-dated case studies in central West Africa: Oursi, Kissi, and Saouga in Oudalan, Burkina Faso; Jenné-jeno and Dia in the Inland Niger Delta, Mali; Sadia on the Seno Plain, Mali; and Kirikongo, Tora-Sira-Tomo, and Kerebé-Sira-Tomo in the Mouhoun Bend, Burkina Faso (fig. 1). For these cases, we review the evidence for settlement abandonment and reorganization in the period 1200–1500 CE, paying close attention to the possible contributions of other factors such as climate and socio-political or religious changes. While it is not possible to prove plague with current data, the effects of the disease are consistent with demographic and cultural changes in several of our case studies.

**Figure 1: Location of sites mentioned in the text**

Map by S. Dueppen and D. Gallagher, 2018.

**Figure 2: Maps of sites mentioned in the text**

Oursi redrawn from L. PETIT *et al.*, 2011, p. 18; Sadia redrawn from E. HUYSECOM *et al.*, 2015, p. 9; Kirikongo, Tora-Sira-Tomo, and Kerebé-Sira-Tomo adapted from S. DUEPPEN, D. GALLAGHER, 2016, p. 154.

- 5 Although we contextualize the focus case studies with regional data, this paper is not a comprehensive review of the archaeological evidence for demographic changes (or lack thereof) in 14th-century West Africa. Rather, we wish to demonstrate that although identifying plague from settlement data poses methodological challenges and requires

nuanced consideration of local histories, this approach represents a productive line of research.

## Identifying Plague in the West African Archaeological Record

- 6 Archaeologically, the presence of plague in medieval West Africa can be best confirmed through the recovery of *Yersinia pestis* aDNA from human remains. However, given the established challenges in recovering the bacterium<sup>8</sup> and the generally poor molecular preservation in West African human remains,<sup>9</sup> proxy data are currently our primary means of evaluating whether the Second Pandemic affected West African populations. Even if the bacterium is recovered in the future, careful analysis of proxy data will be essential for determining the full extent and impacts of the disease. Archaeological proxy data for plague takes three primary forms: establishment of the conditions for transmission; disruptions in burial traditions as communities coped with large numbers of dead; and evidence for rapid loss of population.

### The spread of plague to West Africa

- 7 Plague is typically an enzootic disease extant in sylvatic rodents that, for reasons not fully understood, periodically amplifies and spreads in commensal rodent and human populations.<sup>10</sup> For many years, it was assumed that the transmission of Second Pandemic Plague relied specifically on the commensal black rat (*Rattus rattus*) and its fleas.<sup>11</sup> The late introduction of this species to West Africa (typically placed after the opening of direct shipping lanes with Europe) was a major factor in the assumption that plague did not reach the region until the Third Pandemic in the 19th century CE.<sup>12</sup> Over the past two decades, new scholarship has both expanded our understandings of plague transmission and increasingly highlighted uncertainty regarding the precise mechanisms by which the Black Death spread.<sup>13</sup>
- 8 Historical studies have now documented a wide range of rodents that hosted plague in medieval Eurasia.<sup>14</sup> This research de-emphasizes the role of the black rat in spreading the disease, a result reinforced by the near absence of black rats in archaeological deposits at sites known to have been affected.<sup>15</sup> While rodents remain an essential component of all reconstructions of plague cycles, several scholars have argued that during the Second Pandemic plague was also transmitted directly between individuals via human ectoparasites such as fleas and lice.<sup>16</sup> Consequently, distributions of rodent species may not have inhibited the spread of plague.
- 9 The current levels of uncertainty regarding Second Pandemic plague transmission create challenges for modeling the expansion of the disease to West Africa. By the 14th century, trans-Saharan caravan routes were well traversed and while Sub-Saharan long-distance trade relationships are less well documented, plague could also have spread down the Nile River or to East African port cities, then west across the continent.<sup>17</sup> Whether or not the plague bacterium could have survived these journeys to infect Sub-Saharan communities in West Africa depends on incubation periods and the diversity and characteristics of viable hosts and vectors, all of which are unknown at this time.

10 Once plague reached the population centers of West Africa, it would likely have spread easily within the region. In medieval Europe, plague outbreaks were most severe during rainy summers when rodent and flea populations would have been particularly large, an effect possibly exaggerated in wet years that followed dry years.<sup>18</sup> If rodent hosts were critical for local spread of the disease, candidate species were common. Today, surveys have found that plague can be hosted by numerous genera of African rodents, many of which are found in regional archaeological sites.<sup>19</sup> While the ecology of fleas in tropical Africa does not necessarily mirror that of temperate zones, the region's rainfall is concentrated in summer months, and due to the nature of the ITCZ, savanna and Sahelian West Africa has high interannual variation in precipitation, the extremity of which may have been particularly pronounced in the early-mid second millennium CE.

20

11 Finally, it is an open question as to whether plague could have become a localized enzootic disease that on occasion amplified and infected human populations or whether subsequent epidemics would have required reintroductions of the bacterium.<sup>21</sup> Although West Africa is home to a wide range of potential rodent hosts, it does lack the high elevation regions anecdotally associated with new foci for plague enzootics.<sup>22</sup>

## Plague and burial traditions

12 Identifying changes in the treatment of the dead or the opening of new cemeteries could be a valuable line of evidence for plague in medieval West Africa, particularly since cemetery excavations would provide opportunities for recovering the *Yersinia pestis* bacterium. Studies of burial practice in Europe have found that numerous new cemeteries were established to cope with plague victims. While evidence for decomposition before burial and the use of mass trenches and burial stacking show the extent to which funerary systems were stressed, efforts seem to have been made to maintain Christian funerary customs.<sup>23</sup>

13 Currently, there are no unambiguous examples in savanna/Sahelian West Africa of large cemeteries opened after the mid-14th century, regardless of whether one considers new burial grounds within existing funerary traditions or the adoption of new traditions. In most parts of West Africa, however, there is so little data overall on medieval mortuary practices that it is currently impossible to tell whether plague cemeteries are actually absent and/or whether their absence is meaningful. Among documented cemeteries, many predate the Second Pandemic.<sup>24</sup> In other cases, the use of cemeteries or burial practices spans the 14th century CE, but the number of burials from any given place or time is low.<sup>25</sup> In general, attributing the cessation or transformation in burial traditions to plague is difficult without data on the practices that replaced them, and causal explanation is further complicated by the medieval spread of Islam with its associated funerary practices. Overall, the lack of large excavation samples combined with low-resolution chronologies within the funerary traditions makes it difficult to assess the extent to which existing traditions may have been affected by the Second Pandemic.

14 These challenges are perhaps best illustrated by the megalithic stone circle traditions of the Senegambia. There, researchers have documented over 2,000 cemeteries with more than 17,000 funerary monuments, most of which contain multiple burials.<sup>26</sup> Only a handful of these sites have been dated; and while most recorded sites pre-date the

plague pandemic by several centuries, a few do extend into the 15th century CE, raising the possibility that some circles may contain 14th–15th-century burials. Unfortunately, at this time we currently cannot characterize the pace of cemetery construction over the 600+ years this funerary tradition was likely active or compare earlier and later practices regarding issues such as investment in circle construction or the number of individuals interred together. Human remains recovered from megalithic circle sites typically have extremely poor preservation, and while further research may resolve the chronology, recovery of the plague bacterium seems unlikely.

- 15 One of the best documented continuous funerary traditions in the region is the cave burials of the Bandiagara escarpment, a practice that extended from the first millennium BC through the 20th century CE.<sup>27</sup> In the early second millennium CE, residents of the region deposited their dead in particularly large collective burial caves that in some cases, such as Cave C, contain the remains of over 2,500 individuals.<sup>28</sup> While by the 13th–14th century CE most new burial caves served as the resting place of significantly fewer individuals,<sup>29</sup> direct dates on human bone have demonstrated that Cave C continued in active use through at least the 15th century CE.<sup>30</sup> Previously, the largest caves were thought to date only to pre-plague periods, and these new data open up the possibility for new interpretations. Human remains from the Bandiagara cave sites have exceptionally well-preserved bone collagen<sup>31</sup> but have not yet been tested for preservation of genetic material.<sup>32</sup>
- 16 While much potential exists for identifying epidemics through studies of cemeteries, more research is required before we will be able to make a case for or against plague based on the foundation and use of West African cemeteries. Consequently, in this paper, we focus on the final proxy measure, evidence for rapid and widespread population reductions.

## Plague and population loss

- 17 As mentioned above, the Second Plague Pandemic is thought to have reduced populations by 50% in Europe, the Middle East, and North Africa.<sup>33</sup> Research in Europe has established that these population losses were widespread, affecting communities ranging from small rural settlements to urban centers. While most estimates are drawn from the documentary record (using texts such as church records, tax tables, and wills),<sup>34</sup> environmental reconstructions also indicate substantial decreases in population.<sup>35</sup> Archaeological studies focused on settlement and material culture are more rare, but produce similar results. The most comprehensive of the European archaeological studies to date is Lewis's program of intensive test pitting (1,717 units of 1 m<sup>2</sup>) in eastern England that examined the impact of plague on 50 settlements.<sup>36</sup> Taking advantage of shifts in local pottery styles that coincided with the outbreak of plague, Lewis was able to use changes in the frequency and spatial distribution of common wares as a proxy for population.<sup>37</sup> While some locations fared worse than others, this research systematically demonstrated population loss at all sites (on average 45% across the region, although individual county figures ranged from 12% to 65%) and frequent significant contractions in the spatial extent of communities. Severe losses were observed in large towns and small hamlets, as well as in nucleated and more dispersed settlements, suggesting widespread effects. As all of the tested settlements



had been continuously occupied since the Middle Ages, these results include only “successful survivors”; many communities were likely abandoned entirely as well.<sup>38</sup>

- 18 In West Africa, given the much more limited corpus of documentary sources,<sup>39</sup> the archaeological record is critical for assessing whether the large-scale, widespread mortality associated with the Second Pandemic Plague occurred in the region. While site abandonments and population reductions may occur at the local level for a variety of reasons, the plague would be expected to affect large areas and diverse populations throughout greater West Africa. If the Black Death followed the same patterns identified in other world regions, it should impact large and small communities, and its effects should be observed from the Sahel to the forest zone.<sup>40</sup> While populations might migrate or consolidate following plague epidemics, significant population growth in any part of the region would be unlikely. In contrast, settlement changes caused by political or social factors would be expected to be more locally variable, and the decline of one major center would typically be accompanied by the rise of others.
- 19 Climate change could also produce region-wide shifts in settlement and has been one of the most commonly cited reasons for population changes in the early second millennium CE. During this period, instability and an overall pattern of increasing aridity may have shifted West Africa’s east-west-oriented rainfall isohyets and vegetation zones further south, increasingly resembling modern environmental conditions.<sup>41</sup> Site abandonments spurred by climate change would be most extreme in the marginal Sahelian areas on the southern edge of the Sahara desert and increasingly less significant in the central and southern savanna and the more resilient floodplain environments. The latter regions might even have seen growth as populations migrated to more economically sustainable locations, and people who stayed in the north would likely have shifted away from farming and toward more mobile pastoralist economies. At the same time, as described above, climate instability could also produce conditions that would have facilitated the spread of plague.
- 20 Chronology is of central concern in attributing medieval West African site abandonments and site-level population decreases to plague. Based on our data from Europe and North Africa, plague would most likely have spread to West Africa sometime after 1347 CE.<sup>42</sup> If caused by the Second Plague Pandemic, we would expect widespread population loss events to be clustered in the latter half of the 14th century CE, although as is the case in Europe, outbreaks may have continued over the next several hundred years.<sup>43</sup> Archaeologists face several challenges in reaching this level of precision, as abandonment layers are typically among the most poorly preserved at archaeological sites.<sup>44</sup> In the case of the mounded tell sites that we focus on here, monsoonal rains have typically caused deflation, and in some cases final occupation layers have been additionally disturbed by agricultural activity.<sup>45</sup> Dating is further complicated by a flattening of the radiocarbon calibration curve, such that absolute dates on 14th-century samples often span both the pre- and post-plague periods.
- 21 Finally, throughout this paper, we utilize changes in site size as a proxy for changes in population.<sup>46</sup> As with all archaeological estimates of demography, this methodology is imperfect,<sup>47</sup> and we consider specific concerns regarding the accuracy of this approach for the particular circumstances in our discussions of each case study. In general, by focusing primarily on significant transformations in site size and on relative change at single sites, rather than comparisons between sites, we minimize many sources of error. At the site level, an increase in population that occurred in conjunction with a



decrease in settlement area represents the most problematic scenario for this analysis. We argue that a significantly more compact residence pattern would likely produce identifiable changes in architectural and midden deposits. More complex are the changes that result from shifts in the spatial organization of settlement, such as a move from a nucleated to a more dispersed residential pattern.

- 22 Given the diversity of societies and range of local ecological variants throughout the region, it is possible—and perhaps even most likely—that environmental, social, and political transformations could have co-occurred at this time. However, plague could have combined with this wide array of localized processes to contribute to regional-scale problems.

## The case studies

- 23 As is clear from the above, making a proxy case for plague requires close analysis of sites and careful consideration of occupation histories. For this initial study, we have chosen to focus on a small set of sites in central West Africa. As will be described in detail below, each of the case studies explored has significant changes that occurred in the second quarter of the second millennium CE. Settlement mounds in Oudalan province of Burkina Faso appear to have been abandoned, as were settlements in the Seno plain of Mali. In the Inland Niger Delta, settlement shifted from Jenné-jeno to Djenné; and in the Mouhoun Bend of Burkina Faso, some sites were deserted and other settlements experienced a severe contraction in size. In our analysis, we describe the timing and nature of the changes that took place and critically consider the multiple variables that could have led these transformations.
- 24 These case studies share key characteristics that facilitate the analysis. All are sites with lengthy occupation sequences that have been the topic of extensive previous study. As a result, there is a large corpus of published data that can be drawn on to characterize and contextualize historical processes. Since environmental change and/or landscape degradation are commonly cited explanations for settlement shifts, we chose case studies for which the results of archaeobiological analyses (in some cases, further supplemented with data from other local paleoclimate proxies) were available. This sample does not include every site in central West Africa, much less the greater region, that meets these criteria, but it provides a foundation for future research. Following the presentation of the case studies, we briefly discuss the broader landscape of site abandonment and depopulation in savanna/Sahelian West Africa during the early–mid second millennium CE.

## Plague in the context of climate change? Kissi, Oursi, and Saouga

- 25 Archaeological research in the northern Sahelian province of Oudalan, Burkina Faso has documented over 100 mounded sites, including the complexes of Kissi, Oursi, and Saouga.<sup>48</sup> Data from mounded sites indicate growth over the first and into the second millennium CE, before apparent abandonment before 1400 CE.
- 26 The nature of the formation of mounded archaeological sites in Oudalan Province has been the subject of debate. Described sites tended to be very large, both horizontally

and vertically, with a series of small peaks distributed in space over the surface. Presumed to be settlement tells, excavations into these peaks failed to identify distinct architectural layers, despite very deep cultural deposits reaching 6–8 m depth in some areas.<sup>49</sup> The lack of architectural debris, coupled with the excavation of preserved architectural remains in spaces between mounds (e.g. Oursi Hu-beero), has led scholars to suggest that the mounds at the sites are middens.<sup>50</sup> As these mounds accumulated very rapidly (at a rate of up to 2 m per 100 years) in comparison to tell sites elsewhere in West Africa, it is possible that slower build-up of cultural deposits in the spaces between mounds resulted from systematic removal of debris to these midden locations. As middens, these mounds may have grown laterally; and at Saouga later dates were obtained from excavations on a talus slope than from excavations at the high point of the site.<sup>51</sup> Most excavations exclusively targeted the peaks of the mounds and, consequently, the results may underestimate abandonment dates.

- 27 The extensive excavation data available from Kissi, Oursi, and Saouga indicate that fairly large populations developed in the region over the first millennium CE. Located next to a lake, Kissi includes a series of settlement mounds and a cemetery dispersed over an area of ca. 100 ha. Populations grew between the early (1st–4th centuries CE) and middle periods (4th–9th centuries CE) before a possible reduction in the late phases of occupation (9th–12th centuries CE).<sup>52</sup> In addition to mounds, the majority of burials in the cemetery date to the middle phase, when extensive interregional trading is evidenced by abundant glass beads and imported metals.<sup>53</sup> Based upon the ceramic sequence and radiocarbon dates, abandonment of Kissi occurred by the 12th century CE. While the number of radiocarbon dates is limited, available data suggests that the deposits in settlement mounds accumulated very rapidly (in some cases over a meter within 200 years). Many of the samples are derived from fairly deep in mounds, such that significant cultural deposits could post-date the analyzed radiocarbon samples.<sup>54</sup>
- 28 At Oursi, excavations at a cluster of 28 mounds spread over an area of more than 30 ha identified both deep midden deposits (Oursi Village, BF97/13) and a burned residential area located between mounds (Oursi Hu-beero, BF97/30) (fig. 2). The latter was one of at least 13 areas with surface features that may indicate between-mound residence. The tested midden area accumulated from the middle of the first millennium CE, with Oursi Hu-beero founded a few hundred years later. Oursi Hu-beero was sacked, burned, and abandoned at the turn of the 12th century,<sup>55</sup> although results from Oursi Village excavations indicate that settlement in the complex continued into the 13th century and possibly later. There were 50 cm of cultural deposits above the last dated sample, although again, evidence suggests mounds were built up very rapidly.<sup>56</sup> Dates from excavations at a midden deposit at Saouga have some stratigraphic mixing, but indicate accumulation from the 9th through the 14th centuries CE.<sup>57</sup>
- 29 Kissi, Oursi, and Saouga are located in a marginal zone where climate change significantly affects habitation. Today the region receives 400–500 mm annual rainfall, such that rain-fed agriculture is unreliable—although the environment during the occupation was much wetter, as exemplified by the recovery from archaeological deposits of nine tree species not present in the region today.<sup>58</sup> While many would have grown in riverine habitats or dunal depressions, *Detarium microcarpum* and *Vitellaria paradoxa* (shea) required higher precipitation; and their occurrence, in particular, indicates significant aridification since the end of the archaeological occupation.<sup>59</sup> Likewise, similar patterns are apparent in the differences between the fauna recovered

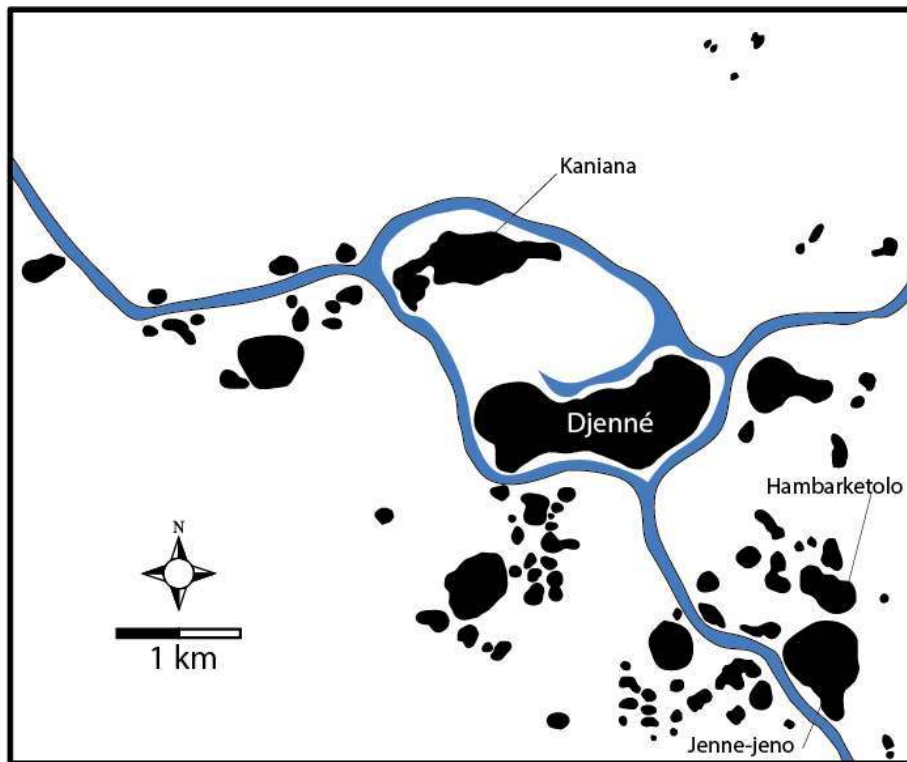
from archaeological deposits and that of the region today.<sup>60</sup> In addition to the evidence for climate change following abandonment, the site-based paleoclimate reconstructions reveal the significant anthropogenic pressure on woody vegetation that accompanied increasing settlement density in the region.<sup>61</sup> In the early second millennium CE, farming became more intensive, fallows grew shorter, and tree cover decreased.<sup>62</sup> The Frankfurt team has argued that the abandonment of settlement mounds reflected a shift to a more mobile subsistence strategy that privileged pastoralism and left a lighter archaeological footprint.

- 30 Overall, while the dating is still fairly low resolution, the results from Oudalan do not contraindicate the occurrence of plague epidemics, although multiple factors likely contributed to site abandonment in the region. Many settlements, notably those near Kissi, were likely already in decline by the early second millennium CE, well before the beginning of the Second Pandemic, although some sites do have longer sequences. Anthropogenic effects on the local environment were clearly a factor, while in comparison the role of increasing aridification is less obvious as higher moisture tree and fish species were found throughout the occupation sequence. If climate change did spur site abandonment, its effects likely came into play only at the very end of the sequence and may have been exacerbated by the already present pressure on woody vegetation. Similarly, if the sites were still occupied by the 14th century, plague epidemics could have influenced the final abandonment of reduced communities.

## Settlement changes in the Inland Niger Delta: Jenné-jeno and Dia

- 31 The Inland Niger Delta of Mali is one of the richest agricultural zones in the West African savanna and Sahel. Not only do the annual floods refresh soils, but flood recession cultivation of African rice (*Oryza glaberrima*) produces high yields in comparison with other regional staple crops.<sup>63</sup> As a result, the region has supported high populations since it became dry enough to farm ca. 800 BC. The Inland Niger Delta is notable for its dense landscape of large settlement mounds. The most well-studied of these is the settlement mound cluster centered around Jenné-jeno that has been the focus of multiple projects examining both the primary mound and many of the surrounding satellite sites.<sup>64</sup> The best comparative data set comes from the site of Dia.<sup>65</sup>
- 32 Jenné-jeno is a very large 33 ha mound set in the middle of an urban cluster of settlement mounds (fig. 3). Settled in the 1st century BCE, the primary site grew until peaking ca. 1100–1200 CE in early Phase IV. As Jenné-jeno itself expanded, its network of satellite mounds grew as well, such that by Phase IV at minimum 40 tell sites totaling over 137 ha total were occupied within 4 km of the central mound.<sup>66</sup> The early second millennium CE mound complex was actively engaged in the trans-Saharan trade, had elaborate ceramic, iron working, and terracotta art traditions, and may have been home to 11,000–50,000 people or more.<sup>67</sup>

Figure 3: Map of the Jenné-jeno urban settlement complex



Redrawn from R. MCINTOSH, 2005, p. 184.

- 33 The 14th century saw significant shifts in population in the Jenné-jeno settlement cluster. Jenné-jeno itself was declining in size by 1200 CE and was abandoned completely by ca. 1400 CE (fig. 4).<sup>68</sup> Similar processes seem to have occurred throughout the urban cluster, where analysis of surface pottery suggests widespread abandonment by 1400 CE,<sup>69</sup> and Clark's analysis of 36 charcoal samples from excavations of 26 surface features on nine mounds in the Jenné-jeno settlement cluster (including Jenné-jeno itself) yielded only two post-14th century absolute dates.<sup>70</sup> At the same time, the earliest occupation layers in the single excavation unit at the currently occupied town of Djenné are dated to 1295–1410 CE.<sup>71</sup> While this date fits well with historical data suggesting that population and commercial activity shifted from Jenné-jeno to Djenné, perhaps in alignment with conversion to Islam, it is unknown whether that date is representative for the mound as a whole.<sup>72</sup>

**Figure 4: Jar eroding from the surface of Jenné-jeno**



Photo by D. Gallagher.

- 34 The size and depth of the sites and lack of chronological resolution in the first half of the second millennium CE complicates interpretation of the observed changes in settlement patterns. First, it is unclear how rapidly Jenné-jeno and the satellite sites decreased in population. While Jenné-jeno was likely already declining in size by the 13th century, it could have remained a significant center or been virtually abandoned by 1350 CE. Likewise, within the settlement complex a gradual contraction may have begun in the early second millennium CE (four of eight studied satellite mounds were likely abandoned by ca. 1275 CE, with an additional three mounds abandoned by ca. 1425 CE).<sup>73</sup> Second, it is not clear whether the abandonment of Jenné-jeno and most of its satellites resulted from a population decrease or simply a consolidation at the location of Djenné. The Djenné tell covers at least 50 ha, and its size at founding and rate of growth is currently unknown.<sup>74</sup> However, given the scope of the urban settlement cluster at the site's peak, a decrease in population is possible.
- 35 The most well-studied comparative example in the Inland Niger Delta is the urban complex of Dia.<sup>75</sup> Also a thriving late first millennium CE urban center, slight differences in the phasing at Dia make assessing 14th-century changes difficult (a ceramic phase spans 1000–1600 CE, and, during survey, sites were assigned to a phase that extended from 700 to 1600 CE).<sup>76</sup> While the central portion of the core site (the currently occupied city of Dia) has not been excavated, occupation at Dia-Shoma extended into the 15th century or later in at least half of the excavated units. In contrast, at Dia-Mara, none of the three excavation units yielded post-14th century dates, although samples were not always submitted for the most recent occupations.<sup>77</sup> Within the urban cluster, the majority of sites were abandoned between 700 and 1600 CE;<sup>78</sup> some scholars have argued that the abandonment of the cluster happened earlier here than at Jenné-jeno and may have been linked to changes in trade routes.<sup>79</sup>



- 36 Overall, similar to the record for northern Burkina Faso, the results are not necessarily indicative of plague, but they do easily allow for a scenario in which plague affected the region. While the changes in settlement pattern in the Jenné-jeno urban complex do not require a decrease in population, they could be consistent with one depending upon the density of occupation at both abandoned and new sites. The record from Dia is less clear; however, there is no evidence of growth or expansion in the 14th–15th centuries CE, and by 1600 CE settlement at the site had become much more nucleated.
- 37 Settlement nucleation and increasing rates of religious conversion may have been spurred by population losses associated with plague, although they also could have been influenced by other events. Current evidence suggests that the rapid growth of Inland Niger Delta urban complexes took place during a period of stable and/or increasingly humid climate.<sup>80</sup> In the early second millennium CE, climate oscillations became larger and more unpredictable, with a generalized trend toward greater aridity, the effects of which may be reflected in the gradual abandonment of satellite sites around Jenné-jeno. Likewise, consolidation of the Mali empire over the late 13th and early 14th centuries CE likely impacted urban culture in the Inland Niger Delta.

## Site abandonment on the Seno Plain: Sadia

- 38 Located to the east of the Bandiagara escarpment, the Seno Plain and its adjacent valleys have been the focus of extensive archaeological research.<sup>81</sup> Small farming communities were present on the Seno Plain from the first millennium BC, although they remained sparse through the late first millennium CE when the region began experiencing significant growth in both the number and size of settlements. In the Guringin Valley (within the Seno Plain), at least 14 settlement mounds date to this period; and in the adjacent Seno Plain, surveys have identified numerous contemporary sites.<sup>82</sup> Excavations at the Guringin Valley mounded settlement of Sadia have established that it grew in spatial extent from 750 CE to 1270 CE, ultimately reaching 3 ha by the early second millennium CE (fig. 2).<sup>83</sup> Home to generalized farmers who produced iron on a local scale and had some access to limited regional trade goods (notably ornaments such as beads, pendants, and rings), Sadia was part of a dense network of small agricultural communities.<sup>84</sup>
- 39 In the 13th–14th centuries, all of the tell sites in the Guringin valley and Seno Plain were abandoned.<sup>85</sup> At Sadia, in particular, where Huysecom and colleagues have accumulated a large suite of AMS dates that includes samples taken from depths as shallow as 20–30 cm from the mound surface, multiple modeling methods have been utilized to precisely target the date of site abandonment. While all estimates predate 1347 CE, some models do allow for settlement to extend into the 14th century.<sup>86</sup> Archaeobiological and paleoclimatological analyses at both Sadia and neighboring sites have identified no changes to the local environment during the several hundred years prior to site abandonment.<sup>87</sup> The charcoal sequence lacks evidence not only of climate change, but also of progressive anthropogenic effects on tree cover (as were found in Oudalan). The faunal sequence likewise shows a continued exploitation of fish and mollusks from the nearby rivers and an increasing focus on livestock.

- 40 Huysecom and colleagues expressly exclude climate instability and environmental degradation as factors leading to the abandonment of Sadia, pointing instead to the possibility of the impact of plague or another disease as well as to political or social factors.<sup>88</sup> There are no clear signs of instability among Seno Plain sites; they are continuously occupied, with no destruction or temporary abandonment levels and no construction of fortifications. However, while not seemingly reliant on long-distance trade, they were tied into numerous networks and by the 14th century were potentially caught between competing large states. Yet to be fully determined is the relationship between the Seno Plain and both pre-Dogon and Dogon sites along the Bandiagara Escarpment.
- 41 The primary point of discontinuity between the Seno Plain sequence and the occurrence of plague lies in the dating, as current absolute dates place abandonment 50–100 years earlier than would be expected if caused by plague. However, the impact of erosion on abandonment sampling cannot be entirely set aside, and Huysecom and colleagues do raise plague as a variable that could be considered, perhaps leaving open the possibility for future adjustments.<sup>89</sup>

## Contracting communities in the Mouhoun Bend: Kirikongo, Kerebé-Sira-Tomo, and Tora-Sira-Tomo

- 42 One of the most compelling data sets illustrating the possible effects of plague comes from the Mouhoun Bend region of Burkina Faso, where the resolution of the chronology is aided by stratification of 14th-century layers in several mounds and a shift in ceramic style that dates to the turn of the 15th century. Enclosed by the U-shaped turn in the Mouhoun River, the region is wetter than those described above, receiving on average 800–1000 mm of rain annually. Two research projects in the region have identified a dense cultural landscape of mounded archaeological sites. From 1997 to 2000, the Mouhoun Bend Archaeological Project (MOBAP) surveyed the northern section of the region and excavated at three different mound complexes (Diekono, Kerebé-Sira-Tomo, and Tora-Sira-Tomo), the latter two of which have occupations that extend into the 14th century CE.<sup>90</sup> Subsequently, the authors carried out the Kirikongo Archaeological Project, a program of research at one of the largest mound complexes in the Mouhoun Bend, from 2004 to 2006.<sup>91</sup> Based on our excavations and AMS dating at Kirikongo, we have developed a fine-grained, well-dated ceramic sequence for the region.<sup>92</sup> Utilizing published descriptions, drawings, photographs, and dates from the MOBAP, we were able to confirm that the sequence applies to nearby sites and improve the chronological resolution for Kerebé-Sira-Tomo and Tora-Sira-Tomo.<sup>93</sup> Overall, the occupation mounds of the Mouhoun Bend attest to iron-producing, agro-pastoral economies that may have been locally oriented in comparison with other regions of West Africa, as the sites contain very little evidence for long-distance trade.



**Figure 5: Excavations at Kirikongo, Mound 1**

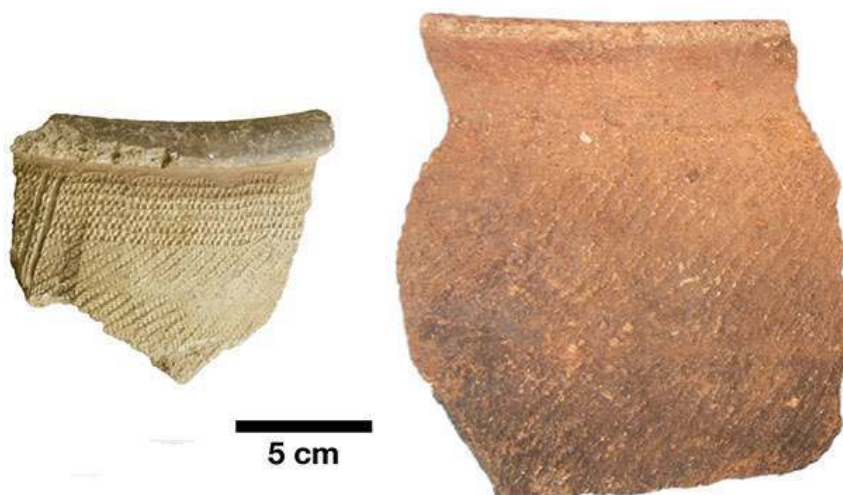
Photo by S. Dueppen.

- 43 By the early second millennium CE, Kirikongo, Kerebé-Sira-Tomo, and Tora-Sira-Tomo were all large, thriving communities (figs. 2 & 5). Kirikongo had started as a single homestead ca. 100 CE and had grown steadily for over a thousand years. By 1000 CE, it had six settled mounds, and the rate of growth increased during the early second millennium such that by 1300 CE (Red III), Kirikongo reached its peak size of 10 mounds, totaling at minimum 5 ha of occupied area across the 37 ha site. At that time, the site included iron-working and specialist potting complexes, active mines for laterite ore, and at least one large communal structure at the central mound.<sup>94</sup> Similarly, Tora-Sira-Tomo had grown to encompass a large mound (ca. 4 ha) and seven very small mounds in the early second millennium CE, at least one of which was an iron production area. Kerebé-Sira-Tomo had a similar structure, although it consisted of only two mounds, largest of which reached a size of slightly less than 2 ha.<sup>95</sup>
- 44 In the 14th century, all three sites underwent dramatic changes. Kerebé-Sira-Tomo was abandoned completely, and both Tora-Sira-Tomo and Kirikongo underwent rapid decreases in population such that by 1400 CE they were half the size they had been 100 years earlier (fig. 2). At Kirikongo, five of the occupied mounds were abandoned completely, and two others had significant contractions in their inhabited surface area.<sup>96</sup> The large mound at Tora-Sira-Tomo decreased to only 2 ha, and the small mounds that had been in use (possibly as activity areas) were abandoned, while fewer new ones were established.<sup>97</sup> Based on current evidence, no new sites were founded in the Mouhoun Bend region at this time.
- 45 To date, archaeobiological evidence from Kirikongo provides no indication that these transformations were caused by a drought that would have significantly altered local ecosystems.<sup>98</sup> Preliminary results from analysis of seeds and fruits show a continuous reliance on pearl millet as the primary staple grain and maintenance of shea tree orchards through the 13th–14th centuries CE.<sup>99</sup> The faunal evidence may indicate a slight increase in aridity at this time due to the loss of forest duikers in the assemblage.

However, these were generally rare during other periods, and many wooded savanna and water-loving species—including cane rats, roan antelope, and sitatunga—were identified in the assemblage, suggesting that average rainfall likely did not fall much below 1000 mm.<sup>100</sup> The nearby Mouhoun River would have further buffered against local effects of lower rainfall. Overall, if regional level aridity was a main component to abandonments further north, like the Inland Niger Delta the Mouhoun Bend would have been more likely to receive migrating populations from elsewhere than rapidly lose population itself.

- 46 There is some evidence of social and political unrest in the Mouhoun Bend region prior to the 14th-century population decreases, as central structures were burned in the 13th century at Kirikongo and Kerebé-Sira-Tomo.<sup>101</sup> However, in all the cases where there was a destruction level, new architectural sequences were rebuilt directly atop; and, moreover, based on the ceramic data, most date to the late 13th / early 14th centuries (mid Red III) and not to the end of the phase. Fairly extensive cultural change occurred in the area following the 14th-century population loss. Changes in material culture (e.g. less elaborate and new ceramic decoration techniques and styles), and new economic activities—including indigo-dying of cloth (Tora-Sira-Tomo) and large-scale leather tanning (Kirikongo)—intensified, indicating transformation in local societies and perhaps a shift from the more localized ideologies attested to earlier to a more external gaze.
- 47 Data from the Mouhoun Bend conform well with the expectations of plague. In a setting in which there is currently little evidence for significant environmental stress, communities in the region lost significant portions of their populations and in at least one case were abandoned entirely. The degree of temporal resolution available indicates that these population reductions likely occurred in the latter half of the 14th century CE, since they had already happened by the time a new ceramic phase began at the start of the 15th century CE (fig. 6).<sup>102</sup> This new ceramic phase marked numerous cultural changes, including significant transformations in material culture styles and new activities. While it is possible that political processes caused these societal developments, there is a strong likelihood that plague epidemics affected the region.

**Figure 6: Left: Red III jar rim from Mound 1; Right: Red IV jar rim from Mound 3**



Color differences in part due to lighting conditions. See also S. DUEPPEN, D. GALLAGHER, 2016, p. 149, Figure 9.

[Photos by S. Dueppen.](#)

## Case studies in regional context

- 48 The evidence from our in-depth exploration of several case studies is generally consistent with data from other areas of semi-arid West Africa, from trading entrepôts on the shores of the Sahara to sites on the southern margins of the savanna. While archaeological coverage of West Africa is patchy with many unsurveyed areas, in the regions that have been the subject of research archaeologists have yet to clearly identify a significant increase in population in the 14th–15th centuries CE despite fairly universal growth over the course of the preceding millennium.<sup>103</sup>
- 49 Sites directly connected to trans-Saharan trade networks could have been the locus of early Second Pandemic Plague outbreaks in West Africa. In the eastern Niger Bend, many centers seem to have declined prior to the 14th century. At Gao,<sup>104</sup> the market (Gao Saney) was occupied from the 8th to 12th centuries CE; the political center (Gao Ancien) largely dated to the 10th to 12th centuries CE; and, based on inscriptions, the cemetery was in use from the 12th to 13th centuries CE. This dating coincides not only with the dating from Kissi and Oursi, but also with sites from further south along the eastern Niger River, such as Bura<sup>105</sup> and Birnin Lafiya,<sup>106</sup> which seem to have been abandoned around the same time in the 13th century CE—perhaps reflecting a general shift in trade routes at this time toward imperial Mali.
- 50 Recent excavations at Essouk-Tadmekka,<sup>107</sup> the Saharan entrepôt connected to Gao, and other eastern Niger sites have yielded more detailed information on the 14th century CE.<sup>108</sup> Essouk-Tadmekka was settled in the last quarter of the first millennium CE and grew to a large settlement by 1000 CE, when Gao was at its peak. Occupation at the site diminished but continued in core areas through the 12th and 13th centuries CE. The beginning of the 14th century CE was marked by significant transformations in architecture, material culture, and diet, potentially reflecting inhabitation by new populations, followed by destruction levels that may indicate conflict with and/or

absorption by imperial Mali. Arabic inscriptions at the site end in the mid-14th century, and Essouk-Tadmekka was abandoned by at latest the end of the 14th century CE.<sup>109</sup>

- 51 Much further to the west, Awdaghost (Tegdaoust) and Koumbi Saleh were both major centers on the northern edge of the Sahel that connected Saharan trade routes with Ghana, Mali, and Takrur. Awdaghost<sup>110</sup> was founded in the late first millennium CE and reached its largest extent around the 11th–12th centuries CE (similar to Gao). Its decline in the 13th century CE may have been connected to shifts in trade as the Mali empire rose to prominence. However, Awdaghost remained occupied in reduced form until the 15th century CE, when it was permanently abandoned. Koumbi Saleh<sup>111</sup> was also founded in the late first millennium CE but was at its peak slightly later, in the 12th–14th centuries CE. The site declined rapidly in the 14th century CE, prior to full abandonment in the 15th century.
- 52 Like many of the focal case studies for this paper, the data from major Saharan entrepôts is not inconsistent with the occurrence of plague epidemics. Among the four sites discussed, none grew in size and many declined or were abandoned in the 14th century CE. However, the narrative is complicated by increasing aridification, which may have made sustaining large populations in and on the margins of the Sahara more challenging, and by the political and economic changes associated with the Mali empire in the 13th and early 14th centuries CE, which may have funneled trade away from earlier centers. Unfortunately, there have not been published excavations into the medieval layers at Timbuktu, the Saharan entrepôt considered to have been most central to the Malian economic system.<sup>112</sup> If the 14th century CE changes at Essouk-Tadmekka, Awdaghost, and Koumbi Saleh were primarily the result of changing caravan routes, Timbuktu would have been likely to grow.
- 53 Further south, plague could have spread from these Saharan entrepôts or from the east if plague initially travelled down the Nile River and through the savanna region. While the archaeological corpus for West Africa has grown such that comprehensive review is not practical here, many sites in the savanna not yet mentioned have evidence of major cultural shifts and/or demographic transformations around the 14th century CE.<sup>113</sup> For example, in the Voltaic region alone, mounded sites in Yatenga<sup>114</sup> occupied in the early second millennium were abandoned in the 14th century; iron production in central Burkina Faso<sup>115</sup> expanded rapidly through the 12th and 13th centuries, then abruptly declined; population increases near the Gobnangou escarpment<sup>116</sup> and in northern Benin<sup>117</sup> from the late first through at least the early second millennium CE were followed by significant cultural transformations in the mid-second millennium CE; and the celebrated terracotta traditions from ritual sites in Komaland<sup>118</sup> (northern Ghana) date from the 6th to 14th centuries CE, perhaps indicating religious change and/or population shifts around this time. These sites span different local ecologies and cultural settings, indicating broader regional processes affecting settlement systems during this era. More systematic analysis is required to fully explore these patterns.

## Discussion

- 54 Although all located in the central West African savanna/Sahel region, the four case studies examined in this paper include sites that vary along multiple axes. Among them are sites located in marginal ecological zones and those set in wetter, more resilient locations; urban centers home to tens of thousands of people to small villages of a

couple hundred; and sites deeply engaged in long-distance trade to those with almost no exotic goods. Residents likely spoke different languages, lived under different political systems, and practiced different religions. At this stage of archaeological research, the case for plague is not incontrovertible. In some cases, the evidence for depopulation is weaker than in others, or abandonments may occur in the 12th–13th rather than the 14th centuries CE. For the latter, increased chronological resolution would significantly strengthen or disprove a plague hypothesis. However, for all of these very diverse sites to potentially have experienced similar depopulations at approximately the same time does provide strong circumstantial support for the effects of a devastating disease.

- 55 Numerous potentially epidemic diseases occur historically in West Africa. Many of them, including dengue,<sup>119</sup> falciparum malaria,<sup>120</sup> influenza,<sup>121</sup> lassa fever,<sup>122</sup> meningococcal meningitis,<sup>123</sup> typhoid,<sup>124</sup> and yellow fever,<sup>125</sup> typically have case fatality rates of <5% (and often <1%), inconsistent with the population changes observed archaeologically.<sup>126</sup> Aside from plague, other diseases with very high case fatality rates (>30%) include cholera, which had not yet spread to the region,<sup>127</sup> smallpox, which may not yet have evolved into its highly virulent form,<sup>128</sup> typhus,<sup>129</sup> and filovirus-associated hemorrhagic fevers such as ebola and Marburg.<sup>130</sup> Ebola and Marburg originated in Africa and, in documented epidemics (all of which have occurred since 1976), have mortality rates comparable to the Second Pandemic Plague. While severe in their local impact, these epidemics have not spread rapidly across large regions, perhaps due to the fact that ebola and Marburg are transmitted through direct contact with bodily fluids. Unfortunately, RNA typically does not preserve as well as DNA in the archaeological record, and we are unlikely to find direct evidence for medieval occurrences of these or related viruses in skeletal human remains using current methodologies. We argue that given plague's spread through the rest of Eurasia and North Africa in the 14th century CE, it is the most likely candidate to have caused sudden, large-scale, widespread mortality.
- 56 If indeed plague did cause a reduction in population, it could have influenced a variety of regional processes and changed power dynamics and the nature of social life in ways that are critical to understanding the region's past. In addition to population dynamics, social, political and religious changes could be expected outcomes of large population losses. At the regional scale, historical sources indicate that after a peak in the early 14th century, the Malian empire seems to have been in decline by the late 1300s.<sup>131</sup> Plague could have contributed to an increasing interregional decentralization of power that ultimately allowed for increasing independence of local polities, including the rise of Songhay in the eastern Niger Bend. In addition to socio-political effects, plague epidemics could have led towards religious changes as societies questioned cosmologies and belief-systems, similar to the development of the Renaissance in Europe after the plague. For example, while clearly important before the plague, the role of Islam may have increased in subsequent centuries, as the decline of the terracotta tradition in Mali, the shift from Jenné-jeno to Djenné, and large-scale construction of mosques may indicate. For the northern Sahelian region, in particular, more drastic changes during this era may have been rooted in the combined effects of disease and aridity on the Saharan margins.
- 57 As described in the introduction, this paper represents a first step toward a broader examination of plague in the archaeological record of West Africa. While caution is

warranted since settlement data alone cannot confirm the presence of plague in the region, the results of this initial analysis are consistent with plague epidemics affecting central West Africa in the 14th century CE. Perhaps more significantly, there is no settlement evidence contraindicating the occurrence of plague. As a next step in this analysis, it is necessary to conduct more comprehensive surveys of archaeological sites from the period 1200–1500 CE, modeling the relative effects of plague, climatic changes, and political processes on settlement systems, and to contextualize the archaeological results with results from analyses of written documents, oral histories, historical linguistics, and art history.

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## NOTES

1. See reviews in P. MITCHELL, 2005; A. MAYOR *et al.*, 2005; K. MACDONALD, 2013; S. DUEPPEN, 2016.
2. E.g. M. POSNANSKY, 1987; R. MCINTOSH, 1998; G. CHOUIN, C. DECORSE, 2010; G. CHOUIN, 2013; M.H. GREEN, 2014a; E. HUYSECOM *et al.*, 2015; S. DUEPPEN, D. GALLAGHER, 2016.
3. For a recent synthesis see B. CAMPBELL, 2016; M.H. GREEN, 2018.
4. A. CARMICHAEL, 2014; B. CAMPBELL, 2016.
5. B. CAMPBELL, 2016, p. 319.
6. E.g. M. POSNANSKY, 1987; R. MCINTOSH, 1998; G. CHOUIN, C. DECORSE, 2010; G. CHOUIN, 2013; M.H. GREEN, 2014a; E. HUYSECOM *et al.*, 2015; S. DUEPPEN, D. GALLAGHER, 2016.
7. See G. CHOUIN, 2018, for an overview contextualizing mixed-methods approaches to plague research in West Africa; M.-L. DERAT, 2018, for documentary and iconographic analysis of plague in Ethiopia; and M.H. GREEN, 2018, for documentary accounts of and genetic evidence for plague in East Africa.
8. K. BOS *et al.*, 2011; M.H. GREEN, 2014a; K. HARKINS, 2016; M. SPYROU *et al.*, 2016; C. WARINNER *et al.*, 2017.
9. See discussions in M. CAMPANA *et al.*, 2013, although methods are rapidly improving. P. SKOGLUND *et al.*, 2017 successfully recovered aDNA from 15 individuals in eastern and southern Africa (dates ranging 8300–400 BP). M. LLORENTE *et al.*, 2015 have also recovered aDNA from human remains in Ethiopia (4500 BP). While the majority (n=13) was interred in caves and rockshelters, aDNA was recovered from three open-air burials.
10. See discussions in A. CARMICHAEL, 2014; B. CAMPBELL, 2016.
11. *Ibid.*
12. Scholars have also argued that the warmer temperatures of the Sahara and West Africa would have inhibited the spread of plague, an assertion based on 20<sup>th</sup>-century experimental studies that showed plague could be transmitted only by "blocked" fleas. Numerous emerging lines of evidence, including documented transmission by unblocked fleas, the new emphasis on human ectoparasites as possible plague vectors, and increasing focus on the distinctiveness of Second Pandemic Plague call this into question. See discussions in B. CAMPBELL, 2016, p. 232-233 and M.H. GREEN, 2018. The Second Pandemic likely spread across desert regions in East Asia (M.H. GREEN, 2014a), and contemporary plague is able to spread in desert conditions (e.g. I. BITAM *et al.*, 2010).

13. See syntheses in K. GAGE, M. KOSOY, 2005; B. CAMPBELL, 2016, p. 230-240; DUBYANSKIY, A. YESZHANOV, 2016.
14. A. CARMICHAEL, 2014; M.H. GREEN, 2014a; N. VARLIK, 2014. This result is unsurprising given that Third Pandemic Plague is hosted by a wide range of rodent species (see review in V. DUBYANSKIY, A. YESZHANOV, 2016).
15. A. HUFTHAMMER, L. WALLØE, 2013.
16. B. CAMPBELL, 2016; K. DEAN *et al.*, 2018.
17. M.H. GREEN, 2018.
18. See discussions in B. CAMPBELL, 2016, p. 230-240, 319-328; D. EADS *et al.*, 2016.
19. R. MAKUNDI *et al.*, 2008; for examples of rodent genera documented by this work (such as *Mastomys* sp. and *Crocidura* sp.) in archaeological sites, see V. LINSELEE, 2007; S. DUEPPEN, 2012a; S. DUEPPEN, D. GALLAGHER, 2013.
20. A. MAYOR *et al.*, 2005; J. MALEY, R. VERNET, 2015; D. NASH *et al.*, 2016.
21. This remains an open question in Europe as well. While A. CARMICHAEL, 2014, has argued convincingly that plague became an enzootic in the mountains of northern Italy, other scholars have suggested that many of the subsequent waves of plague following the original 1347-53 CE outbreak were reinforced by or even the result of reintroductions from Central Asia; B.V. SCHMID *et al.*, 2015; B. CAMPBELL, 2016, p. 317-318.
22. See M.H. GREEN, 2014b, p. 18. Currently, plague is most common in the eastern and southern parts of Africa (including Madagascar), perhaps in part due to the frequency of high elevation regions (S. NEERINCKX *et al.*, 2008; S. NEERINCKX *et al.*, 2010).
23. S. DEWITTE, 2014.
24. E.g. cemeteries at Kissi, Burkina Faso, S. MAGNAVITA, 2015; Kirikongo, Burkina Faso, S. DUEPPEN, 2012a; Bura, Niger, B. GADO, 1993.
25. E.g. Dia, Mali, V. ZEITOUN *et al.* 2004; jar burial traditions of central West Africa, B. DIETHELM, K.P. WENDT, 2017.
26. A. HOLL *et al.*, 2007; A. GALLAY, 2010; L. LAPORTE *et al.*, 2012; A. HOLL, H. BOCOUM, 2014. L. LAPORTE *et al.*, 2017.
27. R. BEDAUX, 1972; MAYOR *et al.*, 2014; A.-F. MAURER *et al.*, 2017.
28. R. BEDAUX, 1972; A.-F. MAURER *et al.*, 2017.
29. For example, 15 individuals were interred in Cave F and 24 individuals in Cave H, R. BEDAUX 1972, p. 127, A.-F. MAURER *et al.*, 2017, p. 291. See also discussions in MAYOR *et al.*, 2014.
30. R. BEDAUX, 1972; MAYOR *et al.*, 2014; A.-F. MAURER *et al.*, 2017.
31. A.-F. MAURER *et al.*, 2017.
32. Efforts are currently underway to recover plague aDNA from Bandiagara human remains, A. MAYOR *et al.*, 2016.
33. B. CAMPBELL, 2016, p. 319.
34. E.g. M.W. DOLS, 1977; B. CAMPBELL, 2016.
35. D. YELOFF, B. VAN GEEL, 2007.
36. C. LEWIS, 2016.
37. *Ibid.*, p. 778-780.
38. *Ibid.*, p. 789.
39. See G. CHOUIN, 2018.
40. For discussion of possible plague-related abandonments in the West African forest belt, see G. CHOUIN, C. DECORSE, 2010; G. CHOUIN, 2013, G. CHOUIN, 2018.
41. J. MALEY, R. VERNET, 2015; D. NASH *et al.*, 2016.
42. M.H. GREEN, 2014a.
43. A. CARMICHAEL, 2014; M.H. GREEN, 2014a; B. CAMPBELL, 2016.

44. C. CAMERON, S. TOMKA, 1996.
45. See discussions of the dramatic effects of erosion on Jenné-jeno, which decreased in size from 33 ha to 30 ha between 1977 and 2008 in S.K. MCINTOSH, in press, p. 6, 12-13.
46. There is an increasing trend towards the utilization of summed probabilities from thousands of radiocarbon dates as a proxy measure for population, e.g. E. CREMA *et al.*, 2017. In West Africa, where our corpus of dates is comparatively small, these methods are unlikely to produce reliable results.
47. I. KUIJT, 2000, p. 81-85; a review of studies on site size and population among agriculturalists can be found in J. FRENCH, 2016, p. 168-169.
48. S. MAGNAVITA *et al.*, 2002; M. VON CZERNIEWICZ, 2004; L. PETIT *et al.*, 2011; S. MAGNAVITA, 2015.
49. M. VON CZERNIEWICZ, 2004.
50. R. VOGELSANG, 2000; L. PETIT, M. VON CZERNIEWICZ, 2011, p. 40.
51. M. VON CZERNIEWICZ, 2004, 72-76.
52. S. MAGNAVITA, 2015.
53. S. MAGNAVITA, 2009; S. MAGNAVITA, 2015; a late first millennium CE florescence in trade in Oudalan is further supported by the large-scale iron-working complexes at Markoye to the northwest, J.-M. FABRE, 2009.
54. S. MAGNAVITA, 2015.
55. M. VON CZERNIEWICZ, L. PETIT, 2011.
56. M. VON CZERNIEWICZ, 2004, p. 49-50.
57. M. VON CZERNIEWICZ, 2004, p. 72-76.
58. A. HÖHN, K. NEUMANN, 2012; see also K. NEUMANN *et al.*, 1998; S. KAHLHEBER, 2004; A. HÖHN, 2005; A. HÖHN, 2007.
59. A. HÖHN, K. NEUMANN, 2012, p. 80.
60. V. LINSEELE, 2007, p. 257
61. A. HÖHN, K. NEUMANN, 2012.
62. *Ibid.*
63. For example, pearl millet yields in the savanna average 500 kg/ha, while in the Inland Niger Delta rice harvests are typically 1000-3000 kg/ha depending on rainfall amounts. NATIONAL RESEARCH COUNCIL, 1996, p. 26, 97.
64. S.K. MCINTOSH, R. MCINTOSH, 1980; S.K. MCINTOSH, 1995; R. MCINTOSH, 1998; S.K. MCINTOSH, 1999; M. CLARK, 2003; S.K. MCINTOSH *et al.*, 2003; R. MCINTOSH, 2005; A. STONE, 2015; S.K. MCINTOSH, in press.
65. R. MCINTOSH, S.K. MCINTOSH, 1987; R. BEDAUX *et al.*, 2005.
66. R. MCINTOSH, S.K. MCINTOSH, 2003, p. 110.
67. S.K. MCINTOSH, 1995; R. MCINTOSH, S.K. MCINTOSH, 2003; R. MCINTOSH, 2005; S.K. MCINTOSH, in press.
68. S.K. MCINTOSH, 1995.
69. S.K. MCINTOSH, R. MCINTOSH, 1980, p. 382; S.K. MCINTOSH, 1995.
70. M. CLARK, 2003, p. 136-139. Throughout the thesis, Clark discusses at length the challenging nature of determining abandonment dates for these large tell sites; she frequently found significant variability in the absolute dates of surface features on different parts of the same mound in the complex and noted the major impact of erosion on mound surfaces. See also discussions of the effects of erosion in S.K. MCINTOSH, in press.
71. S.K. MCINTOSH *et al.*, 2003.
72. S.K. MCINTOSH, 1995, p. 392-393.
73. M. CLARK, 2003, p. 136-139. Sites 5C, 11D, 11G, and Kaniana were abandoned earlier (although the 1977 survey identified Phase V pottery at Kaniana, which could suggest later occupation on parts of the mound, S.K. MCINTOSH, R. MCINTOSH, 1980, p. 382). Sites 12A, 12B, and 14 were abandoned by 1425 CE. Site 3 yielded exclusively post-1650 CE absolute dates.

74. In addition to excavations at the Museum site (S.K. MCINTOSH *et al.*, 2003), a coring project in Djenné yielded inconclusive results regarding the founding and growth of the site (R. MCINTOSH *et al.*, 1996).
75. R. MCINTOSH, S.K. MCINTOSH, 1987; A. SCHMIDT, 2005; see also discussions in S.K. MCINTOSH, 1995 p. 375-376; R. MCINTOSH, 2005, p. 167-169, 181-183, 200-201.
76. A. SCHMIDT, 2005; A. SCHMIDT *et al.*, 2005.
77. A. SCHMIDT *et al.*, 2005, p. 486-493.
78. A. SCHMIDT, 2005.
79. See S.K. MCINTOSH, 1995, p. 375-376; R. MCINTOSH, 2005, 181-183.
80. See discussions in R. MCINTOSH, 2005; J. MALEY, R. VERNET, 2015.
81. N. GUINDO, 2011; A. MAYOR, 2011; S. LOUKOU *et al.*, 2013; A. MAYOR *et al.*, 2014; E. HUYSECOM *et al.*, 2015.
82. N. GUINDO, 2011; S. LOUKOU *et al.*, 2013; E. HUYSECOM *et al.*, 2015.
83. E. HUYSECOM *et al.*, 2015.
84. S. LOUKOU *et al.*, 2013; E. HUYSECOM *et al.*, 2015.
85. E. HUYSECOM *et al.*, 2015, p. 37-38.
86. *Ibid.*, p. 10.
87. *Ibid.*
88. *Ibid.*, p. 29-30.
89. *Ibid.*, p. 30.
90. A. HOLL, L. KOTÉ, 2000; L. KOTÉ, 2007; A. HOLL, 2014.
91. S. DUEPPEN, 2012a; S. DUEPPEN, 2012b; S. DUEPPEN, 2015; S. DUEPPEN, D. GALLAGHER, 2016.
92. S. DUEPPEN, 2012a; S. DUEPPEN, 2015; see in particular S. DUEPPEN, D. GALLAGHER, 2016 for a detailed consideration of the dating of phase Red IV (1400–1500 CE).
93. S. DUEPPEN, D. GALLAGHER, 2016.
94. S. DUEPPEN, 2012a.
95. A. HOLL, 2014.
96. S. DUEPPEN, D. GALLAGHER, 2016.
97. A. HOLL, 2014.
98. S. DUEPPEN, 2012a.
99. S. DUEPPEN, 2012a; D. GALLAGHER *et al.*, 2016.
100. S. DUEPPEN, 2012a.
101. See discussions in S. DUEPPEN, 2012a, p. 98-100, 280-282, 291; A. HOLL, 2014, p. 132-144; S. DUEPPEN, D. GALLAGHER, 2016, p. 154-155.
102. See comparison of Red III and Red IV pottery in S. DUEPPEN, D. GALLAGHER, 2016, p. 149, fig. 9.
103. See syntheses in K. MACDONALD, 2013; S. DUEPPEN, 2016.
104. P. DE MORAES-FARIAS, 1990, 1999; T. INSOLL, 1996, 2000, 2003; M. CISSÉ *et al.*, 2013; S. TAKEZAWA, M. CISSÉ, 2012, 2017.
105. B. GADO, 1993.
106. A. HAOUR *et al.*, 2016.
107. S. NIXON, 2017.
108. *Ibid.*, p. 264-267.
109. It is possible that a very small occupation persisted outside core parts of the site into the 15th century CE. S. NIXON, 2017, p. 267.
110. D. ROBERT *et al.*, 1970; C. VANAKER, 1979, J. DEVISSE, 1983; J. POLET, 1985; D. ROBERT-CHALEIX, 1989; A. HOLL, 2006.
111. S. BERTHIER, 1997; B. VAN DOOSSELAERE, 2014; C. CAPEL *et al.*, 2015.
112. T. INSOLL, 2001.

113. For discussion of the evidence for plague in the forest zones of West Africa, see C. DECORSE, G. CHOUIN, 2010; G. CHOUIN, 2013; G. CHOUIN, 2018
114. Z. LINGANE, 1995.
115. V. SERNEELS, 2017.
116. D. GALLAGHER, 2010.
117. L. PETIT, 2005; D. N'DAH, 2009.
118. B. KANKPEYENG *et al.*, 2011; T. INSOLL, B. KANKPEYENG, 2014.
119. Dengue may have originated in either Africa or East Asia. Genetic studies currently indicate that the disease began spreading in humans only within the last couple hundred years, although there is some historical evidence for earlier cases. E. HOLMES, S. TWIDDY, 2003; D. GUBLER, 2006.
120. Falciparum malaria has been endemic in West Africa for thousands of years. While case fatality rates can be high among children, it would be unlikely for it to cause a sudden significant population loss in the region. J. WEBB, 2014.
121. D. MORENS *et al.*, 2010.
122. Current genetic studies suggest that lassa fever originated in Nigeria in the 9th–10th century CE and did not spread until the past couple hundred years. While lassa fever does not have high case fatality rates overall, due to its extremely high fetal mortality it is possible that a widespread epidemic could have significant demographic impact. K. ANDERSON *et al.*, 2012, 2015.
123. The history of meningococcal meningitis is poorly understood. Based on current evidence, it is likely the disease emerged less than 200 years ago and was introduced to Sub-Saharan Africa from elsewhere. B. GREENWOOD, 1999, 2006.
124. P. ROUMAGNAC *et al.*, 2006.
125. Yellow fever's history is poorly understood, although it likely originated in Central Africa and may have been endemic in medieval West Africa. J. MUTEBI, A. BARRETT, 2002. While typically yellow fever has case fatality rates of 5%, in certain outbreaks significantly higher rates (up to 40%) have been recorded. D. HEYMANN, 2004, p. 643.
126. For case fatality rates of diseases mentioned in this paragraph, see D. HEYMANN, 2004. These case fatality rates are based on 19th- and 20th-century observations; it is possible that rates were higher in the past.
127. Cholera developed in the Ganges River Valley of South Asia. While it occasionally arose in port cities involved in Indian Ocean trade, it was not until the 19th century that it spread through a series of global pandemics. See K. LEE, 2001; M. ECHENBERG, 2011.
128. There are significant debates as to when smallpox became a high mortality disease, with many scholars arguing that its virulence increased significantly around the 16th–17th centuries CE, e.g. A. CARMICHAEL, A. SILVERSTEIN, 1987; A. DUGGAN *et al.*, 2016. See J. WERTHEIM, 2017 for an opposing view.
129. The geographic origins of typhus are currently unknown. Epidemic outbreaks frequently occur during wars, famines, and other periods of societal breakdown. Y. BECHAH *et al.*, 2008; E. ANGELAKIS *et al.*, 2016.
130. M. VAN KERKHOVE *et al.*, 2015; J. WEYER *et al.*, 2015.
131. N. LEVTZION, 1973; D. CONRAD, 1994.

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## ABSTRACTS

Many archaeological sites in the central West African savanna were either abandoned or reduced in size between the 14th and 15th centuries CE. Explanations have tended to invoke the effects of climate change (increasing aridity), political transformations, and religious conversion. However, more recently scholars have increasingly suggested that this regional pattern could be in part the result of plague epidemics. In this paper we explore the methodological challenges inherent in linking abandonments with the effects of epidemics in the archaeological record through a contextualized examination of settlement pattern data from recent archaeological research at sites in Burkina Faso and Mali. While plague cannot be definitively identified based on settlement pattern data alone, current evidence supports the possibility that plague affected populations in this area of West Africa. A broader view of sites throughout West Africa indicates that the possible effects of plague were widespread.

De nombreux sites archéologiques de la savane soudanienne occidentale furent abandonnés ou virent leur taille se réduire entre le <sup>xiv</sup>e et le <sup>xv</sup>e siècle de notre ère. En guise d'explication, on a souvent invoqué les effets du changement climatique (aridité croissante), les transformations politiques et les conversions religieuses. Plus récemment, un nombre croissant de chercheurs ont cependant suggéré que ce phénomène régional pourrait être en partie dû à des épidémies de peste. Dans cet article, nous explorons les défis méthodologiques inhérents à l'établissement d'un lien de causalité entre abandons de sites d'habitat et épidémies, par l'examen contextualisé des données sur l'occupation du territoire produites par les recherches archéologiques récentes au Burkina Faso et au Mali. Bien que la peste ne puisse pas être identifiée de façon irréfutable sur la base de ces seules données, celles-ci vont dans le sens d'un impact de la maladie sur les populations de cette région de l'Afrique de l'Ouest. L'élargissement de la perspective à d'autres sites d'Afrique de l'Ouest suggère un possible impact à grande échelle.

## INDEX

**Mots-clés:** peste noire, peste, deuxième pandémie de peste, dépopulation

**Keywords:** Black Death, plague, Second Plague Pandemic, West Africa, Mali, Burkina Faso, depopulation

**Geographical index:** Afrique de l'Ouest, Mali, Burkina Faso

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