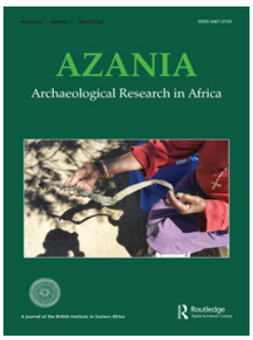

Azania: Archaeological Research in Africa

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/raza20

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To cite this article: Lorraine Hu, Zachary McKeeby, Mulu Muia, John Munyiri & Charles M. Nelson (2022) Examining Late Pastoral Neolithic Settlement at Silanga (GvJm52), Lukenya Hill, Kenya, Azania: Archaeological Research in Africa, 57:1, 37-58, DOI: 10.1080/0067270X.2022.2050566

To link to this article: https://doi.org/10.1080/0067270X.2022.2050566

AZANIA: ARCHAEOLOGICAL RESEARCH IN AFRICA
2022, VOL. 57, NO. 1, 37–58
https://doi.org/10.1080/0067270X.2022.2050566

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Examining Late Pastoral Neolithic Settlement at Silanga (GvJm52), Lukenya Hill, Kenya

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ABSTRACT

Close relationships between human and animal living spaces have been a central element of the settlements of pastoralist communities in eastern Africa since the introduction of herding *c.* 5000 BP. The spatial organisation of pastoralist architecture and material deposits within settlements has been the subject of much ethnographic and ethnoarchaeological research designed to identify variation in social practices and cultural contexts. However, baseline questions regarding settlement layout have proven difficult to examine archaeologically due to poor preservation of household features such as hearths and postholes. New magnetometry data from the late Pastoral Neolithic (PN) settlement site of Silanga (GvJm52) in southern Kenya, combined with unpublished excavation data, delineate several potential structures and middens *c.* 1900–1600 BP. Our data suggest that living structures may have been associated with individual dumps and corrals, similar to the pattern proposed for the PN site of Luxmanda, Tanzania, and contrasting with centralised refuse disposal at the PN site of Prolonged Drift, Kenya. Findings from Silanga may also contrast with the well-known pattern of centrally located livestock spaces seen in ethnographically documented pastoralist settlements in East Africa. The evidence reported here demonstrates the potential of integrated spatial analyses for examining settlement management practices during the PN.

RÉSUMÉ

Les relations étroites entre les espaces de vie humains et animaux ont été un élément central des lieux d'habitat des communautés pastorales en Afrique de l'Est depuis l'introduction de l'élevage vers 5000 BP. L'organisation spatiale de l'architecture pastorale et les dépôts matériels au sein des établissements a fait l'objet de nombreuses recherches ethnographiques et ethnoarchéologiques visant à identifier les variations dans les pratiques sociales et les contextes culturels. Cependant, les questions de base concernant

ARTICLE HISTORY
Received 2 February 2021
Accepted 18 June 2021

KEYWORDS
Pastoral Neolithic; East Africa; magnetometry; settlements; pastoralism

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Supplementary material for this article can be access at https://doi.org/10.1080/0067270X.2022.2050566

la disposition des établissements se sont avérées difficiles à examiner archéologiquement en raison de la mauvaise conservation des éléments importants tels que foyers et trous de poteaux. De nouvelles données magnétométriques issues du site du Néolithique Pastoral tardif (PN) de Silanga (GvJm52), dans le sud du Kenya, combinées avec des données de fouille inédites, délimitent plusieurs structures et amas potentiels *c.* 1900–1600 BP. Nos données suggèrent que les structures d'habitat ont peut-être été associées avec des décharges et des corrals individuels, de manière semblable au modèle qui a été proposé pour le site PN de Luxmanda, en Tanzanie, et contrastant avec la gestion centralisée des déchets observés sur le site PN de Prolonged Drift, au Kenya. Les résultats obtenus à Silanga divergent peut-être également du modèle bien connu des espaces d'élevage centralisés, observé dans les établissements pastoraux d'Afrique de l'Est documentés ethnographiquement. Les données rapportées ici démontrent le potentiel présenté par les analyses spatiales intégrées pour examiner les pratiques de gestion des habitats au cours du PN.

Introduction

The variability of pastoralist settlements around the world reflects a multitude of animal management practices and community preferences influenced by cultural and social context. In eastern Africa, ethnographic literature details how configurations of houses and corrals in a pastoralist settlement relate to factors including age, gendered value systems and other aspects of social organisation and material identity (e.g. Spencer 1965; Moore 1996; Eastman 1988; Straight 2007; Shenjere-Nyabezi 2016). For example, one aspect of settlements frequently seen among modern herding communities in East Africa is the position of livestock corrals encircled by the houses of one or more extended families (Spencer 1965; Jacobs 1975; Mbae 1990). As observed by Jacobs (1975), residence among Maasai settlements was influenced by the need to share labour for herding livestock. Furthermore, a study of Maasai neighbourhoods in eastern Kajiado noted that a shift toward increased sedentism during the 1980s correlated with a downward trend in the number of households per settlement and led to decreased co-operation in settlement management activities, including herding. Modern pastoral practices vary by community and are influenced by a myriad of factors, including political and economic influences rooted in the colonial and postcolonial state, but drawing from ethnographic analogies in considering the relationship between settlement layout and management activities may be productive in interpreting the practices of the earliest pastoralists in the region.

Early herders in southern Kenya and northern Tanzania *c.* 3500–1200 BP are associated with a period broadly named the Pastoral Neolithic (PN), characterised by diverse ceramic, lithic and mortuary traditions, variable dependence on domestic livestock and a variety of settlement patterns across the Rift Valley landscape ranging from open-air settlements to rock-shelters (e.g. Ambrose 1984). Open-air settlements dating to the PN are often visually distinct on the modern landscape as fertile grassy patches (Marshall *et al.* 2018) and are known to be largely circular in shape and variable in size (Robertshaw

et al. 1990; Ambrose 2001). To date, however, the long-term and large-scale ecological legacies of pastoral settlements in East Africa (Boles and Lane 2016; Marshall *et al.* 2018) are better understood than the internal spatial configurations of ancient settlements due to a dearth of preserved settlement features. One approach explored in this paper is the integration of magnetometry survey with legacy excavation data to examine early pastoralist structures and settlement management practices. Applications of near-surface geophysics have become more common in Sub-Saharan archaeological contexts (Magnavita 2016; Klehm and Gokee 2020) and in recent years East African research has featured prominently in expanding geophysical methodologies to explore the construction and use of space (e.g. Fleisher *et al.* 2012; Welham *et al.* 2014; Fitton and Wynne-Jones 2017). Until recently, however, their utilisation within pastoralist research has been limited (Grillo *et al.* 2018).

Lack of preservation of structural indicators such as houses or compacted living floors has made examination of internal site layout difficult (e.g. Shahack-Gross *et al.* 2004). As a result, scholars have looked to other proxies such as household refuse disposal patterns to study the organisation and variable use of space in early pastoralist settlements. Studies of refuse disposal in PN settlements reveal variability in management practices across sites and discuss the potential for individualised as well as more communal practices. At the PN site of Luxmanda, Tanzania, Grillo *et al.* (2018) suggest that herders created separate, potentially household-specific, dumps. A large-scale midden likely used by multiple households, discovered at the PN site of Prolonged Drift, Kenya (Gifford *et al.* 1980), contrasts with Luxmanda as well as with the individual household dumps more commonly documented in ethnographic literature. Gifford-Gonzalez (2014), for example, notes how 'privatised' and gendered household management practices among Dassanetch and Maasai communities serve as a stark contrast with the Prolonged Drift midden, showing fundamental differences in settlement management strategies by different herding communities through time. The variability of disposal practices within the PN, as well as through time, prompts questions about broader settlement arrangements and community practices during the PN. Studying the partitioning and use of space within settlements can provide insights to the links between households, herds and communities to provide a more richly textured image of early pastoralists. Despite the long history of research on PN residential sites (e.g. Leakey *et al.* 1943; Onyango-Abuje 1977; Gifford *et al.* 1980; Ambrose 1984; Mehlman 1989; Robertshaw 1990; Waweru 2001; Simons 2005; Prendergast *et al.* 2013; Grillo *et al.* 2018), there are, however, few baseline data regarding the organisation of structures and relationships of materials to structures within and between sites with which to address such questions.

This project aimed to examine spatial patterning and relationships between archaeological structures and materials at the late Pastoral Neolithic settlement site GvJm52 (*c.* 2050–2030 BP) at Lukenya Hill, Kenya, hereafter referred to as Silanga (Muia 1998; Were 1998). In this paper we present unpublished legacy excavation data alongside artefact descriptions from Silanga, combined with recent magnetometry survey data from a 30×30 m portion of the site. Anthropogenic activity creates localised variations in the earth's magnetic field compared with the surrounding matrix that can be used to locate archaeological features (Fassbinder *et al.* 1990; Kvamme 2006; Bevan and Smekalova 2013; Fassbinder 2017). The integration of magnetic data with traditional excavation can thus spatially contextualise material patterns to create a more detailed study of

material placement in pastoralist settlements. Silanga was selected as a candidate for magnetometry survey because it was one of the only known East African PN sites where excavation had revealed shallowly buried archaeological strata that preserved extensive hardened surfaces with structural features such as postholes (Stanley Ambrose pers. comm., 2019; Fiona Marshall pers. comm, 2019.). As some of the first integrated geophysical data from Pastoral Neolithic settlements in eastern Africa, our findings provide new perspectives on house and corral arrangements in the later Pastoral Neolithic and an additional line of evidence with which to study variability in PN settlement management activities. Such practices, namely animal management, are often envisaged as communal in the ethnographic literature, but data presented in this paper suggest that deposits at Silanga may be reflective of more household-oriented activities.

Pastoral Neolithic settlement sites in eastern Africa

To provide a context for the spatial data from Silanga, we review baseline terminological and spatial data on Pastoral Neolithic settlement sites. Early pastoralism in southern Kenya and northern Tanzania is broadly attributed to two largely contemporary yet materially distinct traditions (Ambrose 1984). The Savanna Pastoral Neolithic (SPN) is characterised by pastoralist assemblages with a range of ceramic traditions (e.g. Narosura, Akira), lithic technologies and sources, as well as varying reliance on domestic livestock (Bower *et al.* 1977; Ambrose 1984; Gifford-Gonzalez 1998). In contrast, the Elmenteitan tradition is associated with greater lithic and ceramic homogeneity, cohesive subsistence and settlement strategies and a distinct system of obsidian procurement and technology (Ambrose 1984; Robertshaw 1988; Goldstein 2017). Social aspects of these material traditions and economies, situated within the dynamic PN landscape of community interaction and differentiation (Marshall *et al.* 2011), are becoming increasingly well understood (e.g. Davies 2013; Gifford-Gonzalez 2014; Sawchuk *et al.* 2018; Goldstein 2019; Shoemaker and Davies 2019; Janzen *et al.* 2020).

Settlements attributed to PN herding groups are variable in ecotone and elevation with Elmenteitan sites at found at higher elevation and further west than SPN sites, but their ranges overlap in southwest Kenya (Ambrose 1984; Robertshaw 1991; Marshall *et al.* 2018). Both SPN and Elmenteitan settlements are relatively shallow, with deposits generally no thicker than 50 cm at excavated sites. Some settlements, such as GvJm 44 and 48 at Lukenya Hill and Oloika 1 and 2 in Ntuka, preserve distinctive, pale sediments that geoarchaeological research has revealed comprise degraded livestock dung (Ambrose 2001; Simons 2004; Shahack-Gross 2011; Marshall *et al.* 2018). However, sites lack definitive corral perimeters or indications of structures. Some dung deposits are suggested to have been burned, although further research is needed to fully characterise these contexts (see Oldorotua 3, Siiriäinen 1990: 265). Other sites have no trace of dung deposits, such as Lemek Northeast (Robertshaw 1990). Only a few published sites, among them Ngamuriak, Sugenya and Narosura (Odner 1972: 31; Robertshaw and Marshall 1990: 60, 66; Simons 2004: 98), preserve any defined household features such as postholes and only one site, Ngamuriak, has clear evidence of a living structure, identified by an oval arrangement of postholes around a compacted and sunken floor that was approximately 4 m in diameter.

The scarcity of structural features has necessitated a variety of methodological approaches, ranging from micro-scale geo-ethnoarchaeology aimed at identifying corral and house sediments (Shahack-Gross *et al.* 2004; Shahack-Gross 2011) to macro-scale, ecological views that have examined the formation of fertile grassy patches overlying dung middens (Boles and Lane 2016; Marshall *et al.* 2018). Although geoarchaeological studies demonstrate the utility of methods in documenting broad variability in site size and stratigraphy, delineating the exact configurations of ancient structures within localities remains difficult.

The Lukenya Hill and Silanga excavations

Lukenya Hill, a ~16 km^2 inselberg of Precambrian granite augen gneiss overlooking the Athi-Kapiti Plain, is the location of over 300 hundred archaeological sites ranging from late Pleistocene to Holocene times (Gramly 1976; Kusimba 2001; Tryon *et al.* 2015). Material culture from Lukenya Hill sites dating to the PN is generally considered to fall within the diverse suite of SPN material traditions (Marshall *et al.* 2018; Janzen *et al.* 2020). Other scholars have noted temporal variability, suggesting that the material assemblages from later sites (Silanga, GvJm44, GvJm47, GvJm48, GvJm184 and GvJm299) be termed Lukenyan due to a pattern of increased site size, greater access to obsidian than earlier SPN sites in the area and distinctive aspects of their lithic and ceramic assemblages (Muia 1998; Were 1998). The previously proposed identifying features of the Lukenyan lithic industry and ceramic ware are discussed in the Supplementary Online Material for this paper. The Silanga site, located on the eastern flank of Lukenya Hill (1°26'58"S, 37°04'50"E; 1669 m a.s.l.; Figure 1), is a PN settlement dating to *c.* 1900–1600 BP. The site was first surveyed and tested by a crew led by one of us (Nelson) between June and August 1978 as part of a larger survey project (Nelson 1979). This report is constructed from unpublished records held by Nelson and draws from unpublished MA theses on the lithic and ceramic assemblages from the site by Mulu Muia (1998) and Isaac Were (1998). Magnetometry survey took place in early March 2020.

The 1978 excavation grid was laid out using a transit and metal tape stretched with a tension pull. One-metre square pits were centred on two areas of concentrated white deposits revealed by burrow tips. A total of 34 units (Figure 1) were excavated with 24 test pits concentrated around material-rich deposits in the eastern half of the site (Figure 2), nine test pits in the western half and three more between the two areas. The site is estimated to be over 8800 m^2 in area, but no obvious site boundary was documented. Cultural deposits were found within 50 cm of the surface throughout the site. Two dating samples (see Supplementary Online Material) were gathered from faunal remains, with one sample (GX-5692A, 1855 ± 110 BP) from the northeast area and another (GX-5772A, 1840 ± 140 BP) from the southwest. The western concentration was smaller, with a slightly lower material density, but the dates demonstrate that both areas were likely occupied contemporaneously. Except where noted in excavation logs, each pit was excavated in 10-cm-thick spits parallel to the ground surface. Hardened floors and rock features, all located at the base of the cultural deposits, were left intact for future excavation. All sediments were passed through a quarter-inch (~6 mm) mesh screen and all cultural materials were saved by spit, sorted and bagged separately on site. All site artefacts and catalogues are curated at the National Museums of Kenya.

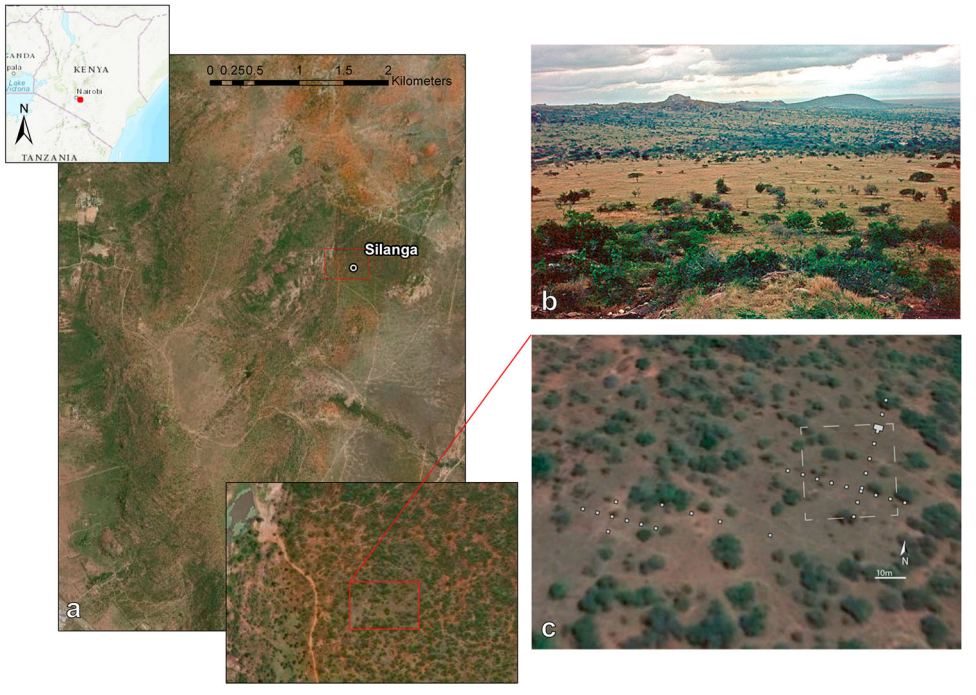

Figure 1. Silanga: a) the location of Silanga in relation to Lukenya Hill with an inset showing the open grassy patch atop the site, detailed in (c); b) 1978 photograph by Charles Nelson of the open area marking Silanga, taken from the GvJm84 quarry site. c) the locations of the excavation units denoted by grey squares and the magnetometry survey area denoted by a dashed line. ArcGIS basemap imagery source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, and IGN.

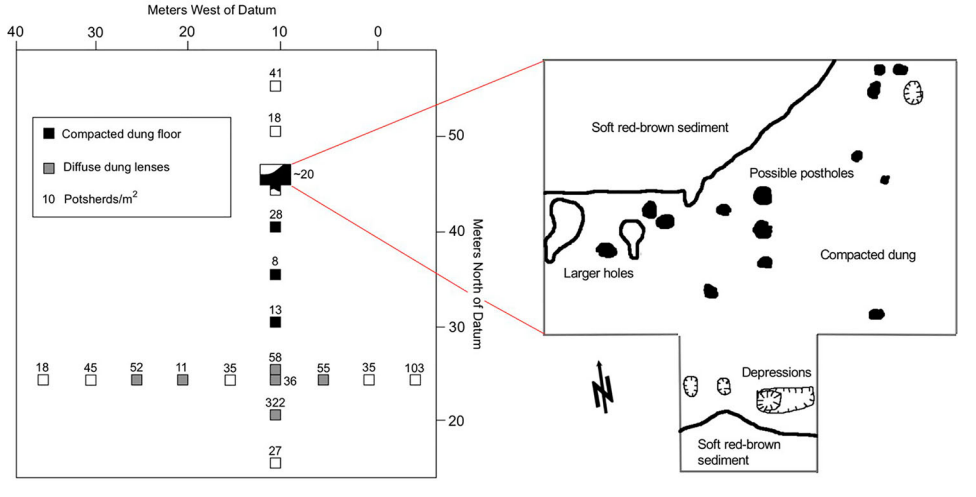

Figure 2. Silanga: plan of the dung concentrations and potsherd quantities in the eastern excavation area.

Excavated structural features at Silanga included hard white compacted layers with postholes and surface depressions (Figures 2 and 3), a possible house floor surrounded by piles of stone (Figure 4) and slabs of rock in separate squares that may cap two pits that were left unexcavated. Compacted deposits frequently contained postholes of various diameters, but one-metre test pits were insufficient to reveal patterns of arrangement. The clearest examples of postholes (Figure 3) were filled with midden deposit 10 to 12 cm deep. This indicates that the posts had been withdrawn, leaving open holes, and that the area was immediately recast as a stock pen where dung and refuse filled the holes. All structural features at Silanga rested atop colluvium at the base of the site's stratigraphy. There is no immediate off-site trench for geoarchaeological comparison, but nearby GvJm44 provides a reasonable proxy of the natural sediments at Lukenya Hill to 60 cm below surface. The off-site profile at GvJm44 showed 10 cm of topsoil and 20 cm of dark brown to red-brown sandy loam, further underlain by sandy loam (Marshall *et al.* 2018).

Features were commonly overlain with dung deposits, potentially marking a remodelling of stock pens due to site expansion or seasonal occupation. Interpretation at the time of excavation suggested that all structures were likely constructed separately from corrals which were later expanded or moved, covering abandoned dwellings and other features. New houses were then constructed outside the new corrals. Similar site formation processes were suggested at Ngamuriak, where several phases of settlement attributed to 'lateral creeping' of houses and corrals were identified within the same depositional unit (Robertshaw *et al.* 1990: 295). Thus, the site history at Silanga is primarily

Figure 3. Silanga: Excavation unit N45-46 W10-11 with postholes surrounded by radial cracks: a) a posthole with intact fill; b) an example of pale compacted sediments corresponding to the visible characteristics of compacted, trampled livestock dung in corrals as described by Marshall *et al.* (2018). The dotted line demarcates margin of raised platform; c) the extent of daub-like, earthen structure material. The photograph was taken in 1978 by Charles Nelson.

Figure 4. Silanga: a possible circular floor surrounded by stone. An overlying band of grey sediments marks a second occupation and is visually consistent with a dung horizon. The floor is composed of a thin hardened layer and a daub-like material where stones are absent at the edge of the feature. The exact unit is unknown, but it is one of the six pits between 70 and 100 W in the southwest concentration. The photograph was taken in 1978 by Charles Nelson.

distributed horizontally rather than vertically and the period of site use was likely no longer than a few decades, although future dating is needed to confirm this. Ethnographic observations show that pastoralist settlements in the region are generally occupied for no longer than a decade before pests or the build-up of excrement pose health risks to both animal and human inhabitants (Western and Dunne 1979; Århem 1985: 64). Resettlement of the area may occur after organic matter is degraded within a 30 year period (Shahack-Gross *et al.* 2003).

Lithic technology

The assemblage from Silanga may be broadly considered as SPN, although the term Lukenyan Industry has also been used to characterise localised variability in lithic assemblages from late PN sites at Lukenya Hill *c.* 2200–1200 BP (Muia 1998; Supplementary Online Material). Here, we present a basic summary of the lithic assemblage from Silanga (Figure 5, Table 1), with a more detailed discussion in the Supplementary Online Material.

Eight of the 24 pits in the northeast concentration were selected for sampling during the 1978 excavations (Supplementary Online Material Table S1). Bulk lots of microcrystalline silica and obsidian were sampled at the 100% level and every piece recorded typologically. Over half the shaped stone tools (N = 166) are *outils écaillés* (N = 93), worked blade segments also referred to as splintered pieces in recent Elmenteitan research (Goldstein 2019, 2021). These are of unknown function at Silanga. There is only one utilised obsidian flake in the sample. Microliths are not made from flakes derived from *outils*

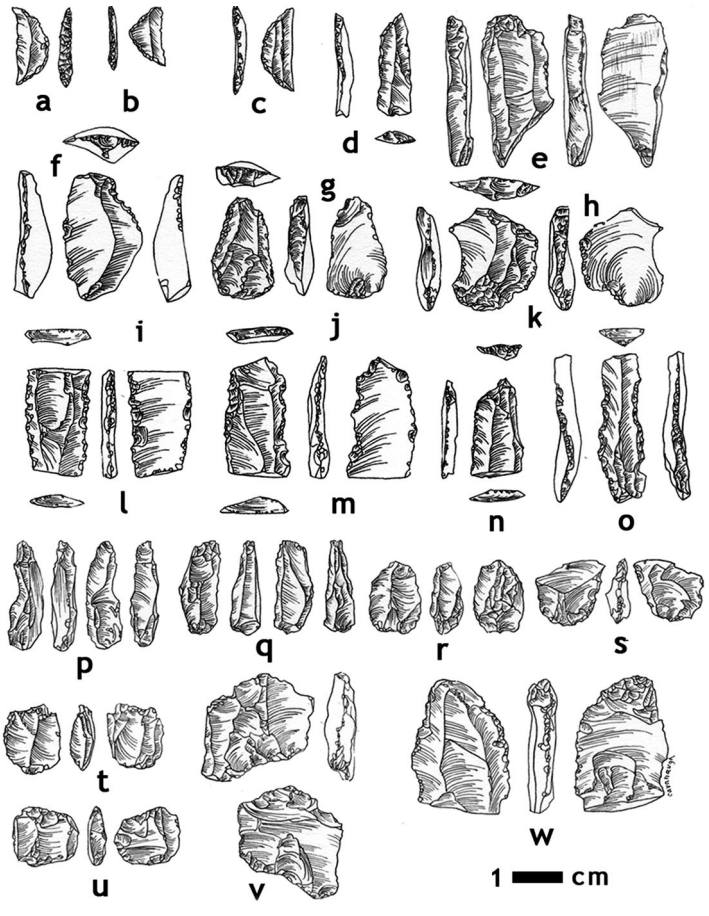

Figure 5. Silanga: shaped stone tools: (a–c) microliths; (e) burin; (f–h) and (o) scrapers; (n) *perçoir*; (l–m) segmented blades; (p–q) and (t–v) *outils écaillés*; (s) segmented *outil écaillé*; (w) *outil écaillé* on a segmented blade. See Supplementary Online Material Figures S4–8 for additional illustrations. Lithic illustrations by Eric Irene Cavanaugh.

écaillés. Many tools are clearly made on blades that were segmented before being used or manufactured into tools such as scrapers or burins, as were the *outils écaillés* themselves. The next most abundant category is segmentary flakes and blades (N = 24) (Nelson 1980), which exhibit the full range of characteristic edge damage, from utilisation to purposeful retouch. Corners were resharpened through segmentation, which is attested by 41 derived segments in the sample. The remainder of the shaped stone tools (29.5%) are mainly microliths, convex scraper forms and burins, all typical in frequency and form within the spectrum of Lukenyan Industry occurrences. See Supplementary Online Material Table S3 for comparisons between late PN sites at Lukenya Hill.

The debris of different raw materials is summarised in Table 2 and discussed in detail in Supplementary Online Material Table S2. Note that vein quartz comprises an atypically high proportion of the lithic debris compared with other PN sites, probably because of the site's proximity to a quartz quarry (GvJm84). Lithic artefacts at Silanga were found in every test pit, but none showed trampling damage, suggesting that if

Table 1. Silanga: summary of the lithic industry found.

Shaped tools	Microcrystalline silica	Obsidian	Total	Percentage
Geometric microliths	-	10	10	6.0
Truncated microliths	-	3	3	1.8
Fragmentary microliths	2	6	8	4.8
Endscrapers	1	3	4	2.4
Nosed scrapers	1	3	4	2.4
Sidescrapers	3	1	4	2.4
Notched scrapers	1	1	2	1.2
Informal scrapers	2	1	3	1.8
Perçoirs	-	2	2	1.2
Burins	-	6	6	3.6
Outils écaillés	8	85	93	56.0
Flakes with inverse retouch	1	1	2	1.2
Segmentary flakes and blades	1	23	24	14.5
Outil écaillé transformed into a *perçoir*	-	1	1	0.6
Sub-total	20	146	166	
Unshaped tools	**Microcrystalline silica**	**Obsidian**	**Total**	
Casually retouched	1	1	2	
Casually trimmed	1	-	1	
Utilised flakes	3	1	4	
Sub-total	5	2	7	
Cores	**Microcrystalline silica**	**Obsidian**	**Total**	
Tabular	-	2	2	
Flake and blade	4	3	7	
Informal	6	1	7	
Semi-discoidal and conical	2	-	2	
Sub-total	12	6	16	

they were discarded in areas where livestock were present it was on fresh dung surfaces where the movement of stock would simply press them into the soft dung. Obvious trampling is not common at most SPN sites. An exception is the main SPN site on Crescent Island where edge damage, surface scratches and a high rate of fragmentation document trampling by stock (Charles Nelson, pers. obs.).

Ceramics

The ceramics found at Silanga contrast with the mostly undecorated, mica-tempered pottery from Elmenteitan assemblages. Silanga ceramics have previously been described as Narosura Ware (e.g. Ambrose 1984) as well as Lukenya Ware, a term defined by Were (1998) to describe the localised variability of ceramics from late PN assemblages at Lukenya Hill (see Supplementary Online Material for further definition). One of us (Nelson) suggests that notable features in Lukenya Ware assemblages that distinguish

Table 2. Silanga: summary of the lithic waste.

Waste	Microcrystalline silica	Obsidian	Phonolite	Vein quartz	Total
	138	746	56	16,140	17,080
	0.8%	4.4%	0.3%	94.5%	
Special categories					
Derived segments	1	41	-	-	42
Platform removal flakes	8	21	-	-	29
Burin spalls	1	32	-	-	33

them from Narosura ceramics include banded decorations that sometimes lack bounding lines, as well as a lack of burnishing or use of slips. Were's analysis of the ceramic styles from Silanga examined 840 excavated sherds, of which only 127 were decorated. Most sherds are dark grey or dark brown in colour with a heavy coarse quartz temper and a high frequency of coil fractures. Most of the decorated sherds have single bands of decorations between the rim and shoulder. The most frequent decorative motifs include line incision and dotted impression, with predominant motifs including cross-hatching, hatching and dotted lines (Figure 6).

Faunal remains

The Silanga faunal assemblage has not been studied as a whole, but is known to be dominated by cattle with small numbers of caprines, including sheep (Janzen 2015: 350), reflecting a pastoralist assemblage similar to others at Lukenya Hill where domestic livestock comprise the vast majority (unpublished data, Diane Gifford-Gonzalez, as cited in Janzen *et al.* 2020; unpublished data, John Kimengich and Michael Gramly; Supplementary Online Material Table S6). One thick lens of bone and other debris (Figure 7) and two scatters of bone and debris that left little trace in pit profiles were encountered outside the main areas of material concentration. Interpretation of faunal material awaits future analysis, but intriguingly recent carbon isotope analyses of caprine remains from Silanga and the nearby GvJm44 site display some of the greatest intra-individual variation among PN caprine assemblages studied by Janzen *et al.* (2020). This isotopic variation may result from increased mobility, herding in varied environments or livestock acquisition from others (Janzen *et al.* 2020: 13). The extent to which different

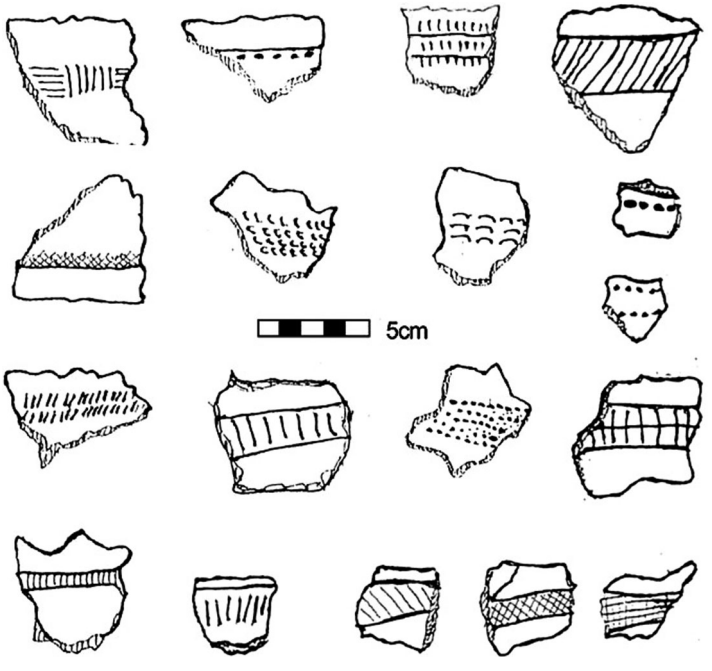

Figure 6. Silanga: decorated sherds as drawn by Isaac Were (1998).

Figure 7. Silanga: midden deposits from close to the surface, in unit N24-25, W10-11 (photograph taken in 1978 by Charles Nelson).

environmental or social factors influenced the isotopic signature of livestock at Silanga and GvJm44 is unknown. Future research on the faunal material, community practices and livestock management at Silanga may aid in resolving some of these questions.

The 2020 magnetometry survey

In March 2020, three of us (Hu, McKeeby and Munyiri) relocated the site and conducted a magnetometer survey to test the efficacy of magnetometry in a PN context and to place the original excavation data into a broader spatial context. Using a compass and a Garmin GPSMAP 64x handheld GPS, we established a 30 × 30 m survey grid in the northeast area of the site to target the original grid of test pits with the highest material concentration excavated by Nelson. The survey covered 21 of 24 pits in this part of the site, representing 10% of the total estimated site area. These test pits from 1978 were still visible as regularly spaced depressions on the ground surface as of 2020. The survey encompassed 60% of the test pits and thus likely provide a representative sample of the excavated areas. Additional grids for magnetic surveys were planned, but efforts were cut short due to the outbreak of the COVID-19 pandemic. Surface inspection and previous excavations at Silanga indicated that the site was free from iron, archaeological or modern, and that the underlying gneiss geology at Lukenya did not pose a source of potential noise.

Magnetic data were acquired using a Bartington Grad 601-1 single-sensor fluxgate gradiometer with a 1 m vertical sensor spacing. Eight readings per metre (0.125 m spacing) were taken along parallel north-south transects using a zig-zag method at one

meter transect spacing. Sensor height was kept constant at approximately 30 cm above the ground for a depth of penetration of about 0.7 m and data recorded in nanoteslas (nT). Gathering higher resolution data was not feasible due to the extent of overgrown vegetation and time constraints. Post-processing in TerraSurveyor geophysical software was kept to a minimum. After de-striping the data, we applied a high-pass filter to remove potential low-frequency background noise and clipped the data at three standard deviations to increase anomaly visibility and aid interpretation. Anomalies were then analysed according to size, shape and alignment.

Based on data from Narosura, Ngamuriak and Sugenya, potential features expected to be visible in magnetometer survey at Silanga included circular arrangements of postholes 3–6 m in diameter that would be indicative of house structures. Structural features of livestock enclosures were expected to appear as similar linear posthole arrangements, but to be larger in diameter. Induced anomalies from features such as postholes generally appear as slightly magnetically positive anomalies against a more neutral or negative background (Baires *et al.* 2017). These are generally much more subtle than highly heated features (Fassbinder 2015) such as hearths, fireplaces or otherwise burned deposits, where iron molecules are realigned with the prevalent magnetic field in a process referred to as thermoremanent magnetisation. The visibility of archaeological dung deposits was considered an unknown factor due to a lack of available comparative data as few magnetometry surveys have been conducted on early archaeological pastoralist settlements globally. Surveys of the Botai Culture (fourth-millennium BC) sites of Krasni Yar and Vasikovka in Kazakhstan provided insights into archaeological pastoral settlement contexts and delineated houses, hearth, and postholes from possible livestock enclosures, but did not detect clear signs of livestock dung deposits (Olsen *et al.* 2006). Similarly, a magnetic susceptibility survey of the Iron Age agropastoralist settlement of Mmadipudi Hill in Botswana, which dates to AD 550–1200, showed relatively nondescript magnetic signatures of dung deposits when compared with the surrounding human living areas that demarcated the limit of the enclosure (Klehm and Ernenwein 2016: 51). Bulk magnetic susceptibility sampling by Boles and Lane (2016) and Marshall *et al.* (2018) on archaeological pastoralist sites in Kenya likewise demonstrated that dung deposits were unlikely to be magnetically distinct. Based on these observations, corral deposits were not expected to be seen in the survey at Silanga unless previously burned or otherwise outlined by areas of human activity like those in the Mmadipudi Hill study. Instead, corral identification was based on arrangements of structural anomalies in combination with stratigraphic observations.

Magnetometry results

We identified several magnetic anomalies within the survey area with the most prominent being two lines of regularly spaced, relatively strong (~+/-10-15 nT, raw) bipolar anomalies set on roughly north-south and east-west axes. When compared to the 1978 excavation map it is quickly evident that these anomalies relate to the 1978 excavation trenches as they match with the original site plan and with the depressions still visible on the ground surface. Correlating these anomalies with the 1978 site plan allowed us to better relate other anomalies present in our survey to excavation records, thereby facilitating and strengthening magnetics interpretations.

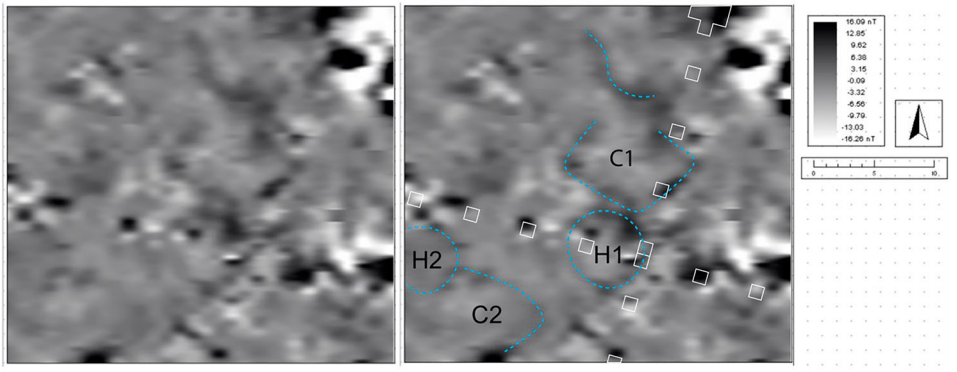

Figure 8. Silanga: raw gradiometer data with hypothesised structures outlined based on the linear arrangements of magnetically positive anomalies. These positive anomalies, visualised in black, are interpreted as potential posthole arrangements. H1 and H2 refer to houses and C1 and C2 to corrals.

We also noted a series of subtle (~1-10 nT) linear anomalies that may correspond with posthole arrangements. The largest of these (Figure 8, C1) formed a sub-angular shape roughly 10 m across. One 1978 test unit was placed along the eastern side of the anomaly and contained compacted dung deposits with a high frequency of faunal remains. Another large curved linear feature, of roughly the same size, is located approximately 10 m to the southwest and may represent a second partial enclosure. However, no units were excavated nearby so its identification as a corral depends on future ground-truthing. Directly adjacent to each of these possible corrals were two smaller roughly circular anomalies (Figure 8, H1 and H2), approximately 5 m in diameter and identifiable as subtle magnetically positive features. In the northeast corner of the survey, and along the eastern side, were a set of stronger bipolar anomalies (~+40-33 nT) set at different orientations to one another. The nature of these anomalies is unclear as they are located several metres away from excavation trenches and thus lack ground-truthing. Another set of smaller anomalies was clustered in the northwest corner of the survey area; however, these likely correspond to heavy animal burrowing activity that we noted during our survey work.

Discussion

The integration of remote sensing survey with legacy excavation data provides an additional line of research with which to examine PN settlements in finer scale and allows for the formulation of testable hypotheses regarding spatial aspects of early pastoralist households and lifeways. Estimated to be over 8800 m^2 in area, Silanga is relatively large, but with only two dating samples of coarse resolution we cannot determine whether the site area is influenced by the number of households and herd sizes present or whether it simply reflects shifting over time. The two previously published dates demonstrate that the eastern and western concentrations were roughly contemporary, but the likelihood of palimpsests of occupation makes detailed discussion of material patterning and site configuration complex. It is notable, however, that its size is similar to those of the two largest sites found by Robertshaw *et al.* (1990) in their

survey of PN sites in the Lemek-Mara region. As we discuss below, preliminary magnetometry data provide finer resolution on spatial features of individual structures at Silanga.

Identification of corrals

Based on the dimensions and shapes of the magnetic anomalies at Silanga, we hypothesise that the two large sub-angular anomalies identified provide evidence of corral structures. The largest of these proposed corrals, Corral 1 (Figure 8, C1), forms a sub-angular enclosure that is roughly 10 m across. This interpretation is supported by the thick ash-like dung deposits excavated in the vicinity of the proposed enclosure structures. We identify these deposits as dung rather than burned ash layers on the basis of their visual similarity to known archaeological dung deposits at Lukenya Hill (e.g. at GvJm 48), although future micromorphological work is necessary to confirm this at Silanga. Furthermore, a strong thermoremanent signature indicative of burning was not detected in our magnetic survey, making identification of these pale sediments as ash unlikely. Relationships among artefact densities in two excavated units along C1's corral walls (see Figure 9) support this interpretation. Low artefact densities indicate sparse refuse disposal, very few ceramics and relatively little lithic material along corral walls. The excavation unit in the southeastern wall of C1 is an exception as it contained a large quantity of faunal remains. The generally low numbers of artefacts associated with C1 are consistent with the low densities of archaeological material recovered from identified corral deposits at Indapi Dapo and the Oloika sites in southwestern Kenya (Marshall *et al.* 2018). The interpretation of C2 on the southwestern edge of the survey awaits future ground-truthing, but its similar shape and size to C1 make it a strong candidate. Other remote sensing methods may be better suited for examining magnetically indiscernible corral deposits, as trampling and compaction may be more visible using electrical resistivity methods.

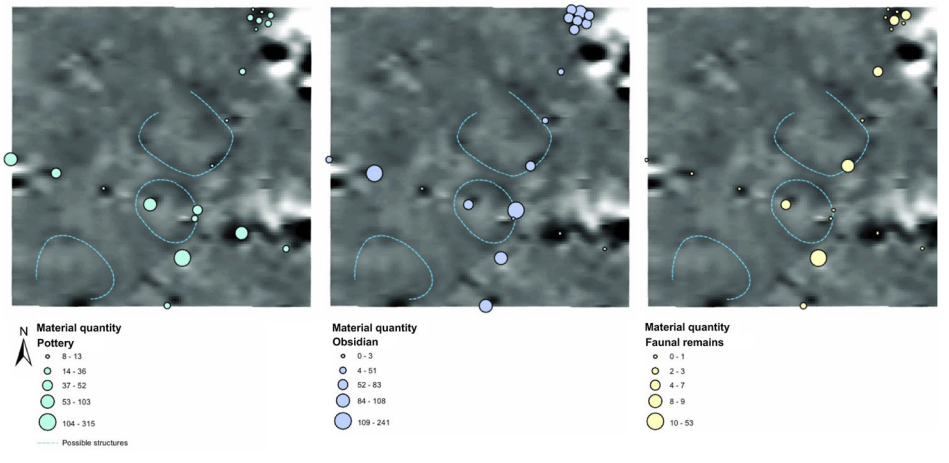

Figure 9. Silanga: material quantity distributions of ceramics, obsidian (OBS), and identifiable faunal bone (ID_bone).

Hard floors and postholes

A 7 m^2 area excavated at the northern edge of the survey area (Figure 2) revealed 14 possible postholes in a compacted floor visually consistent with compacted livestock dung as described by Marshall *et al.* (2018). A photograph from an unlabelled trench (Figure 3) shows a circular section of a floor, raised about 4 cm and containing four postholes surrounded by slightly elevated lips and radial cracks where the wet floor may have been formed and allowed to dry. One posthole is surrounded by a slightly elevated patch of floor that was pale brown rather than white, potentially comprising a paste of subsoil mixed with dung. Similar material appears to have been used to patch the floor in an arc-shaped patch in the upper right corner of the trench. Together, these additions suggest that the structure was in use for a prolonged time. Units with postholes generally correspond to a higher total material density than those without postholes, which may support the hypothesis that refuse was discarded along structure walls.

Identification of living structures

We identified circular magnetic anomalies that were approximately 5 m in diameter adjacent to the possible corrals as likely house structures (Figure 8, H1 and H2) based on magnetically positive signatures and comparisons with the size and shape of house floors at Ngamuriak (Robertshaw and Marshall 1990) and Narosura (Odner 1972). A 1978 excavation unit at Silanga was situated in the interior of what we identify as House 1 based on magnetic data, with another near the northeast wall of the structure. Large numbers of lithic fragments (see Figure 9) were found outside the northeast wall of the structure, whereas only a few were recovered from the interior. Furthermore, the interior excavation unit contained a notable lack of diffuse dung lenses, compared with surrounding units in which dung was ubiquitous (see Figure 2). Taken together, these excavation data support the magnetometry data and suggest the presence of a house floor cleared of lithic fragments with discard areas exterior to the structure.

The unit south of House 1 contained a diverse, high-density artefact assemblage, characterised by the largest number of identifiable faunal fragments and potsherds in the survey area, as well as by a substantial number of lithic artefacts. Based on the mixed composition of materials and proximity to the proposed structure we hypothesise that this was a household dump. In comparison, the unit east of House 1 contained a notable number of ceramics, while units west of the house contained virtually no material. The scarcity of artefacts in this western area, as well as the presence of diffuse lenses of dung, may be indicative of deposits from a corral used for a shorter period than Corral 1, but no obvious structure is visible in the gradiometer imagery. Structures without posts, such as brush fences, are unlikely to be captured in magnetic imagery. Overall, the excavated areas in the vicinity of House 1 were the most materially rich in the survey area.

An arc of somewhat discrete magnetic anomalies, possibly postholes, suggests the presence of a structure located on the southwestern edge of the survey. No excavations were conducted in 1978 within this structure, but, based on its shape and size, we tentatively hypothesise that it is a second house (H2). The two units excavated ~1 m to the

north of the anomaly lack dung deposits, which may support this interpretation. Future ground-truthing is needed to further investigate this.

Accumulations of discarded artefacts at feature boundaries or outside houses and corrals at Silanga are similar to the patterns observed at Narosura and Ngamuriak. At Narosura, Odner (1972) notes that cattle bones were discarded in association with post-holes and therefore along walls. At Ngamuriak, Robertshaw and Marshall (1990: 69) suggested that an area containing distinct 5-m-wide arcs of postholes and lacking compacted floors may have been the site of houses constructed over at least two successive occupations. The structures lay immediately adjacent to dung deposits truncated by a line of postholes, which they interpreted as a possible corral fence. A high concentration of faunal remains was found along the fence, indicating that food refuse was disposed of away from the structure and towards the corral. Furthermore, a high frequency of small lithic chips within the Ngamuriak structure, in addition to a small concentration of heavier débitage immediately to the southeast, suggested that lithic debris had likely been cleaned and deposited away from both the house and corral interiors (Robertshaw and Marshall 1990: 68). The evidence for refuse disposal away from house interiors at both Ngamuriak and Narosura resembles the material distributions identified at Silanga. In weaving these data together, we suggest that corrals at Silanga may have been constructed in association with adjacent house structures, rather than being centrally located.

Settlement management practices

A spatial layout in which corrals were associated with adjacent houses instead of being centrally located within the settlement diverges from a general architectural pattern seen among many eastern African pastoralist homesteads in recent times. It is important to note, however, that recent settlements and land use patterns change and adapt at family and regional levels with resource availability, demographic shifts and government influence, among other factors (Spencer 1973; McCabe 2004; Grillo 2012; Mwangi 2016). Pastoralist settlement configurations and land tenure have become increasingly individualised with the push for privatisation of land (Fratkin 2001) that began with the early colonial administration (Bollig and Österle 2008). Relational analogies from pastoral ethnographic literature are drawn from the physical and labour-related logistics of management of pastoralist settlements and livestock herds in grasslands environments and are used here solely to help us conceptualise a potential range in variation of settlement-based practices for future exploration and testing at Silanga.

As illustrated by Mbae (1990: 280), a typical settlement in his Lemek, Purko Maasai study area in the 1980s consisted of a circular post-and-brush fence with multiple houses arranged on the interior side according to the social relationships between its inhabitants with houses grouped around a brush-fenced livestock enclosure. Cattle were kept in the interior of the circle with one pen on the settlement perimeter for small stock. The layout of structures at Silanga is unlikely to parallel the centralised pattern described by Mbae (1990: 280) due to the distances between the hypothesised structures and the multiple sizes of the structures seen in the gradiometer imagery. The settlement styles recorded by Shahack-Gross *et al.* (2004) in their study with Kisongo Maasai, and by Spencer (1965) among Samburu families, on the other hand, have several small stock

pens located on the perimeter of the settlement and may more closely resemble that seen at Silanga. In these examples, houses were similar in size to those recorded by Mbae (1990) but spaced further apart, with most corrals still centrally placed. Together, ethnographic examples allow for the exploration of the relationship between settlement architecture and animal management practices. It is not yet possible to draw any strong conclusions about such practices based on the available data from Silanga, but the potential proximity of corrals to houses may suggest differences in management activities compared with some ethnographic case studies. Additionally, further analysis of herd composition at Silanga may provide insights into corral use, as the ethnographic examples discussed above indicate that corrals are used only for smaller stock (sheep, goats, calves) while cattle move more freely within the settlement fencing. It may be significant here that the faunal remains from Silanga are suggested to be dominated by cattle, with fewer numbers of small stock (Janzen 2015: 350), raising the possibility of corralling cattle instead of relying on settlement perimeter fencing. Carbon isotopic analyses of corral deposits from the Elmenteitan site of Sugenya indicate the presence of cattle dung enclosed by postholes (Simons 2004; Shahack-Gross *et al.* 2008) and lend credence to this possibility.

The use of lithic, ceramic and faunal materials to posit the presence and location of activity areas within Silanga must proceed with caution at this time, although it will likely prove fruitful if the site is more extensively excavated. Our interpretation of refuse disposal practices at Silanga is influenced by the distribution of test pits; ground-truthing of proposed house and corral features will be necessary to allow further exploration of household deposition and settlement management practices. The expansion of corral deposits or reorganisation of structures over time, for example, are both likely to have been involved in creating a palimpsest of activity at the site. Additional confounding factors at Silanga include bioturbation and a lack of fine-grained chronological control. Based on the available data, we propose that middens used for general refuse disposal were located away from houses and corrals and may have been household-specific or otherwise used by a small number of individuals. The largely undifferentiated mix of lithic, ceramic and faunal materials in middens is consistent with refuse disposal patterns at other SPN sites (Gifford-Gonzalez 2014; Grillo *et al.* 2018). The localised distribution of household waste at Silanga resembles findings from Narosura, Ngamuriak and Luxmanda (Odner 1972; Robertshaw and Marshall 1990: 68; Grillo *et al.* 2018: 110), suggesting that the communal disposal practices observed at Prolonged Drift (Gifford-Gonzalez 2014) may have been the exception rather than the norm.

Conclusion

Systematic studies of variation in the spatial organisation of settlements provide an additional line of evidence through which archaeologists may study practices of pastoralist families and communities during the spread of herding throughout Africa. Studying the layout of structures and surrounding deposits provides data on settlement management practices such as livestock corralling and rubbish disposal, which, with further research, may provide insights into other social aspects of everyday life. This paper demonstrates that magnetometry is a useful method for gathering such baseline data from pastoralist sites where features such as postholes are preserved. Based on the data presented here, we propose that households at the PN site of Silanga had individual

household rather than communal rubbish dumps, in contrast with the centralised refuse disposal seen at the unique SPN site of Prolonged Drift (Gifford-Gonzalez 2014). We also propose that livestock corrals at Silanga were dispersed, instead of being central to a ring of houses, and that each house may have been associated with a separate corral, in contrast with relational analogies drawn from selected ethnographic examples from pastoralist settlement patterns within the region (e.g. Mbae 1990). These findings may suggest less communal living arrangements or livestock management practices than those seen among some historic and modern pastoralists, where labour-sharing influences settlement composition. Ground-truthing, higher-resolution gradiometer survey and obtaining further radiocarbon samples will be necessary to examine the details of site organisation at a finer level, but our findings allow us to build a framework for future targeted research at Silanga, enabling further exploration of settlement histories and providing insights into community practices of pastoralist settlements.

Acknowledgements

The 2020 team is grateful to Prof. Stanley Ambrose for his assistance in relocating the site and lending his vehicle. We thank Mrs Martha Mulwa for her hospitality and stewardship of the site. We should also like to thank Dr Emmanuel Ndiema and the Archaeology Section staff from the National Museums of Kenya for their assistance, as well as Francis Mutua, Sebastian Mutiso, Albanus Nzioka and Peter Kazola for their help at the site. We thank the anonymous reviewers whose detailed feedback greatly improved this manuscript. Finally, we gratefully acknowledge Prof. Fiona Marshall for her guidance through the turbulence of the COVID-19 outbreak and feedback on early drafts of this paper. Permission to conduct fieldwork in 2020 was granted by the research permit NACOSTI/P/19/58189/31256 and the National Museums of Kenya Archaeology Section.

Funding details

2020 fieldwork was supported by the National Science Foundation under the Graduate Research Fellowship Program and Doctoral Dissertation Improvement Award (BCS-1931521) awarded to LH.

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