Title: The Howieson's Poort fauna from Sibudu Cave: Documenting continuity and change within Middle Stone Age Industries

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Abstract:

The Howieson's Poort (HP; ~65-59 ka) continues to be a source of interest to scholars studying human behavioral evolution during the Late Pleistocene. This is in large part because the HP preserves evidence for a suite of innovative technologies and behaviors (including geometric backed tools and engraved ostrich eggshell), but also because the disappearance of the innovative behaviors associated with this phase is not well understood. Here, I present taphonomic and taxonomic data on the full sample of macromammal remains excavated from the HP deposits at Sibudu Cave under the direction of Lyn Wadley. With a total number of identified specimens (NISP) of 5921, Sibudu provides the largest sample of HP fauna published to date. Taken as a whole, the data suggest a focus on a diverse range of prey. Ungulates dominate the assemblage, as do taxa that preferentially inhabit closed (particularly forested) environments. Small bovids

are common throughout; blue duiker (*Philantomba monticola*) alone comprises ~33% of the total NISP. A diverse smaller game assemblage is also present. Taphonomic data implicate humans as the primary contributor to the fauna; however, low levels of gastric etching (~1% of the NISP) suggests that non-human agents may have played some role in the accumulation of the smaller game. Despite broad similarities in the fauna, a number of directional trends are evidenced. Most notably, the lowermost deposits of the HP contain the highest frequency of blue duiker and other small ungulates, taxa which prefer closed environments, and miscellaneous smaller game. All of these decline throughout the HP, and these differences are statistically significant. After considering possible explanations for these trends, I discuss the potential implications of the variation evidenced in the assemblage to our understanding of the onset—and disappearance—of this important substage of the MSA.

Keywords: Howieson's Poort; Middle Stone Age; Sibudu Cave; zooarchaeology; fauna; human behavioral evolution

Introduction

Scholars interested in understanding the dynamics of human behavioral evolution during the Late Pleistocene have increasingly focused on the southern African record (see Wadley, 2015 and sources cited therein). This interest has been fueled by evidence for a suite of cultural and technological innovations associated with two distinct phases of southern African Middle Stone Age (MSA): the Still Bay (SB) and the Howieson's Poort (HP). While there is some controversy surrounding the dating and duration of both of these industries (e.g., Jacobs et al., 2008a, 2013; Tribolo et al., 2013), the most broadly accepted date ranges are ~75-71 ka for the SB and ~65-59 ka for the HP (Henshilwood, 2012). The innovative behaviors associated with the SB and HP include the production of shell beads (d'Errico et al., 2005), engraved ochre fragments (Henshilwood et al., 2002), engraved ostrich eggshell (Texier et al., 2010; Henshilwood et al.,

2014), heat treatment and pressure flaking (Brown et al., 2009; Mourre et al., 2010), the production of bifacial, leaf shaped points (SB) and backed tools (HP), some of which are microlithic in nature (Henshilwood, 2012; Soriano et al., 2015), and possibly the use of the bow and arrow and remote capture technologies (Backwell et al., 2008; Wadley and Mohapi, 2008; Lombard and Phillipson, 2010; Wadley, 2010).

The southern African record is interesting not only for the early emergence of some of these behaviors, but also for their subsequent disappearance after the HP. Early attempts to characterize the nature of human behaviors during the SB and HP—and to explain their onset and disappearance—often considered these phases as homogenous entities (e.g., McCall, 2007; Clark and Plug, 2008; Chase, 2010; Henshilwood, 2012). Yet, a growing body of data indicates that neither the SB nor the HP are static entities—within each, significant changes in human behavior can be documented across both time and space. Focusing here on the HP record, published data from Diepkloof (Porraz et al., 2013), Klasies River Cave 1A (hereafter Klasies; Villa et al., 2010), Rose Cottage Cave (Soriano et al., 2007), Klein Kliphuis (Mackay, 2011), and Klipdrift (Henshilwood et al., 2014) are consistent in demonstrating a gradual evolution of lithic production strategies over time, marked by a shift from blade to flake production and changes in final tool forms. Researchers working at Sibudu have also documented technological variability in the HP, although the nature of this variation appears somewhat different (Lombard, 2008; Wadley and Mohapi, 2008; de la Peña, 2014; Soriano et al., 2015). Technologically speaking, then, it has become clear that the HP should not be characterized as a homogenous phenomenon.

If we ultimately seek to understand the complex interplay of factors driving the emergence—and disappearance—of the HP, a consideration of variation within the HP will be as important as exploring variation between the HP and the periods that pre- and post-date it (see

Archer et al., 2015 and Discamps and Henshilwood, 2015 for similar discussions regarding the Still Bay). Furthermore, we must consider variation along multiple dimensions of human behavior and in the natural environment on both the local and regional scales; Kuhn (2013) provides a particularly salient discussion of the relevance of local-scale analyses to our understanding of broader scale cultural transitions. While we have a growing understanding of the types of variation present in the lithic record, we know much less about variation in the zooarchaeological record. In addition to providing information on human subsistence behavior, faunal data can speak to changes in the environment, providing much-needed context against which the lithic data can be compared. Recent work by Reynard and colleagues (Reynard et al., 2016a; 2016b) on the HP faunal assemblage at Klipdrift demonstrates the relevance of this line of inquiry. Based on variation in the macromammal and shellfish assemblages, they propose that shifts in occupational intensity throughout the HP may be associated with changing environmental conditions—particularly as relates to fluctuations in the shoreline (Reynard et al., 2016b). They compare their results to preliminary lithic data, highlighting potential links between environmental change and shifts in raw material and tool kit components documented in the middle of the HP sequence.

With its rich deposits and excellent organic preservation, Sibudu provides a key opportunity for exploring the nature and extent of variation in human behavior within the HP. The current paper enlarges upon previous work on the HP fauna from Sibudu (Clark and Plug, 2008; Plug and Clark, 2008; Clark, 2011) by considering both the complete HP assemblage excavated at the site under the direction of Lyn Wadley (effectively doubling the available sample) and by breaking the HP into its three constituent layers, allowing for a consideration of change over time within the HP. The focus here is on the macromammal assemblage; details on

the avian remains have been published in Val (2016) and Val et al. (2016) and analysis of the remainder of the fauna (comprising fish, reptiles, micromammals and shells) is ongoing.

Following a summary of research into the HP at Sibudu, I present the faunal data, beginning with a consideration of taphonomic variables and an assessment of the most likely agents of accumulation. I will then consider what the fauna indicates about variation within the HP, both in terms of paleoenvironmental conditions and as relates to the exploitation of ungulate and non-ungulate fauna. I close with a discussion of the potential implications of the temporal trends identified in the data, both in terms of our understanding of the HP and as relates to its onset and disappearance.

The Howieson's Poort at Sibudu Cave

Sibudu is situated on a cliff above the uThongathi River, approximately 40 km north of Durban and 15 km inland from the Indian Ocean (Fig. 1). Sibudu has a long MSA sequence, with occupations corresponding to the pre-Still Bay (~77 ka), Still Bay (~71 ka), Howiesons Poort (~65-62 ka), post-HP MSA (~57 ka), late MSA (~48 ka), and final MSA (~38 ka; Wadley and Jacobs, 2006; Jacobs et al., 2008a, 2008b). The MSA is capped by Iron Age deposits; no Later Stone Age (LSA) deposits have been identified at the site (Wadley and Jacobs, 2004). From 1998-2011, Lyn Wadley (University of the Witwatersrand) directed excavations at the site; the project has since continued under the direction of Nicholas Conard (University of Tübingen). Wadley's team excavated a total of 21m² of MSA deposits; however, the lower portion in the sequence (including most of the post-HP MSA and all the HP, SB and pre-Still Bay) derives from a 6m² unit known as the deep sounding (squares B4, B5, B6, C4, C5, and C6, see Figure 2). The material reported here derives from Wadley's deep sounding.

Deposits were excavated in 50 cm quadrants following natural stratigraphy and sediments were sieved through nested 2 mm and 1 mm screens. The three primary layers associated with the HP are Pinkish Grey Sand (PGS), which consists of a loose, pinkish-grey sand, Grey Sand (GS), a silty grey sand, and Grey Rocky (GR), a sandy deposit with rock spalls (Figure 3; Table 1). When layers exceeded five centimeters in depth, they were divided into artificial spits (e.g., PGS2, PGS3). Note that Dark Reddish Grey (DRG) is a lens of limited horizontal extent that has been combined with GS for analytical purposes (L. Wadley, personal communication). Each of the three layers of the HP has been dated by single-grain optically stimulated luminescence (OSL); ages range from ~65 ka in PGS to ~62 ka in GR (Table 1; Jacobs et al., 2008a, Jacobs and Roberts, 2008).

Geoarchaeological work indicates that the deposits at Sibudu are predominantly anthropogenic in origin, with micromorphological analysis revealing the remains of numerous anthropogenic events and activities (Goldberg et al., 2009, Wadley et al., 2011). While the HP deposits show evidence of extensive trampling, most layers retain their stratigraphic integrity, and some combustion features remain intact (Goldberg et al., 2009; Wadley, 2012). However, it has been proposed that rock fall between the upper-most Still Bay deposits (Reddish Grey Sand, or RGS) and the oldest HP deposits (PGS) may have caused minor disturbance/mixing between these layers (de la Peña and Wadley, 2014b). According to Soriano et al. (2015), the presence of both HP segments and Still Bay bifacial pieces in PGS and RGS provides further support for the hypothesis that some disturbance occurred at the contact between these layers.

A significant amount of research has focused on the artifacts and ecofacts recovered from the HP deposits at Sibudu (e.g., botanical remains: Allott, 2005, 2006; Sievers, 2006; Hall et al., 2008, 2014; Bruch et al., 2012; faunal remains: Glenney, 2006; Plug, 2006; Clark and Plug, 2008;

Plug and Clark, 2008; Clark, 2009, 2011, 2013; Clark and Ligouis, 2010; Wadley, 2010; Val, 2016; Val et al., 2016; lithic/organic technology: Backwell et al., 2008; Lombard, 2008, 2011; Wadley and Mohapi, 2008; Lombard and Phillipson, 2010; d'Errico et al., 2012; de la Peña et al., 2013; de la Peña and Wadley, 2014a, 2014b; de la Peña, 2015; Soriano et al., 2015; geoarchaeology/dating: Jacobs et al., 2008a, 2008b; Goldberg et al., 2009; other: Wadley, 2008, 2012; Hodgkiss, 2013); here I will summarize the results of those aspects of the data most relevant to our understanding of the faunal assemblage: 1) paleoenvironmental reconstruction and 2) hunting technologies/techniques.

Paleoenvironmental reconstruction: botanical data

Three classes of data deriving from the botanical record provide information on paleoclimate during the HP: charcoal, seeds, and the isotopic analysis of charcoal (Allott, 2005, 2006; Sievers, 2006; Hall et al., 2008, 2014). Published data are thus far limited to material recovered from units B5 and B6; furthermore, analyses by Allott (2006) and Hall et al. (2008, 2014) incorporated only layers GS and GR. In all cases, the HP was considered as a single unit, although Hall et al. (2008) include a data table that presents results for both GS and GR.

Charcoal in GS and GR is dominated by evergreen forest taxa, particularly *Podocarpus* spp. (yellowwood), which generally occurs in environments that receive at least 900 mm of rainfall per annum (Allott, 2006). However, the HP sample includes some species indicative of more open conditions, including *Kirkia* spp. (wild seringa), which occurs in deciduous savanna woodland. This type of open vegetation would not necessarily have been far from the shelter, as taxa favoring open environments, such as *Acacia*, are currently found on the slope opposite the site (Allott, 2005, 2006). Allott (2006) notes that while the specific combination of taxa represented in the HP is not recorded in South Africa today, there are some similarities with

vegetation communities in northern KwaZulu-Natal where temperature and humidity are high throughout the year, suggesting the possibility of relatively warm and moist conditions during the HP.

The sample of identified seeds reported in Sievers (2006) is small ($n=27$), with Cyperaceae (sedges) being the most commonly identified seed type. These are present throughout the MSA sequence and indicate the presence of standing water, likely associated with the uThongathi River. Beyond sedges, only three seeds could be identified to genus or species, providing limited additional information on environmental conditions during the HP.

Hall et al. (2008, 2014) report on the isotopic analysis of *Podocarpus* ($n=122$) and *Celtis* (white stinkwood, $n=7$) charcoal from layers GS and GR. The $\delta^{13}\text{C}$ values are indicative of warm and moist conditions during the HP. However, the range, variance and standard deviation of carbon values deriving from *Podocarpus* charcoal (reported in Table 2 of Hall et al., 2008), suggest that conditions may have been slightly drier and warmer when GS was deposited, such that *Podocarpus* may have been more restricted in its distribution around the site (G. Hall, personal communication).

Bruch et al. (2012) utilize a GIS based coexistence approach (CA_{GIS}) to reconstruct past conditions at Sibudu. Based on the data presented by Allott (2006) and Sievers (2006), Bruch and colleagues propose that HP winters were colder and drier than at present, while summer temperature and precipitation may have been similar to modern conditions. More generally speaking, they argue that the data are consistent with the presence of humid or moist conditions during the HP. The various lines of botanical data thus provide a consistent picture. However, it is important to keep in mind that these reconstructions are based on material from the upper two

layers of the HP (GS and GR) and may not fully reflect conditions during the earliest HP occupation of the site.

Paleoenvironmental reconstruction: faunal data

Details on certain aspects of the macromammal (Clark and Plug, 2008; Clark, 2009, 2011, 2013) micromammal (Glenny, 2006), aquatic (Plug, 2006), and avian (Plug and Clark, 2008; Val, 2016; Val et al., 2016) fauna from the HP are available; however, as was the case with the botanical remains, most of these studies were limited to material recovered from units B5 and B6 (i.e., Glenny, 2006; Plug, 2006; Clark and Plug, 2008; Plug and Clark, 2008), and Glenny (2006) considered the microfauna from layers GS and GR only. Clark (2011, 2013) incorporated material from 3m² (B5, B6 and C5) of the HP, while Val (2016) included all 6m² of the HP deposits. With the exception of Clark (2013) and Glenny (2006), these studies also treated the HP as a single unit.

Results from the first stage of analysis of the HP macromammal assemblage (Clark and Plug 2008; Clark 2009, 2011, 2013) support the paleoenvironmental reconstructions based on the botanical data, in that the fauna was primarily comprised of species that prefer closed (particularly forested) environments. Commonly identified species include *Philantomba monticola* (blue duiker), *Potamochoerus larvatus* (bushpig), and *Chlorocebus pygerythrus* (vervet monkey), all of which are characteristic of modern *Podocarpus* spp. forest (Cooper, 1985), although they may also occur in other types of woodland environments. Species more common in (or restricted to) open environments, including *Connochaetes taurinus* (blue wildebeest) and *Equus* sp. (zebra) were present but rare. The presence of *Cricetomys gambianus* (Gambian giant rat), which occurs primarily in evergreen and scrub forests in regions receiving more than 800 mm of rainfall per year, provides further evidence for increased moisture

availability during the HP, as does the presence of *Rhinolophus clivosus* (Geoffroy's horseshoe bat), which prefers caves with high humidity (Glenny, 2006; Wadley, 2006). Forest-dwelling taxa are also represented in the avian assemblage, including *Tockus* sp. (hornbill) and *Poicephalus robustus* (Cape parrot; Val, 2016).

In terms of change over time within the HP, Clark (2013) presents data on the frequency of taxa favoring open vs. closed environments for each of the three layers of the HP. Species which preferentially inhabit closed or semi-closed environments are most common in PGS and decline thereafter; however, statistical tests indicated that the shift in the relative frequency of open vs. closed species was only significant between GS and GR. The current study expands upon that work by incorporating the total excavated assemblage.

The botanical and faunal data published to date thus correspond in indicating the presence of an evergreen forest in the vicinity of the site during the HP. Both datasets suggest that conditions were relatively humid or moist, particularly as compared to later periods of occupation. Finally, there are hints in both records that some environmental changes may have taken place over the course of the HP.

Hunting technologies/techniques

Analysis of the complete lithic assemblage from the HP is ongoing; however, the available data indicate that the formal tool assemblage is blade rich and is comprised primarily of the geometric backed tools that define the industry (c.f. Wadley, 2008; Wadley and Mohapi, 2008; de la Pena, 2015; Soriano et al., 2015). Three primary raw materials were utilized: quartz, hornfels, and dolerite, all of which are available within 20 km of the site (Wadley and Kempson, 2011). As the most frequently identified backed tool type, the segments at Sibudu have been subjected to the most thorough analysis and reporting; details can be found on raw material type

and morphometrics (Wadley and Mohapi, 2008), as well as use wear, macro-fracture, and residue analysis (Lombard, 2008, 2011; Lombard and Pargeter, 2008; Lombard and Phillipson, 2010). In addition to the large assemblage of backed tools, bifacial quartz points have been documented in the HP layers at Sibudu; these are present throughout the HP but are most common in GR (de la Peña et al., 2013; de la Peña and Wadley, 2014a, 2014b). Because excavation of the HP deposits from units B4 and C4 did not begin until 2008, lithic studies pre-dating 2009 incorporated material from units B5, B6, C5 and C6 only. The study by Soriano et al. (2015) was also restricted to these units.

Use-wear, macro-fracture and residue analysis suggest that segments were hafted and at least sometimes used as hunting weapons (Wadley et al., 2009; Lombard, 2011). When considered in combination with the metric data, several scholars have argued that some of the segments may have served as arrow points (Pargeter, 2007; Lombard, 2008, 2011; Lombard and Pargeter, 2008; Wadley, 2008; Wadley and Mohapi, 2008; Lombard & Phillipson, 2010). Detailed use-trace analysis was also conducted on three of the bifacial quartz points; two of these are interpreted as the tips of hunting weapons, while the third, an unfinished point, is argued to have been a hand-held butchery tool. Metric analysis indicates that the bifacial points could have served to tip darts or arrows (de la Peña et al., 2013).

A number of studies have addressed variation in the lithic assemblage over the course of the HP. Soriano et al. (2015) argue that changes in knapping strategies were more subtle at Sibudu than at other HP sites (including Klasies and Rose Cottage), although it is important to note that their analysis focused only on GS and GR. They also argue that Sibudu shows a different trajectory of change, in that the gradual changes in knapping strategies identified at Klasies and Rose Cottage continued into the post-HP, whereas Sibudu shows a more drastic shift

at the HP to post-HP transition. Based on these findings, Soriano et al. (2015) propose that the final phases of the HP may actually be absent from Sibudu, although preliminary evidence for continuity in the fauna (Clark, 2013) and the relatively tight chronology (Jacobs et al., 2008a; Jacobs and Roberts, 2008) do not seem to support this hypothesis; I will return to this point later.

Both Wadley and Mohapi (2008) and Lombard (2008) consider variation in the production and use of segments. Wadley and Mohapi (2008) conclude that there are three separate populations of segments based on the three raw material types represented in the assemblage. Quartz, hornfels, and dolerite segments vary markedly in size and shape, leading Wadley and Mohapi (2008) to argue that they may have been components of distinct hunting weapons—ranging from arrow to spear points. They propose that variation over the course of the HP may be linked to variation in raw material usage, with small quartz segments more common in PGS and larger dolerite segments most common in GR. In considering the backed tools more broadly, Soriano et al. (2015) also found that the dimensions of the tools were related to the size of the available raw materials. Lombard (2008) identified potential variation in hafting strategies over time, with use-wear and residue analysis indicating that segments may have been more commonly hafted to bone during the earlier stages of the HP, with wood hafting more common later in the HP.

To date, fifteen bone implements have been identified from the HP deposits at Sibudu: five from PGS, three from GS, and seven from GR (Backwell et al., 2008; d’Errico et al., 2012). Only one of these has been proposed as a possible hunting implement—Backwell et al. (2008) suggest that a bone point from GS may have served to tip an arrow; however, the fact that the proximal end of the tool is missing makes a definitive interpretation of the object difficult (d’Errico et al., 2012).

Finally, in addition to hunting implements made of bone and stone, Wadley and colleagues (Wadley, 2006, 2010; Clark and Plug, 2008) have proposed that remote capture technology such as snares and traps may have been employed during the HP. Given that there is no direct evidence for these technologies, which are generally made of perishable materials that would not survive to become part of the archaeological record, these arguments were based on the nature of the initial faunal sample from the HP. In addition to the blue duiker and bushpig, a diverse assortment of smaller game was also identified, including mongoose, leporids, and the vervet monkey—animals which are known to be taken using nets or remote capture technology by modern hunter-gatherers (see Wadley, 2010 for a detailed discussion). The larger sample provided in this study will allow for an evaluation of the hypothesis that remote capture technology was being utilized.

Taken as a whole, it appears as though several different weapon systems may have been in use during the HP at Sibudu. The available data suggest some changes in the production and use of hunting weaponry over the course of the HP; however, a more complete understanding of the nature and extent of technological variability will require detailed analyses of the total lithic assemblages for each layer. This is particularly true given that a recently published analysis of the GR lithics documented a high degree of technological variability within that layer alone (de la Peña, 2015).

Materials and methods

As discussed above, this analysis includes the complete sample of macromammal remains excavated from the HP layers at Sibudu under the direction of Lyn Wadley. Following on previous work at the site, macromammals are defined as species larger than 300 g in mass (Glenny, 2006; Clark and Plug, 2008). Methods of analysis follow those presented in Clark and

Plug (2008) and Clark (2009). Processing of the faunal remains was undertaken either by or under the direct supervision of the author. In order to be considered identifiable, a specimen had to be identifiable to skeletal element and taxon (minimally to class and a size category within that class, i.e., small mammal). This means that long bone shaft fragments were included only if they could be identified to specific skeletal element. Although it has been demonstrated that cross-sectional geometry can be useful for identifying limb shafts to element, blind tests by Pickering et al. (2006) found that only ~48% of specimens preserving less than 50% of the shaft circumference and length could be accurately identified to element. As discussed in Clark and Plug (2008), the vast majority of limb shafts in the Sibudu assemblage preserves less than this amount, precluding the use of that method. The identification of long bone shaft fragments thus relied upon diagnostic features such as foramina and muscle attachments. Furthermore, while some have proposed that cortical thickness may be useful for identifying long bone shaft fragments to size class (see Reynard et al. 2014 and references therein), cortical thickness was not recorded for this study, in part because shaft fragments were often fractured in such a way that the full cortical thickness was not preserved. In any case, Reynard et al. (2014: 20) also propose that their methodology is most useful in “regions with relatively few species”, whereas Sibudu shows marked taxonomic diversity (Clark and Plug, 2008; Clark 2009; 2011).

Once the potentially identifiable remains had been pulled for further study, the non-identifiable material was sorted into a variety of fragment categories (e.g., long bone shaft, skull, enamel, rib, vertebrae, and miscellaneous); fragments less than and greater than 2 cm were treated separately. Because the focus of this paper is the identifiable remains, presentation of the non-identifiable material will be limited primarily to a consideration of count/weight data.

Specimens were identified with the aid of the comparative collection housed at the Ditsong National Museum of Natural History in Pretoria, South Africa (formerly the Transvaal Museum). Bovids are the most common taxa at the site; when species level identification was not possible, these were assigned to size class utilizing a modified version of Brain's (1974) classificatory scheme (Table 2). All identified faunal remains were weighed and measured, and age at death was estimated based on epiphyseal fusion and tooth eruption/wear. Each specimen was then examined under a binocular microscope at 8-40x magnification in order to assess the degree of cortical preservation and to identify surface modifications.

Cortical preservation was coded as good (surface well preserved), fair (surface shows light cracking or peeling or is partially obscured), or poor (little to no preservation of the original bone surface or surface obscured). Data were collected on the presence and orientation of cut/chop marks, percussion damage, carnivore activity (tooth punctures/scores or gnaw marks), rodent gnawing, gastric etching, insect damage and raptor damage. These were identified following the diagnostic criteria outlined by Binford (1981), Andrews (1990), Blumenschine and Selvaggio (1991), Lyman (1994), Milo (1994), Blumenschine et al. (1996), Pickering and Egeland (2006), and Backwell et al. (2012). The presence of chemical weathering and root damage was also noted. Only unambiguous marks were recorded. Finally, bones were categorized as non- or lightly burned (NB/LB, <50% carbonized), moderately burned (MB, >50% carbonized), and highly burned (HB, >50% calcined). Note that the non- and lightly burned bones were treated as a single category because it was occasionally difficult to distinguish heat damage from mineral or bacterial staining; see Clark and Ligouis (2010) for more details.

Taxonomic representation is quantified using both NISP (number of identified specimens) and MNI (minimum number of individuals) counts. Symmetry and age were taken into account when calculating MNI, and material identified to higher-level taxonomic categories (e.g., Bov II, medium felid) was assigned an MNI count only if those specimens must have come from individuals beyond that identified to the species-level. The only exception relates to the calculation of MNI for the Bov I size class. With an average mass of only ~4.5 kg, the blue duiker was small enough that it could be identified by size alone—the next largest species, *Raphicerus campestris* (steenbok) is more than twice its size (~11 kg; size data from Skinner and Chimiba, 2005). As such, the blue duiker remains were excluded when calculating the MNI for the Bov I size class.

Although both NISP and MNI counts are provided, analyses reported herein are based on NISP. The reasons for this choice have been detailed elsewhere (e.g., Clark and Plug, 2008; Clark, 2009); however, to summarize: compared to minimum number counts (MNI and MNE, minimum number of elements), NISP is more straightforward to calculate and, as such, should be more directly comparable to results presented by other researchers and for other assemblages (Lyman, 2008). It is also not subject to the aggregation effects that plague minimum number counts (Grayson, 1984; Lyman, 2008). Minimum number counts can be significantly under-represented when fragmentation rates are high (Grayson, 1984; Marshall and Pilgram, 1993; Lyman, 1994), as is the case at Sibudu. While NISP is not immune to fragmentation effects, in cases where fragmentation results in a mismatch between NISP and minimum number counts, it is not necessarily clear which statistic provides a more accurate measure of abundance (Grayson and Frey, 2004; see also Morin et al. 2016a; 2016b). Grayson and Frey (2004) and Lyman (2008) have demonstrated that the two measures are often tightly correlated, such that information that

resides in minimum number counts should also reside in NISP data—this is true for both taxonomic-level analyses and considerations of element frequency data. Given this, Lyman (2008) strongly advocates for the use of NISP over minimum number counts (but see Domínguez-Rodrigo, 2012 for a counterargument). Use of NISP data has become standard in MSA faunal studies; recent studies from Boomplaas (Faith, 2013), Blombos (Thompson and Henshilwood, 2011; Discamps and Henshilwood, 2015), Klipdrift (Reynard et al., 2016a), and Pinnacle Point (Thompson, 2010) all rely upon NISP counts. MNI values are included primarily so that those who prefer to use them can do so.

Given that the Sibudu fauna is known to be heavily fragmented (Cain 2005; Clark and Plug 2008; Clark and Ligouis, 2010; Clark, 2011; Collins, 2016), before exploring variation in the faunal assemblage over time, it is necessary to evaluate the degree of fragmentation and its possible impacts. There are a variety of ways in which fragmentation can impact analyses based on taxonomic abundances. The bones of small animals are expected to be less affected by severe fragmentation than those of larger species. This is in part because larger animals may be processed more intensively prior to consumption (Klein, 1989; Lyman, 1994). It has also been argued that the greater surface area of large animal remains makes them more susceptible to post-depositional destruction (Yeshurun et al., 2007). That heavy fragmentation may result in an over-representation of smaller animals makes logical sense—if all bones are fragmented to a similar degree (for example, if all bones have been reduced to ~2 cm fragments), the bones of small animals should be more likely to retain identifiable features than the those of larger animals.

Given this, it is important to explore whether the degree of fragmentation is similar across units. Unfortunately, assessing the degree of fragmentation is not a straightforward task,

particularly if there is a high degree of taxonomic diversity—and especially if there are changes in the representation of large vs. small animals over time (see Cannon 2013 and references therein). Among the methods for characterizing the general degree of fragmentation, two are applied here: average fragment weight (in grams) and the distribution of fragments of different lengths (Lyman, 1994; Outram, 2001; Villa et al., 2004; Ugan, 2005). These measures are not designed to identify the agent of fragmentation, but simply to provide a general picture of the degree of fragmentation and similarities or differences across the three layers of the HP.

The relative extent of post-depositional destruction will be compared using a modified version of Marean's "completeness index" (Marean, 1991). Because experimental studies have indicated that carpals and tarsals (excluding the calcaneus) are unlikely to be fragmented during human processing or carnivore ravaging, Marean (1991) argued that the degree of fragmentation among these bones provides insight into the degree of post-depositional fragmentation. As originally defined by Marean, calculating this index requires data on the percentage of total bone represented by each fragment; because I did not collect data in this way, I follow the modifications proposed by Villa et al. (2004), in which the number of complete and almost complete carpals and tarsals are added together and then divided by the total number of fragments. Completion indices will be compared across time within size class; these data can also be used to explore whether the bones of larger animals were more impacted by post-depositional destruction than those of smaller game.

Although skeletal part data can provide insight into human transport and processing strategies, interpretation of these data is notoriously complicated, particularly when assemblages are highly fragmentary (see Munro and Bar-Oz 2004 and the articles cited therein). Prior to drawing inferences from skeletal part data, one must evaluate the possibility of density-mediated

attrition (Lyman, 1994; Marean and Frey, 1997; Lam et al., 2003). For this analysis, skeletal element representation for the bovid remains will be compared to the bone mineral density (BMD2) values provided by Lam et al. (1999) for blue wildebeest using Kendall's tau-b, a non-parametric test which can be more sensitive to tied data than Spearman's rho (tests conducted using JMP Pro 11). Portion codes were aligned to Lam et al.'s (1999) scan sites as closely as possible (a complete list of portion codes, the corresponding scan sites, and density values can be found in Clark, 2009). The frequency of each scan site was expressed in terms of normalized NISP (nNISP), which corrects for the number of times the given scan site occurs in a complete skeleton. Within each layer, each bovid size class is considered independently. While recognizing that wildebeest may not be the best analogue for the small bovids, given that the blue duiker is nearly two orders of magnitude smaller, in the absence of data from a more comparable species, wildebeest seemed the most appropriate proxy.

Finally, in presenting the results of this study, the ungulate remains are occasionally combined into size classes; these are defined as follows: small ungulates are comprised of the Bov I remains, medium ungulates include the Bov II specimens as well as suids, large ungulates comprise the Bov III and Bov IV specimens as well as equid remains, and the very large ungulate category includes the Bov V specimens, hippopotamus, rhinoceros, and giraffe. Because the diverse assemblage of smaller game identified during earlier work at Sibudu has been a focus of interest, I also utilize a "miscellaneous small mammals" category, which comprises non-ungulate fauna that averages less than 25 kg in mass. The analyses reported herein primarily rely upon comparisons of frequency data; these comparisons were made using chi-squared analysis, with significance at the $\alpha = .05$ level.

Results

Table 3 presents a complete species list, while Tables 4 and 5 provide summary data on the HP faunal assemblage. The faunal assemblage is extraordinarily rich—as a point of comparison, Wadley’s team recovered more than 110 kg of bone from the ~1.8 cubic meters of HP deposits at Sibudu, whereas excavators at Klipdrift reported the recovery of ~12.7 kg of bone (and 30 kg of shellfish) from 2.3 cubic meters of HP deposits (Henshilwood et al., 2014; Reynard et al., 2016a). With a total NISP of 5921, Sibudu provides the largest sample of HP fauna published to date, more than twice that reported for the HP at Diepkloof ($n= 2161$; Steele and Klein, 2013) and Klipdrift ($n= 2266$; Reynard et al., 2016a). The density of faunal remains (expressed as kg/m^3) is high throughout the HP (Table 4). PGS shows a slightly higher density of faunal remains than GS or GR; however, in the absence of similar data for the lithics and other artifacts and/or fine-grained geoarchaeological data, it is difficult to ascertain the significance of this finding—i.e., whether it reflects changes in sedimentation rates, the intensity of occupation, or some other factor.

Table 6 presents data on the occurrence of various types of surface damage, while Figure 4 shows the frequency of burning damage; the latter is directly relevant to a consideration of surface damage as the relative degree of cortical preservation is strongly correlated with the intensity of burning damage in this assemblage, with more intensely burned bone showing a lesser degree of cortical preservation (Figure 5; see also Clark and Liguois, 2010). There is an increase in burning damage throughout the HP; 31.2% of the PGS assemblage was coded as moderately or highly burned, compared to 49.2% in GS and 53.1% in GR. These differences are statistically significant (total assemblage: $\chi^2 = 232.667$; $p < 0.0001$; PGS vs. GS, $\chi^2=156.892$, $p < 0.0001$, GS vs. GR $\chi^2=4.407$; $p = 0.0358$). Given this, and because there is a parallel increase in specimens with poor cortical preservation, comparisons of damage frequencies across the three

units should be made with caution. The frequency of surface damage evidenced at Sibudu is markedly lower than that identified at other HP sites (e.g., Klipdrift and Boomplas; see Faith, 2013 and Reynard et al., 2016a). This can be partially attributed to the intensity of burning damage/poor cortical preservation. However, it could also relate to the exclusion of the non-identifiable shaft fragments. Long bone midshaft fragments are often the focal point of studies of surface modification; the relative frequencies of human and carnivore damage on these bones can be compared to experimentally derived datasets to model the nature of human and carnivore interaction with a given assemblage, although this is not always a straightforward process (see Thompson and Henshilwood, 2011 for a detailed discussion). A small subsample of the >2 cm non-identifiable shaft fragments from the HP has been subjected to detailed taphonomic analysis (Table 7); the results indicate that the low frequency of surface damage reported in Table 6 is generally representative of the total assemblage and not a methodological artifact relating to the treatment of non-identifiable shaft fragments.

Taphonomic considerations: fragmentation

The HP fauna is highly fragmentary, with the vast majority of the assemblage (~92%) comprising non-identifiable fragments less than 2 cm in maximum dimensions (Table 4). The extreme nature of fragmentation is evidenced by the average specimen weight, which ranges from .22 grams in PGS to .28 grams in GR. The distribution of fragments by maximum length is illustrated in Figure 6 (see Supplementary Online Material [SOM] Table S1 for raw data; specimens larger than 6 cm were combined in the figure because no single bin accounted for more than 1% of the total). Small fragments are dominant even among the identified sample; more than 65% of the remains from each layer are less than 2 cm in maximum dimensions. The distribution of fragment lengths is remarkably similar in PGS and GS, while GR preserves

relatively fewer fragments that are less than 2 cm; however, that difference is largely made up by specimens in the 2-3 cm category. Both of the basic measures of fragmentation are therefore consistent in suggesting that the degree of fragmentation is similar across the three units—and that this fragmentation is extensive in nature. However, both measures also indicate that fragment size is slightly larger in GR. The magnitude of the difference is small enough that interpretation is not straightforward, particularly given that GR does preserve a relatively higher frequency of large game (Table 3) and thus may be expected to preserve more large fragments (I return to this point later in the paper).

As discussed above, it has been proposed that the degree of fragmentation among the carpal/tarsal bones can speak to the relative extent of post-depositional destruction (Marean, 1991; Villa et al., 2004). Table 8 presents data on the frequency of complete/almost complete vs. fragmentary compact bones by ungulate size class and layer within the HP; the very large ungulates are not included in the table because no carpals/tarsals were identified for this size class. The frequency of complete/almost complete bones spans from ~17-66%, indicating that the HP fauna has suffered from extensive post-depositional destruction. It is well documented that burning can promote fragmentation, both pre and post-depositionally (e.g., Stiner et al., 1995; Costamagno et al., 1998; 2005). As such, given that the fauna is heavily burned—and because micromorphological analysis found evidence for extensive trampling of the deposits (Goldberg et al., 2009)—this result is not surprising. However, within each size class, chi-square testing indicates no significant difference in the frequency of complete/almost complete bones across the three layers (small ungulates; $\chi^2 = 2.02$, $p = 0.3642$; medium ungulates: $\chi^2 = 0.386$, $p = 0.8245$; large ungulates $\chi^2 = 0.976$, $p = 0.6139$). This implies that the degree of post-depositional fragmentation is consistent over the course of the HP.

The data presented in Table 8 also speak to the question of whether the remains of large and small animals were equally affected by post depositional destruction. Because no significant differences in fragmentation were identified within each size class, the assemblages from all three layers can be pooled and the size classes can be compared using Cochran's test, a variant of the chi-square test that can identify whether there is a significant linear trend in the data (see Cannon, 2001 and reference therein). The results indicate that not only is there a significant difference in the relative frequency of complete/almost complete carpals/tarsals across the size classes ($\chi^2 = 32.175$, $p < 0.0001$), but also that there is a significant linear trend—as body size increases, so too does the degree of fragmentation. (linear trend: 31.203; $p < 0.0001$). This suggests that small animals may be overrepresented in the assemblage. However, since the degree of fragmentation appears to be broadly consistent through time, this bias should apply equally throughout. As such, variation in the presence of small vs. large animals over time should not merely be a reflection of differential fragmentation.

Given the well-documented relationship between post-depositional destruction and density mediated attrition (Lyman, 1994 and sources therein), the fact that no significant relationships between element frequency and structural density were found for any size class in any of the three layers under consideration is unexpected (Table 9). In discussing another highly fragmented assemblage in which no relationship between element frequency and density was found, Lyman et al. (1992) propose that heavy fragmentation might confound studies of density mediated attrition. This relates to the identifiability of various elements (and portions of elements) in heavily fragmented assemblages. When highly fragmentary, shaft fragments are less likely to be identifiable to element than epiphyses, which generally have more distinctive morphologies (Marean and Kim, 1998; Bartram and Marean, 1999). This could result in an

underrepresentation of the most dense portions of the skeleton, which may help explain the lack of relationship between element frequency and structural density in the assemblage.

The degree of fragmentation arguably confounds considerations of the skeletal part data. This is particularly the case given that the data suggest that larger game was more heavily impacted by post-depositional destruction than smaller game. While some studies have addressed how the identifiability of various long bones may be impacted by fragmentation (e.g., Pickering et al., 2006), less has been done to address how heavy fragmentation may impact the identifiability of a broader range of elements and how this may function differently across size classes—it is thus difficult to address how heavy fragmentation may bias skeletal element profiles (see Morin et al., 2016a for a detailed discussion). As such, I would argue that the nature of fragmentation in the HP at Sibudu precludes comparisons of skeletal element profiles across size classes. Yet, since the degree of post-depositional fragmentation seems broadly consistent from layer to layer within each size class, variation in skeletal part frequencies within a size class may provide meaningful information about variation in human behavior. As such, I will present these data as part of the broader consideration of the ungulate assemblage.

Taphonomic considerations: assessing agents of accumulation

The results of the analysis of the initial sample of HP fauna from Sibudu suggested that humans were the primary contributor to the assemblage (Clark and Plug, 2008; Clark, 2009, 2011); this conclusion was based on a number of factors, including the high degree of burning and fragmentation, the low frequency of carnivore remains and the fact that human produced damage (in the form of cut marks and percussion damage) was more common than carnivore damage. However, given the larger debates about the role played by MSA humans in the accumulation of small ungulates and other smaller game (e.g., large rodents, hyraxes, etc., see

Marean et al., 2000; Faith, 2013), it is worth re-assessing this question, particularly as regards those subsets of the assemblage.

In identifying possible contributors to the assemblage, it is relevant to begin with a brief discussion of the site's context. As previously mentioned, Sibudu is located on a cliff above uThongathi River. The excavation unit is at ~100 m above sea level (asl) and the entrance slopes from north to south, with the southern entrance at ~85 m asl (Figure 2; Wadley and Jacobs 2004). The river below is at 75 m asl—ascending to the site requires scaling a 3 m high rock face, and, as such, the site is not equally accessible to all species. Large ungulates, for instance, would not be expected to naturally occur; if their remains are present, they were carried there by another species. Although referred to as Sibudu Cave, the site is technically a rockshelter; the shelter is long and narrow (roughly 55 m wide and 18 m high) and thus relatively exposed. The site was thus unlikely to have served as a den for carnivores such as hyena, which prefer caves that have chambers suitable for securing juveniles (Pokines and Kerbis-Peterhans, 2007); however, this does not preclude hyena from having visited the site. The fauna itself gives some indication of the range of carnivores that were present in the region; identified species span from smaller taxa like mongoose to larger predators like *Panthera pardus* (leopard; Table 3). No coprolites have been identified to date—as such, we must rely on other lines of evidence to identify the potential agents of accumulation.

Table 10 presents data on the distribution of surface damage by animal type/size class. Evidence for human activity includes cut/chop marks and percussion damage, while evidence for carnivore activity includes tooth marks/scoring. Data on gastric etching are presented separately as these data are somewhat ambiguous; as discussed below, while this type of damage is often linked to carnivore or raptor accumulation, experimental work has demonstrated that human

digestion can also cause gastric etching (e.g., Butler and Schroeder, 1998; Dewar and Jerardino, 2007). Note that because none of the remains in the “very large ungulate” category preserved signatures of either human activity or carnivore involvement, they have not been included in Table 10.

Although the total number of specimens bearing marks is low, signs of human processing are most common on large ungulate specimens (3.6%) and least common on the miscellaneous smaller game (0.3%); the two specimens within the small game category bearing cut marks are a *Cercopithecus albogularis* (Sykes’ monkey) innominate and a *Procavia capensis* (hyrax) ulna. This difference may suggest a greater degree of human involvement in the accumulation of larger game. However, the fact that the small ungulates and other small game bear fewer cut marks/evidence for percussion damage could also be linked to the fact that these animals can be transported and cooked whole, resulting in fewer opportunities for butchery damage to occur.

The fact that only nine specimens bear evidence of tooth punctures or tooth scoring suggests that carnivores did not make a significant contribution to the accumulation of the assemblage. This is further supported by the fact that very few carnivore remains were recovered, accounting for ~2.2% of the total NISP. Most of these are smaller carnivores (particularly mongoose), which would not be expected to contribute to the accumulation of ungulate remains (Skinner and Chimimba, 2005); however, these may have contributed to the collection of some of the miscellaneous smaller game.

In contrast to the pattern identified for signs of human activity, gastric etching was identified at higher frequencies for the miscellaneous small game and small ungulates than for medium or large ungulates, the latter of which bore no evidence of this type of damage. The most common taxa bearing gastric etching is the blue duiker ($n=34$), accounting for 65.4% of the

total sample of gastrically etched bone. Note, however, that only 1.7% of the total sample of blue duiker ($n=1962$) bears this damage.

Although the overall frequency of specimens bearing gastric etching in the MSA deposits at Boomplaas was much higher than that identified here, with up to 29.3% of the small mammal remains from certain contexts showing gastric etching, Faith (2013) also found a discrepancy in the occurrence of gastric etching between small and large mammals. Based on information presented in Marean (1991); Faith (2013) argued that carnivores should be equally likely to consume the bones of larger ungulates, and, as such, could be ruled out as a primary accumulating agent for the Boomplaas assemblage. While this may allow one to rule out larger carnivores such as hyena or large felids (including leopard and cheetah; see Skinner and Chimimba, 2005 and sources therein), Andrews and Nesbit Evans (1983) demonstrate that smaller carnivores, including mongoose, can produce gastric etching. Analysis of modern scat indicates that rodents are the most common mammalian prey of the mongoose present in the southern African subregion (Skinner and Chimimba, 2005), although Andrews and Nesbit Evans (1983) report that larger mongoose may occasionally take species such as hare. Given this, it would seem that neither the largest (i.e, hyena, leopard, cheetah) nor the smallest (mongoose, viverrids/mustelids) carnivores were likely responsible for the majority of gastrically etched bone in the HP at Sibudu. Rather, the mammalian carnivores more likely to have contributed to the assemblage are *Canis mesomelas* (black-backed jackal), *Carcacal caracal* (caracal), and *Leptailurus serval* (serval). The first two species are known to take small bovids and miscellaneous small game, while serval prey upon smaller game such as hare and cane rat (Skinner and Chimimba, 2005).

Raptors have been implicated in the accumulation of small mammals—including small bovids—at other MSA sites, including Die Kelders 1, Boomplaas Cave, and Blombos Cave (Marean et al., 2000; Henshilwood et al., 2001; Faith, 2013). Raptors do seem to have played a role in the accumulation of the avian and microfaunal assemblages at Sibudu (see Glenney, 2006; Val, 2015). However, the species that have been implicated are *Tyto alba* (barn owl) for the microfauna and *Falco peregrinus* (peregrine falcon) and/or *Falco biarmicus* (lanner falcon) for the avian assemblage, and none of these commonly preys upon macrofauna (e.g., Kemp and Calburn, 1987; Jenkins and Avery, 1998); in fact, Jenkins and Avery (1998) state that African peregrine falcons prey almost exclusively upon flying species. While this does not preclude the possibility that another raptor may have contributed to the accumulation of small game at Sibudu, given the lack of evidence for raptor activity in the form of beak/talon marks, raptors do not seem to have been a major contributor to the assemblage.

The last possible source for gastric etching is human activity. Experimental data indicates that human consumption of bones can result in gastric etching that may be indistinguishable from that produced by other predators (e.g., Butler and Schroeder, 1998; Dewar and Jerardino, 2007). Furthermore, the remains of many different species of small mammals have been identified in human coprolites from prehistoric sites. In an analysis of coprolites from the southwestern US, Reinhard et al. (2007) found bones from a diverse array of taxa, and while many of these were smaller than the blue duiker (~4 kg), the most common taxa bearing gastric etching in the Sibudu assemblage, the remains of mammals of comparable size, such as the raccoon (~6 kg) and fox (~5 kg), were present. As such, the possibility that some of the gastric etching reflects human activity cannot be dismissed out of hand.

Beyond a consideration of surface damage, an additional line of evidence may speak to the degree of human involvement with the small ungulates and miscellaneous smaller game—the burning data. Clark and Ligouis (2010) proposed that the most likely explanation for the high frequency of burned bone in the HP and post-HP at Sibudu was the deliberate disposal of bone into fire as a means of disposing of food waste (see also Cain, 2005). If this were the case, and if humans were responsible for the introduction of the smaller game into the site, one might expect to find a similar degree of burning among the small game fraction as for the medium and large ungulates. As indicated in Figure 6, the miscellaneous small game remains do show the lowest frequency of burned bone, with 30.1% of the assemblage coded as moderately or highly burned, vs. 45.9% for the medium and large/very large ungulates. This difference is statistically significant ($\chi^2 = 57.723$; $p < 0.0001$). This may imply a greater role of non-human actors in the accumulation of this fauna. The picture is somewhat more complicated for the small ungulate remains. With 39.5% of the remains coded as moderately or highly burned, the frequency of burned bone is significantly higher for the small ungulates than for the miscellaneous smaller game ($\chi^2 = 22.021$; $p < 0.0001$). However, it is also significantly lower than the frequency of burned bone identified for medium and large/very large ungulates ($\chi^2 = 20.677$, $p < 0.0001$). This appears to be driven at least in part by the high frequency of burning among the medium ungulates, as the difference in the relative frequency of non- or lightly-burned bone is not statistically significant between the small and large/very large ungulates ($\chi^2 = 2.462$, $p = 0.1166$).

Taken as a whole, then, the data seem consistent with the results of the analysis of the initial assemblage, suggesting that humans were the primary contributor to the HP fauna—this seems true for both the large and small game. However, non-human agents—mostly likely

medium carnivores, and possibly an as yet unidentified raptor—may have played some role in the accumulation of the smaller game.

Paleoenvironmental implications

Figure 8 presents habitat preference data for the HP fauna. The sample is limited primarily to species-level identifications, although if all members of a genus occupy similar habitat types, these data were also incorporated (see SOM Table S2 for the assignment of species to habitat type). The current study is consistent with previous results (Clark and Plug, 2008; Clark, 2011, 2013), in that the assemblage is dominated by species that preferentially inhabit closed or semi-closed habitats ($n=2553$, or ~92% of the total). In all three layers, the most common species-level identifications are the blue duiker and bushpig, both of which prefer forested habitats.

Despite the fact that closed-dwelling species dominate in all three layers, there is a gradual decline in their frequency over time. In analyzing the initial sample of the material, these differences were only statistically significant between GS and GR (Clark, 2013). However, when considering the total assemblage, the change in the frequency of open- vs. closed-dwelling species between PGS and GS is also statistically significant (PGS vs. GS: $\chi^2=7.976$, $p=0.0185$; GS vs. GR: $\chi^2=34.516$, $p<0.0001$). As evidenced in the data table accompanying Fig. 8, this pattern appears to be driven more by a reduction in the number of specimens from closed-dwelling species rather than a gross increase in number of bones deriving from open-dwelling taxa. Given that the blue duiker is present in such high frequencies (accounting for ~71% of the assemblage that could be assigned to habitat type), I removed this species from the analysis in order to explore whether the observed pattern may reflect changes in the exploitation of a single species (SOM Figure S1). The general pattern remains intact; however, while the difference

between GS and GR remains statistically significant ($\chi^2 = 25.51, p < 0.0001$), the difference between PGS and GS does not ($\chi^2 = 4.016, p = 0.1343$). Finally, it is perhaps relevant to note that the same patterns are evidenced when MNI values are used (i.e., a shift towards more open-dwelling taxa), the only difference being that the trends are slightly less marked.

Animal exploitation strategies: the ungulate data

As indicated in Table 3, ungulates (particularly bovids) make up the vast majority of the identifiable assemblage. In this section of the paper, I will focus on evidence for variation in the ungulate assemblage over the course of the HP. In addition to utilizing taxonomic data, I will also present element frequency data. As previously discussed, the nature of fragmentation is such that the element data must be treated with a degree of caution—in particular, comparisons across size classes do not seem appropriate. However, given that the degree of fragmentation seems to be relatively similar within each size class, variation in skeletal part profiles within each size class may provide some information on behavioral variation. The skeleton was divided into six anatomical units: skull, axial, forelimb, hindlimb, distal limb, and feet; Table 11 provides a listing of the elements contained within each unit. Note that because ribs and vertebrae are exceptionally difficult to assign to size class when in highly fragmentary form, these are not represented in the identified assemblage outside of the axis and atlas. Table 12 provides NISP counts on the number of bones identified in each anatomical unit by size class and layer. These data form the basis of the statistical comparisons of element frequencies and for the skeletal element profiles presented later in this section. The profiles were constructed by normalizing the raw data based on the number of bones in each anatomical unit in a single skeleton. Note that teeth and horn fragments were not included in analyses of skeletal element profiles; these are included in Table 12 for the sake of completeness.

In all three layers, the blue duiker is the most commonly identified taxon. There are two reasons why blue duiker may be over-represented relative to other species. First, as discussed, in heavily fragmented assemblages, the bones of smaller species may be more readily identifiable than those of larger species. Second, blue duiker remains could often be identified based on size alone. In contrast, species-level identification of the other bovids required complete (or nearly complete) teeth or other rare diagnostic elements. However, these biases should act equally across the layers of the HP, and although blue duiker is the most commonly identified taxon in each layer, there is a decline in the presence of the species over time. Blue duiker account for 39.3% of the total assemblage in PGS, 29.6% in GS, and 23.7% in GR; these differences are statistically significant (PGS vs. GS: $\chi^2 = 46.808$, $p < 0.0001$; GS vs. GR: $\chi^2 = 12.803$, $p = 0.0003$).

Particularly given the proposal that blue duiker may have been captured using nets or remote capture technology such as traps or snares (see Clark and Plug, 2008; Wadley, 2010), it is worth considering the exploitation of this species in greater detail. Ethnographic and ethnoarchaeological research have documented that the age structure of blue duiker can vary based on method of capture, with net hunting, for instance, resulting in the capture of more young juveniles than when traps or snares are used (Noss 1995, 1998; Lupo and Schmitt, 2002, 2005). Unfortunately, I could not locate data on the proportion of juveniles taken when spears (or other single-capture techniques) are used; however, based on the principles of optimal foraging theory, when taken individually, adults should be preferentially targeted due to their larger body size (Speth and Clark, 2006). As such, a higher frequency of adults may be expected using these methods, as net hunting/remote capture technology should result in a more random age distribution (Lupo and Schmitt, 2002).

In an attempt to reconstruct age profiles for the blue duiker, I collected crown height data for all blue duiker lower molars for which measurements could be taken. Unfortunately, due to the fragmentary nature of the remains, this resulted in only 35 measurements. Furthermore, only four partial tooth rows (defined as having more than two teeth in sequence) were identified. As such, conducting age profiles on the dental remains was not possible. However, the relative proportion of juvenile and fetal/neonate remains (based on deciduous dentition and unfused post-cranial remains) can be compared (Table 13). Fetal/neonate and juvenile individuals account for ~11% of the assemblage in PGS and GS but only 4.9% of the sample from GR; the decline in younger individuals from GS to GR is statistically significant ($\chi^2 = 9.035$, $p = 0.0026$). While the focus on adults may indicate that blue duiker was primarily taken using a single capture technique (spears and/or the bow and arrow), Wadley (2010) argues that snaring could also produce a prime-dominated pattern. This is because juvenile blue duiker travel lesser distances than adults and thus may be less likely to be captured in snares. Given this, a predominance of adults may not be useful for distinguishing precisely which method(s) of capture was/were being employed, although it may suggest that net hunting was not being practiced. However, the fact that GR contains a significantly lower number of juveniles—and is the only layer that contains no fetal/neonate remains—may indicate a shift in duiker exploitation strategies, perhaps reflecting a change in the primary method of capture between GS and GR. Of course, the decline in younger individuals in GR need not solely reflect changes in human exploitation. It may also reflect a greater degree of non-human accumulation in PGS and GR. GR does show a lower frequency of gastrically-etched blue duiker remains than PGS or GS—2.1% in PGS, 2.2% in GS and 1.1% in GR; however, this variation is not statistically significant ($\chi^2 = 1.221$, $p = 0.5431$;

data from Table 10; all the small ungulate remains bearing gastric etching were identified as blue duiker).

Skeletal part data may provide further insight into variation in the treatment of blue duiker over time. Figure 9 illustrates skeletal part frequencies for blue duiker—note that because no blue duiker sesamoids were recovered (likely due to their small size), sesamoids were not taken into account when calculating the relative frequency of foot bones. The data show some variation over the course of the HP; however, on a layer-by-layer basis, these differences are only significant between PGS and GS (Table 14). The fact that GS and GR show a differing representation of young individuals but a similar distribution of skeletal elements implies that even if blue duiker were taken using an alternative method of capture in GR, carcasses were treated in a similar way.

The decline in the prevalence of blue duiker is also reflected in the broader ungulate size class data; as seen in Figure 10, the smallest ungulates are most common in PGS and then decline steadily over time. These differences are statistically significant (total assemblage: $\chi^2 = 203.147$, $p < 0.0001$; PGS vs. GS: $\chi^2 = 62.536$, $p < 0.0001$; GS vs GR: $\chi^2 = 50.173$; $p < 0.0001$). Given the general consistency in the numbers of large and very large ungulates, these differences seem to be driven by a decline in the exploitation of small and medium ungulates over time. Once again, in order to see whether the changes are primarily tracking the decline in the prevalence of blue duiker, I removed that species from the analysis (see SOM Figure S2). However, as was the case with the habitat preference data, the pattern remained intact, and the shifts in the frequency of the different size classes remained statistically significant (total assemblage: $\chi^2 = 59.21$; $p < 0.0001$; PGS vs. GS: $\chi^2 = 10.601$, $p = 0.0140$; GS vs. GR: $\chi^2 =$

25.843; $p < 0.0001$). In other words, the focus on smaller ungulates during the early stages of the HP was not just limited to the blue duiker.

Looking at the skeletal part data for the remainder of the bovid assemblage (Figure 11; Table 12), a couple of points are worthy of note. First is the variation in skeletal part profiles between PGS and GS—the distribution of skeletal elements is significantly different between the two layers for all three size categories (Table 14). Second is the degree of similarity in skeletal element frequencies in GS and GR; the medium bovids are the only size class which shows significant variation. Given that ethnoarchaeological work has indicated that smaller bovids (Bov I and II) are frequently transported whole (Oliver, 1993; but see Lupo, 2006), one might expect some similarity for these taxa. The lack of significant variation between GS and GR for the blue duiker and Bov I remains thus makes some sense, although that does not explain the discrepancy for the Bov II remains. The differences between PGS and GS, which occur across the size spectrum (including the blue duiker) warrant further attention and will be explored in more detail in future work.

There has long been interest in the exploitation of suids by MSA populations, in part because they represent dangerous—and thus more costly to procure—game. As such, it has been argued that their presence (or absence) in the record may be informative about the hunting capabilities/skill of MSA people (e.g., Klein and Cruz-Urbe, 1996, 2000; Faith, 2008, 2011; Weaver et al., 2011). Suids are present throughout the HP at Sibudu, accounting for 10.2% of the assemblage in PGS, 11.2% in GS, and 12.5% in GR; these differences are not significant (total assemblage: $\chi^2 = 4.572$, $p = 0.1017$). While both bushpig and *Phacochoerus africanus* (warthog) were identified, diagnostic specimens are almost exclusively bushpig—347 specimens were identified as bushpig vs. nine for warthog. This suggests that the majority of the remains

identified as “Suid” in Table 3 ($n=287$) are also bushpig. Furthermore, all but one of the warthog specimens derive from GR; given the environmental data, the greater presence of warthog in the upper-most layer of the HP may reflect an increased presence of that species on the landscape due to a shift towards more open conditions.

None of the suid remains bear evidence of either carnivore damage or gastric etching, while four specimens preserve cut marks and one preserves percussion damage, implying humans played a key role in the accumulation of this fauna. Not only are suids present at a consistent frequency over the course of the HP, but the skeletal part data also suggest some consistency in the treatment of their remains (Figure 12). While there is some variation in the distribution of skeletal parts, this variation is not statistically significant (Table 14). Because bushpig is both nocturnal and highly aggressive (Skinner and Chimimba, 2005), its presence suggests proficiency at procuring dangerous game. The use of remote capture technology or projectile weaponry such as the bow and arrow would have served to reduce the risk, and thus the costs, of procuring this game. As such, the greater frequency of suids in the HP as compared to later occupations at Sibudu—8.1% in the post-HP MSA (J. Clark, unpublished data), 6.4% in the late MSA (Wadley et al., 2008), and 0.2% in the final MSA (Collins, 2016)—may in part reflect differences in hunting technology.

Finally, very large ungulates are rare throughout the HP ($n= 10$, 0.2% of the total assemblage), which is consistent not only with data from other HP assemblages, but also with findings at MSA sites, more generally (e.g., Klasies, Blombos, and Diepkloof, see Klein, 1976; Thompson and Henshilwood, 2011; Steele and Klein, 2013). Florisbad serves as an exception to this rule, as *Hippopotamus amphibius* (hippopotamus) remains account for 59 of the 308 identified specimens (i.e., 19.2% of the NISP) from MSA Unit F (~128 ka); however, these

remains were interpreted as representing human scavenging of a natural death assemblage (Brink, 1987; Kuman et al., 1999). Given the small sample size and lack of diagnostic surface damage, is not possible to discern whether the very large ungulate remains at Sibudu reflect active hunting or scavenging. As indicated in the species list (Table 3), only one of these specimens could be confidently identified to the species level—a complete lower M1 identifiable as *Ceratotherium simum* (white rhinoceros) was recovered from GS. Of note, the four specimens in PGS assigned to the Bov V size class—two cranial base fragments, a proximal femur, and a nearly complete second phalanx—were from adjacent sub-squares and identified as juvenile and may represent a single individual. The morphology of the second phalanx was more consistent with *Megalotragus priscus* (giant hartebeest) than with *Pelorovis antiquus* (giant buffalo), but to be conservative, these were assigned to the generic Bov V category.

The non-ungulate fauna

The diverse assemblage of smaller game identified in the initial sample of HP fauna received attention because of the possibility that these animals were collected using some form of remote capture technology (see Wadley, 2010 for a detailed discussion). As discussed above, while direct evidence for human involvement with the miscellaneous smaller game (in the form of cut marks or percussion damage) is somewhat limited, the data suggest that humans did contribute to the accumulation of this material. However, ascertaining which methods of capture were being employed is far from straightforward. As demonstrated in Figure 13, the miscellaneous small game is most prevalent in PGS and declines over the course of the HP, comprising 15.0% of the assemblage in PGS, 12.5% in GS, and 6.3% in GR. These differences are statistically significant (total assemblage, $\chi^2 = 54.529$, $p < 0.0001$; PGS vs. GS, $\chi^2 = 5.859$, $p = 0.0155$; GS vs. GR, $\chi^2 = 29.302$, $p < 0.0001$).

Looking at other aspects of the non-ungulate assemblage, while *Papio ursinus* (chacma baboon), Sykes' monkey, and vervet were identified in each of the three layers of the HP, the overall frequency of primates drops from 5.7% of the assemblage in PGS to 4.1% in GS and <1% in GR. Once again, these differences are statistically significant (total assemblage: $\chi^2 = 45.546$, $p < 0.0001$; PGS vs. GS: $\chi^2 = 6.134$, $p = 0.0133$; GS vs. GR: $\chi^2 = 25.693$, $p < 0.0001$). The diversity of primates is also the highest in PGS, which includes one specimen (a proximal ulna) identified as cf. *Otolemur crassicaudatus* (greater galago) as well as several teeth and a maxilla fragment from an as-yet unidentified primate (possibly a colobine; these specimens are identified as "Primate" in Table 3 and are awaiting specialized analysis). That humans were involved in the collection of at least some of these primates is indicated by the presence of cut marks on the innominate of a Sykes' monkey, while a vervet ulna showed potential evidence for being worked (this specimen has been submitted to Lucinda Backwell for analysis).

As previously mentioned, carnivores are rare in the assemblage, accounting for ~2.2% of the total NISP—2.3% in PGS, 2.7% in GS, and 1.3% in GR. This is one class of data for which there is not a purely directional trend, in that carnivores are most frequent in the middle of the sequence; however, while the decline in carnivores between GS to GR is significant, the difference in the representation of carnivores between PGS and GS is not (PGS vs. GS: $\chi^2 = .705$, $p = 0.4011$; GS vs. GR: $\chi^2 = 6.758$, $p = 0.0093$). Not only does Grey Rocky preserve the fewest carnivore remains, but it also shows the lowest diversity of carnivore species—no canids or felids were identified in GR, whereas both have been identified in PGS and GS (with multiple felid species present in each). Large carnivores are rare throughout, with only a small number of specimens ($n=13$) identified as belonging to species in excess of 25 kg. Mongoose are the most frequently identified taxa, accounting for 56.9% of the identified carnivore remains. Most of the

mongoose specimens could not be identified to the species level. This may in part reflect the nature of the comparative collection utilized for this study, as I did not have access to comparative specimens for all of the mongoose species known to occur in the region. While Wadley (2010) cited the diverse assemblage of smaller carnivores as possible evidence for the use of remote capture technology, none of these remains bore surface modifications indicative of agent (or method) of capture.

Finally, given the fact that Sibudu seems to be ideal hyrax territory—there is ample evidence for the presence of the species at the shelter in modern times in the form of hyrax dung—the relative dearth of the species is worthy of note. Hyrax account for less than 1.1% of the total assemblage and never more than 1.7% of the assemblage from any given layer. Hyrax has been identified at other MSA sites, including Blombos Cave, where the species accounts for 28% of the identified mammalian fauna from the layers dating to ~100 ka (levels CH-CL; Badenhorst, 2014). Badenhorst (2014) argues that the distribution of skeletal elements, combined with some evidence for cut marks, implies that these were primarily preyed upon by humans. At Sibudu, only one hyrax bone bears a cut mark, while five bear gastric etching, indicating that the species was likely accumulated by a combination of human and carnivore activity.

Discussion

Temporal trends in the faunal data

This analysis has highlighted a number of directional trends in the HP fauna at Sibudu. PGS, the lowermost layer of the HP, contains the highest frequency of 1) closed-dwelling taxa, 2) blue duiker and other small ungulates, and 3) miscellaneous smaller game, and all of these decline in frequency over the course of the HP. These differences are statistically significant. The lower deposits of the HP also show a greater frequency of primates and a greater number (and

diversity) of carnivores. PGS also shows the lowest frequency of burning; the increase in heat damage over time is also significant. The skeletal element data do not show any clear directional trends; however, while skeletal element frequencies varied significantly between PGS and GS for small and large animals (the only exception being the suids), GS and GR showed a great deal of consistency in anatomical unit profiles (the only significant difference being for Bov II remains). There are a number of potential explanations for these patterns.

First, the decline in closed-dwelling taxa, the reduction in blue duiker and other small ungulates, and the decreasing frequency of miscellaneous small game could reflect changes in the local environment in the form of a gradual shrinking of the riparian forest around the site. Not only does blue duiker primarily occur in forested habitats, but so do many of the small game species identified in the assemblage, including the Gambian giant rat, vervet monkey, and Sykes' monkey. As such, the decline in the exploitation of these species may reflect a shift in their availability due to changes in local habitat. Yet, Hall et al.'s 2008 isotopic study of *Podocarpus* charcoal from the HP at Sibudu indicates that conditions may have actually been warmer and more open in GS than in GR, with *Podocarpus* reaching its maximum distribution in GR—this is not the pattern that would be expected if there was a gradual opening of the environment over time. As previously noted, botanical data from PGS are thus far largely unpublished, and the available data from GS and GR incorporate only a small portion of the total sample; high-resolution analysis of the remainder of the botanical assemblage will be important in evaluating the degree and nature of environmental change over time.

Under the framework of optimal foraging theory, blue duiker and the other smaller game present in the assemblage represent low ranked prey on account of their small body size (c.f., Broughton and Grayson, 1993; Kelly, 1995; Lupo and Schmitt, 2005). As such, the data may be

reflective of changes in subsistence intensification over the course of the HP, in that the decline in low-ranked prey may reflect a narrowing of diet breadth over time. This may also explain the shift in the age profile of blue duiker; not only were blue duiker exploited more intensively in the early stages of the HP, but those that were taken included a higher frequency of fetal/neonate and juvenile remains, which represent the smallest (and thus lowest ranked) individuals (cf. Speth and Clark, 2006). If diet breadth varied over the course of the HP, one may also expect variation in the skeletal part data, with evidence for more intensive carcass use and processing during the early stages of the HP. Skeletal part frequencies do appear to be different in PGS as compared to GS and GR; future work will be aimed at exploring the possible significance of this variation.

The patterning identified in the faunal data could also reflect changes in site use and/or settlement patterns over time. The deposits in PGS and GS could be interpreted as reflecting a series of shorter-term occupations of the site that were focused on exploiting the resources available in the immediate vicinity of the site (i.e., the riverine forest). In contrast, GR could reflect a shift towards more intensive occupation of the shelter and/or the use of a wider catchment area that incorporated more of the open landscape around the site. A longer-term occupational strategy could explain the increased intensity of burning damage in GR and may also account for the lower frequency of miscellaneous small game and lesser diversity of carnivores relative to GS and PGS. Again, while there is evidence that humans contributed towards the accumulation of these remains, the data suggest a greater input of non-human activity for this portion of the assemblage. As such, accumulation of these remains may have been more likely during periods in which the site was less frequently inhabited.

If there was a significant shift in site use/function in GR—including the use of a wider catchment area—one might expect to find more variation in the skeletal part data as compared to

GS. This would particularly be the case for the large ungulates, which have the highest transport costs (Oliver, 1993)—and yet there was no significant difference in skeletal element frequencies for the Bov III/IV remains in GS and GR. A number of additional data sources will be critical to reconstructing occupation intensity and landscape use, including geoarchaeological data and especially data on variation in lithic production strategies and raw material use (Barton and Riel-Salvatore, 2014). Of potential relevance is a recent analysis of the lithic assemblage from GR, in which de la Peña (2015) identified a higher degree of technological variability than expected. Similarly detailed analyses for GS and PGS will be important for establishing how unique the GR assemblage is—and what the technological diversity evidenced in GR represents.

Finally, could variation in hunting weaponry explain some of the trends in the faunal data? Certain characteristics of the initial sample of HP fauna led Wadley and colleagues (Clark and Plug, 2008; Wadley, 2010) to argue that remote capture technology such as snares or traps may have been employed during this phase. More specifically, it has been proposed that the use of this technology may have contributed to the accumulation of blue duiker, suids, and the miscellaneous smaller game. While the data suggest that humans did play a role in the accumulation of all three, we are still lacking any “smoking gun” evidence that remote capture technology was being utilized. If it were being employed, the fact that blue duiker and miscellaneous small game both decline over time could suggest that this technology fell out of use as the HP progressed.

Implications for thinking about the onset—and disappearance—of the HP

Thinking about the HP more broadly, some have argued that the combined focus on seemingly low-ranked prey and costly weaponry systems reflects an expansion of dietary breadth, particularly as compared to other periods of the MSA (e.g., Clark, 2011; Clark and

Kandel, 2013). As discussed above, if the exploitation of small ungulates—and other smaller game—is related to subsistence intensification, the data suggest that this intensification was greatest at the beginning of the HP and declined thereafter. This may support the hypothesis that the emergence of the HP reflects an adaptive response to some type of stress, whether driven by environmental changes at the onset of MIS 4, demographic factors, or some combination of the two. Addressing this will require high-resolution datasets from sites that preserve both the HP and immediately preceding deposits (generally the Still Bay). While Sibudu does appear to have a brief occupational hiatus between the Still Bay and the HP, a direct comparison of the two may provide further insight into the impetus behind the emergence of the HP; this analysis is ongoing.

Given that sites such as Klein Kliphuis, Rose Cottage, and Klasies show gradual changes in lithic production strategies throughout the HP (Soriano et al., 2007; Villa et al., 2010; Mackay, 2011)—changes that blend across the transition from the HP to the post-HP MSA—the gradual, mostly directional, changes in the fauna in the HP at Sibudu—trends which continue into the post-HP MSA (see Clark, 2013)—are perhaps not surprising. More surprising in this regard is Soriano et al.'s (2015) proposal that changes in lithic production at the end of the HP at Sibudu were more abrupt than at these other sites—so much so that they suggest the final HP may be absent at Sibudu. Given that de la Pena's (2015) analysis of the complete lithic assemblage from GR shows a component of flake production—something also shown in the late HP at Klein Kliphuis, Rose Cottage, and Klasies—I suspect a higher resolution analysis of the Sibudu lithics across the transition from the HP to the post-HP MSA will also show gradual changes in lithic production strategies. This is particularly the case given that Soriano et al.'s (2015) analysis did not include material from the lower portion of the post-HP MSA sequence (often referred to as the post-HP MSA 2).

Taken as a whole, the growing body of evidence for gradual changes (in a number of realms of human behavior) across the HP to post-HP transition suggests a complex situation in which demographic and social factors no doubt played an important role (e.g., Soriano et al., 2007; Villa et al., 2010; Mackay, 2011; Clark, 2013; Porraz et al., 2013; Mackay et al., 2014; Wadley, 2015; Reynard et al., 2016b). It also highlights the continuing need for high-resolution analyses of variation in behavior within the HP at the site-level—analyses that incorporate multiple classes of data; Reynard et al.’s (2016b) recent work at Klipdrift provides an excellent example of the potential of this type of work.

Conclusions

Given its evidence for innovative cultural and technological behaviors, the HP has continued to capture the interest of scholars studying human behavioral evolution during the Late Pleistocene. While initial studies of the HP treated the industry as a single entity, a growing body of work has aimed at documenting the nature and extent of variability in human behavior within the HP (e.g., Soriano et al., 2007, 2015; Villa et al. 2010; MacKay, 2011; Wurz, 2013; Henshilwood et al., 2014; Reynard et al., 2016a,b). Not only is this work critical to building a more refined definition of the industry, but it will also allow us to more effectively compare HP sites across both time and space (de la Pena, 2015). Ultimately, a deeper understanding of this variability will help shed light on the factors underlying both its onset and its disappearance. To this end, the faunal record has a great deal to offer, both as relates to reconstructing human subsistence strategies, and as a means of reconstructing past environmental conditions.

Speaking first at the assemblage level, the data indicate that Sibudu’s HP inhabitants exploited a diverse range of prey. Taphonomic data suggest that the assemblage was accumulated primarily by human activity; this is true for both large and small prey, although low

frequencies of gastric etching suggest that that non-human agents played some role in the accumulation of the smaller fauna. The fauna is dominated by taxa that preferentially inhabit closed environments. This is consistent with the available botanical data (Allott, 2006; Sievers, 2006), which also show a strong evergreen forest signature (keeping in mind that we currently lack published data on the charcoal assemblage from PGS).

Ungulates make up the vast majority of the identifiable assemblage; the prevalence of small bovids suggests a particular focus on this prey; blue duiker alone makes up more than 33% of the total NISP. The consistent presence of suids suggests proficiency at procuring dangerous game, while the presence of a diverse range of smaller prey indicates an aptitude at acquiring smaller game (here defined as species averaging less than 25 kg). While the focus here was on the mammalian remains, Val et al. (2016) demonstrate that birds were also taken by the HP residents of Sibudu. The small game assemblage has been cited as potential evidence for the use of remote capture technologies during the HP (Clark and Plug, 2008; Wadley, 2010); while this possibility cannot be ruled out, the current study does not provide any “smoking gun” evidence that these technologies were being employed.

In a general sense, the current study also confirms the robusticity of the initial sample, in that these results are broadly consistent with those deriving from the analysis of that sample (Clark and Plug, 2008; Clark, 2011). The primary benefits of the enlarged sample come in the ability to break down the data on a layer-by-layer basis. Although heavily fragmented, the data presented here suggest that the degree of fragmentation is similar across the three layers of the HP, facilitating comparison. A number of directional trends are evidenced. PGS, the lowermost layer of the HP, contains the highest frequency of blue duiker and other small ungulates, miscellaneous smaller game, and closed-dwelling taxa. Each of these show a significant decline

over the course of the HP. PGS also showed the lowest frequencies of burned remains. As discussed, there are a number of potential explanations for these changes; while many of them may relate to changes in the local environment, they may also reflect changes in subsistence intensification, hunting weaponry, and/or changes in site use and/or settlement intensity over time.

As cogently argued by Kuhn (2013), detailed studies of variation on a local scale serve as an important first step towards our understanding of broader cultural transitions. By documenting the nature and extent of variation in the HP faunal record at Sibudu, this study provides important context against which to explore variability in other dimensions of human behavior at Sibudu. It also provides a point of comparison for other HP faunal assemblages. Understanding the broader implications of the identified trends will not only require considering the faunal data alongside other classes of data (e.g., lithic, botanical, geoarchaeological) but will also require considering the faunal data within a broader temporal context—i.e., in comparison to the Still Bay and post-HP MSA. These projects are ongoing.

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Figure Captions:

Figure 1: Map showing location of Sibudu Cave (SIB) and other MSA sites mentioned in the text: Blombos Cave (BBC), Boomplaas Cave (BPA), Diepkloof (DRS), Klasies (KRM), Klein Kliphuis (KKH), Klipdrift Complex (KDC), Pinnacle Point (PP13B), and Rose Cottage Cave (RCC).

Figure 2: Plan map of Sibudu Cave showing the extent of the Wadley excavations; the units marked with Xs illustrate the location of the deep sounding.

Figure 3: Stratigraphic profile drawing of unit B4; the bracket on the left indicates the extent of the Howieson's Poort deposits.

Figure 4: Variation in burning damage across the three stratigraphic units of the HP (identified bone only, NISP)

Figure 5: Relationship between the degree of heat damage and cortical preservation in the HP (identified bone only, NISP)

Figure 6: The distribution of specimens by fragment length (NISP; raw data presented in SOM Table S1)

Figure 7: Variation in burning damage between the miscellaneous small mammals and ungulates (NISP)

Figure 8: Habitat preference data (NISP)

Figure 9: Skeletal part profiles for *Philantomba monticola* (blue duiker; based on data presented in Table 11)

Figure 10: Ungulate size class data (NISP)

Figure 11: Skeletal part profiles for small (Bov I), medium (Bov II), and large (Bov III/IV) bovids (based on data presented in Table 11)

Figure 12: Skeletal part profiles for suids (based on data presented in Table 11)

Figure 13: Variation in the presence of miscellaneous small mammals vs. ungulate remains across the three layers of the HP (NISP)

Stratigraphic Unit	Layers	OSL ages
Grey Rocky (GR)	GR	
	GR2	61.7 +/- 1.5 ka
Grey Sand (GS)	Dark Reddish Grey (DRG)	
	DRG2	
	GS	
	GS2	63.8 +/- 2.5 ka
	GS3	
Pinkish Grey Sand (PGS)	PGS	64.7 +/- 1.9 ka
	PGS2	
	PGS3	

Table 1: HP stratigraphic units and dating information (OSL ages from Jacobs et al., 2008a)

Size Class	Live Weight (kg)	Species (list not inclusive)
Bov I	< 23	<i>Philantomba monticola</i> (blue duiker), <i>Sylvicapra grimmia</i> (common duiker)
Bov II	23-84	<i>Aepyceros melampus</i> (impala), <i>Tragelaphus scriptus</i> (bushbuck)
Bov III	85-295	<i>Connochaetes taurinus</i> (blue wildebeest), <i>Kobus ellipsiprymnus</i> (waterbuck)
Bov IV	295-950	<i>Syncerus caffer</i> (African buffalo), <i>Tragelaphus oryx</i> (eland)
Bov V	> 950	<i>Pelorovis antiquus</i> (giant buffalo), <i>Megalotragus antiquus</i> (giant hartebeest), both extinct

Table 2: Bovid size classes (adapted from Brain, 1974)

Taxon	PGS	GS	GR
	NISP/MNI	NISP/MNI	NISP/MNI
<i>Orcyterops afer</i> , aardvark	1/1	-	-
<i>Procavia capensis</i> , rock hyrax	30/2	16/1	19/1
cf. <i>Procavia capensis</i>	-	-	1/-
cf. <i>Lepus saxatilis</i> , scrub hare	2/1	1/1	-
<i>Pronolagus crassicaudatus</i> , Natal red rock rabbit	-	2/1	-
<i>Pronolagus</i> sp.	5/1	2/-	-
<i>Lepus/Pronolagus</i>	11/-	6/-	4/1
<i>Hystrix africaeaustralis</i> , Cape porcupine	-	2/1	1/1
<i>Thryonomys swinderianus</i> , greater canerat	6/1	1/1	3/1
cf. <i>Thryonomys swinderianus</i>	-	-	1/-
<i>Cricetomys gambianus</i> , Gambian giant rat	59/3	17/1	5/1
Rodent large	7/-	2/-	-
cf. <i>Otolemur crassicaudatus</i> , greater galago	1/1	-	-
<i>Papio ursinus</i> , chacma baboon	16/1	14/2	1/1
cf. <i>Papio ursinus</i>	1/-	-	-
<i>Chlorocebus pygerythrus</i> , vervet monkey	47/2	46/2	4/1
<i>Cercopithecus albogularis</i> , Sykes' monkey	42/2	3/1	2/1
Primate: vervet or Sykes' monkey	27/-	14/1	3/-
Primate: Sykes' monkey or baboon	18/-	3/-	-
Primate	10/1	-	-
<i>Manis temminckii</i> , ground pangolin	1/1	1/1	-
<i>Panthera pardus</i> , leopard	1/1	1/1	-
<i>Caracal caracal</i> , caracal	1/1	-	-
<i>Leptailurus serval</i> , serval	-	1/1	-
Felid small (African wild cat size)	2/1	3/1	-
Felid medium (serval/caracal size)	-	2/-	-
Felid large (cheetah/leopard size)	2/-	5/-	-
cf. <i>Genetta tigrina</i> , large-spotted genet	1/1	-	-
Viverrid	2/-	-	-
<i>Galerella sanguinea</i> , slender mongoose	2/1	-	-

Taxon	PGS	GS	GR
	NISP/MNI	NISP/MNI	NISP/MNI
<i>Galerella</i> sp.	2/1	-	-
<i>Atliax palundinosus</i> , marsh mongoose	1/1	2/1	-
Mongoose	39/-	21/1	7/1
cf. <i>Canis mesomelas</i> , black-backed jackal	3/1	-	-
Canid small (fox size)	-	2/1	-
Canid medium (black-backed jackal size)	3/-	-	-
Canid large (African wild dog size)	1/1	-	-
cf. <i>Ictonyx striatus</i> , striped polecat	1/1	2/1	2/1
Mustelid	-	1/-	-
Carnivore small	1/-	6/-	2/-
Carnivore medium	3/-	2/-	3/1
Carnivore medium-large (hyena size)	-	3/-	-
<i>Ceratotherium simum</i> , white rhinoceros	-	1/1	-
Rhinocerotidae	1/1	-	1/1
<i>Equus quagga</i> , plains zebra	-	1/1	5/1
<i>Equus</i> sp.	4/1	1/-	-
<i>Potamochoerus larvatus</i> , bushpig	146/5	127/4	74/3
cf. <i>Potamochoerus larvatus</i>	-	-	5/-
<i>Phacochoerus africanus</i> , common warthog	1/1	-	8/1
Suid	143/-	91/-	53/-
cf. <i>Hippopotamus amphibius</i> , hippopotamus	-	-	1/1
cf. <i>Giraffa camelopardalis</i> , giraffe	-	1/1	1/1
<i>Syncerus caffer</i> , African buffalo	6/1	6/2	12/1
cf. <i>Syncerus caffer</i>	2/1	-	1/-
<i>Tragelaphus scriptus</i> , bushbuck	4/1	4/1	-
<i>Tragelaphus oryx</i> , eland	2/1	-	4/1
cf. <i>Tragelaphus oryx</i>	-	-	2/1
<i>Connochaetes taurinus</i> , blue wildebeest	-	-	2/1
cf. <i>Connochaetes taurinus</i>	-	-	2/2
Alcelaphine medium-large	-	-	1/-

Taxon	PGS	GS	GR
	NISP/MNI	NISP/MNI	NISP/MNI
Alcelaphine large	-	1/1	4/-
<i>Hippotragus equinus</i> , roan antelope	-	5/1	1/1
cf. <i>Hippotragus equinus</i>	1/1	-	-
<i>Philantomba monticola</i> , blue duiker	1118/19	579/15	265/6
<i>Cephalophus natalensis</i> , red duiker	3/1	-	-
cf. <i>Cephalophus natalensis</i>	-	1/1	-
<i>Sylvicapra grimmia</i> , common duiker	-	2/1	-
cf. <i>Sylvicapra grimmia</i>	-	3/1	1/1
<i>Cephalophus/Sylvicapra</i>	-	5/-	-
<i>Kobus ellipsiprymnus</i> , waterbuck	-	-	4/1
cf. <i>Kobus ellipsiprymnus</i>	-	-	1/-
<i>Redunca</i> sp.	-	1/1	-
<i>Pelea capreolus</i> , grey rhebok	2/1	2/1	4/1
cf. <i>Pelea capreolus</i>	1/-	-	2/-
<i>Raphicerus campestris</i> , steenbok	1/1	3/1	14/3
cf. <i>Raphicerus campestris</i>	-	2/-	-
<i>Raphicerus/Oreotragus</i>	-	-	2/-
<i>Aepyceros melampus</i> , impala	-	2/1	5/1
Bov I	331/4	214/1	104/1
Bov I/II	19/-	18/-	14/-
Bov II	329/2	351/1	224/2
Bov II/III	13/-	18/-	9/-
Bov III	131/2	150/2	122/1
Bov III/IV	34/-	21/-	42/-
Bov IV	71/1	54/1	42/1
Bov IV/V	3/-	5/-	-
Bov V	4/1	-	-
Mammal small	82/-	71/-	13/-
Mammal medium	37/-	25/-	12/-
Mammal large	10/-	7/-	5/-

Taxon	PGS	GS	GR
	NISP/MNI	NISP/MNI	NISP/MNI
Total ID (NISP/MNI)	2848/72	1953/59	1120/44

Table 3: Species list for the HP assemblage from Sibudu (NISP)

Stratigraphic Unit	ID		Non-ID > 2 cm		Non-ID < 2cm*		Total Count	Total Weight (kg)	Avg. frag. size (g)	% ID
	Count	Weight (kg)	Count	Weight (kg)	Estimated Count*	Weight (kg)				
Grey Rocky	1,120	2.6	8,991	16.1	112,764	16.2	122,875	34.95	.28	0.9%
Grey Sand	1,953	3.0	7,965	14.1	132,242	20.0	142,160	37.03	.26	1.5%
Pinkish Grey Sand	2,848	2.9	10,173	15.0	161,267	20.3	174,288	38.19	.22	1.6%
Grand Total	5,921	8.5	27,129	45.2	406,273	56.5	439,323	110.17	.25	1.3%

*Full counting of this material was limited to material from units B5 and B6 and then to one quadrant per layer for the other units. These data were used to calculate average fragment weights, which allowed for the calculation of an estimated count based on the total weight.

Table 4: Summary data for the identified and non-identified fauna

Stratigraphic Unit	Sediment Volume (m³)	Total Bone Weight (kg)	Density (kg/m³)
Grey Rocky	0.59	34.95	59.24
Grey Sand	0.63	37.03	58.77
Pinkish Grey Sand	0.59	38.19	64.73
Grand Total	1.81	110.17	60.87

Table 5: Density of faunal remains in the HP at Sibudu (expressed as kilograms of bone per cubic meter of deposit); sediment volume calculated using data recorded in the field on the number of liters of sediment from each unit

	PGS	GS	GR
Cut marks	33 (1.3%)	18 (1.0%)	11 (1.2%)
Percussion damage	5 (0.2%)	9 (0.5%)	5 (0.5%)
Carnivore damage	3 (0.1%)	3 (0.2%)	3 (0.3%)
Gastric etching	26 (1.1%)	18 (1.0%)	8 (0.8%)
Rodent damage	2 (0.1%)	3 (0.2%)	-
Termite damage	-	5 (0.3%)	-
Root etching	-	2 (0.1%)	2 (0.2%)
Possible chemical weathering	2 (0.1%)	5 (0.3%)	2 (0.2%)
Total Analyzed	2457	1731	946
% of analyzed with poor cortical preservation	16.1%	19.5%	22.0%

Table 6: Surface damage recorded during taphonomic analysis (analyzed sample included all identified bone with the exception of tooth/enamel fragments; note that no evidence for raptor activity in the form of beak or talon marks was recorded)

	PGS	GS	GR
Cut marks	2 (2.0%)	6 (2.5%)	4 (2.6%)
Percussion damage	1 (1.0%)	2 (0.8%)	1 (0.6%)
Carnivore damage	1 (1.0%)	1 (0.4%)	2 (1.3%)
Root etching	-	1 (0.4%)	-
Possible chemical weathering	2 (2.0%)	11 (4.5%)	6 (3.9%)
Total Analyzed	100	243	155
% of analyzed with poor cortical preservation	30.3%	28.0%	39.2%

Table 7: Surface damage recorded during a pilot study of non-identifiable shaft fragments > 2 cm in maximum dimensions.

	Small Ungulates			Medium Ungulates			Large Ungulates		
	PGS	GS	GR	PGS	GS	GR	PGS	GS	GR
CO/ACO	118	84	29	28	31	9	3	3	3
Fragments	63	42	23	27	36	8	6	15	11
% CO/ACO	65.2%	66.7%	55.8%	50.9%	46.3%	52.9%	33.3%	16.7%	21.4%

Table 8: Complete/almost complete (CO/ACO) vs. fragmentary carpal/tarsal bones by ungulate size class and layer (NISP)

	PGS			GS			GR		
	τ_b	<i>p</i>-value	#ss	τ_b	<i>p</i>-value	#ss	τ_b	<i>p</i>-value	#ss
Bov I	-0.0546	0.4919	76	-0.0976	0.2458	70	-0.0995	0.2778	61
Bov II	-0.0769	0.4510	53	0.0562	0.5856	50	-0.0939	0.4013	44
Bov III/IV	-0.2157	0.0916	37	0.1352	0.3007	42	0.0543	0.6339	43

Table 9: Results of analysis of density mediated attrition. τ_b : Kendall's tau-b; #ss: the number of different scan sites represented in each run of the test

	PGS	GS	GR	Total	% of Analyzed Sample
Human activity (cut marks/percussion damage)					
Misc. small mammals (<25 kg)	2	0	0	2	0.3%
Small ungulates (Bov I)	18	7	5	30	1.3%
Medium ungulates (Bov II and suids)	8	11	7	26	1.9%
Large ungulates (Bov III-IV and equids)	10	9	4	23	3.6%
Total	38	27	16	81	
Carnivore damage					
Misc. small mammals (<25 kg)	1	0	1	2	0.3%
Small ungulates (Bov I)	0	1	1	2	<0.1%
Medium ungulates (Bov II and suids)	2	1	0	3	<0.1%
Large ungulates (Bov III-IV and equids)	0	1	1	2	<0.1%
Total	3	3	3	9	
Gastric etching (may reflect human or non-human involvement)					
Misc. small mammals (<25 kg)	2	3	4	9	1.4%
Small ungulates (Bov I)	23	13	4	40	1.7%
Medium ungulates (Bov II and suids)	1	2	0	3	0.2%
Large ungulates (Bov III-IV and equids)	0	0	0	0	0
Total	26	18	8	52	

Table 10: Distribution of evidence for human activity vs. non-human predation by size class (NISP)

Anatomical Unit	Elements
Skull	Cranium, mandible, hyoid
Axial	Atlas, axis
Forelimb	Scapula, humerus, radius, ulna
Hindlimb	Pelvis, femur, patella, tibia
Distal limb	Carpals, tarsals, metapodials
Feet	Phalanges, sesamoids

Table 11: Anatomical units utilized in analysis of skeletal part frequencies

Anatomical Unit	Blue duiker			Bov I			Bov II			Suid		
	PGS	GS	GR	PGS	GS	GR	PGS	GS	GR	PGS	GS	GR
Skull	85	23	12	42	22	12	8	14	15	7	6	4
Axial	12	3	3	10	2	1	1	-	5	-	-	-
Forelimb	128	50	26	53	27	14	29	57	38	10	10	7
Hindlimb	117	55	30	49	21	16	27	25	21	9	5	3
Distal limb	368	219	100	78	56	21	86	93	46	73	46	14
Feet	212	167	61	81	73	34	169	157	99	131	110	69
Other elements:												
Teeth	184	55	27	19	25	23	13	10	8	47	41	56
Horn	12	7	6	2	3	0	3	2	3	n/a	n/a	n/a
Total	1118	579	265	334	229	121	336	358	235	277	218	153

Anatomical Unit	Bov III/IV			Equid			Very large ungulates		
	PGS	GS	GR	PGS	GS	GR	PGS	GS	GR
Skull	152	98	87	-	-	-	2	-	-
Axial	26	45	43	-	-	-	-	-	-
Forelimb	12	26	19	-	-	-	-	-	-
Hindlimb	21	23	25	1	1	-	1	-	-
Distal limb	4	-	-	2	-	-	-	-	-
Feet	8	12	20	-	-	-	2	1	1
Other elements:									
Teeth	3	3	1	1	1	5	-	1	2
Horn	35	32	29	n/a	n/a	n/a	-	-	-
Total	261	239	224	4	2	5	5	2	3

Table 12: Skeletal part data for the ungulate remains (NISP)

	Fetal/Neonate	Juvenile	% of Total
Grey Rocky	0	13	4.9%
Grey Sand	4	62	11.4%
Pinkish Grey Sand	9	116	11.2%

Table 13: Frequency of fetal/neonate and juvenile remains for blue duiker only (NISP)

	Blue duiker		Bov I		Bov II		Suid		Bov III/IV	
	χ^2	<i>p</i> -value	χ^2	<i>p</i> -value	χ^2	<i>p</i> -value	χ^2	<i>p</i> -value	χ^2	<i>p</i> -value
PGS vs GS	28.997	<0.0001	11.397	0.0441	11.548	0.0415	2.323	0.6784	26.003	<0.0001
GS vs GR	4.229	0.5169	3.08	0.6877	12.684	0.0265	4.952	0.2923	3.623	0.6049

Table 14: Results of statistical tests on variation in skeletal part frequencies between layers; χ^2 : chi-square; italicized *p*-values are significant at $\alpha = 0.05$.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Figure 13