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ORIGINAL ARTICLE

Cultivating Complexity: Thirteenth Century AD Crop Systems and Wild Plant Utilization, South Africa

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Abstract The thirteenth century AD was a period that was marked by significant social changes, including the development of a class-based social system and the rise of elite sites like Mapungubwe, which became regional political centers. While substantial gains have been made in understanding MIA agriculture, some problems remain. For one, our knowledge of the spatial distribution and variability of agricultural practices is limited. As a result, this article provides a detailed analysis of macrobotanical assemblages from six archaeological sites located north of the Soutpansberg. Five crop species and 11 wild taxa were identified. *Cenchrus americanus*, *Sorghum bicolor*, and *Vigna unguiculata* were present at most sites. *Eleusine coracana* was identified from a single site within a higher rainfall zone. *Vigna radiata* was present at two sites, which attests to the incorporation of this imported crop into the interior. Our study is the first to compare macrobotanical results from communities that occupied different sociopolitical strata within the Mapungubwe world and from different regions. The results shed light on thirteenth-century crops and potential factors that influence plant use, thereby contributing to a more comprehensive understanding of the diet and agricultural practices of MIA communities.

Résumé Le treizième siècle de notre ère fut une période marquée par d'importants changements sociaux, notamment le développement d'un système social basé sur les classes et l'essor de sites élitaires comme Mapungubwe, qui devinrent des centres politiques régionaux. Bien que des avancées significatives aient été réalisées dans la compréhension de l'agriculture de l'Âge du fer moyen, certaines problématiques subsistent. En particulier, notre connaissance de la répartition spatiale et de la variabilité des pratiques agricoles reste limitée. En conséquence, cet article propose une analyse détaillée des assemblages macrobotaniques provenant de six sites archéologiques situés au nord du massif du Soutpansberg. Cinq espèces cultivées et onze taxons sauvages ont été identifiés. *Cenchrus americanus*, *Sorghum bicolor* et *Vigna unguiculata* étaient présentes sur la majorité des sites. *Eleusine coracana* a été identifiée sur un seul site situé dans une zone à plus forte pluviométrie. *Vigna radiata* était présente sur deux sites, ce qui atteste de l'intégration de cette culture importée dans l'intérieur du territoire. Notre étude est la première à comparer des résultats macrobotaniques issus de communautés ayant occupé différentes strates sociopolitiques au sein du monde de Mapungubwe et provenant de différentes régions. Les résultats apportent un éclairage sur les cultures du treizième siècle ainsi que sur les facteurs susceptibles d'influencer l'usage des plantes, contribuant ainsi à

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une compréhension plus complète de l'alimentation et des pratiques agricoles des communautés de l'Âge du fer moyen.

Keywords Mapungubwe · Iron Age · Crops · Agriculture · Wild plants · Macrobotanical · Archaeobotany

Introduction

The southern African Middle Iron Age (c. 900–1300 AD), or MIA, is a period of profound social change in northern South Africa, southern Zimbabwe, and eastern Botswana. It sees a marked increase in social complexity with the in situ development of a class-based social system. During this period, large politically important sites like Mapungubwe exerted influence over an extended hinterland. From its location in the central Limpopo River Valley, Mapungubwe's rulers controlled the distribution of trade goods, such as glass beads imported from Asia, in exchange for gold, ivory, and other primary products from the African interior (Huffman, 2009; Meyer, 2000).

At its core, MIA society was agrarian, with settlements located in areas that held sufficient water for household use and arable soil for cultivating their crops (Du Piesani, 2008; Hall, 1987; Huffman, 2007). Although much remains to be explored about the complexities of crop cultivation and the use of wild plants during the MIA, recent studies are starting to offer concrete evidence regarding the variety of plant use (Antonites et al., 2024; Antonites, 2019a; Schoeman, 2006; Steyn & Antonites, 2019). Crops identified from these studies, as well as earlier reports (Eloff, 1979; Fouché, 1937; Gardner, 1963), included *Cenchrus americanus* (pearl millet), *Sorghum bicolor* (sorghum), and *Vigna unguiculata* (cowpea). The study of plant use at the MIA site of Mutamba, a settlement in the southern hinterland of Mapungubwe, was the first to publish the results of a dedicated sampling strategy for botanical material using systematic large-scale flotation as a botanical recovery technique (Steyn & Antonites, 2019). The Mutamba study added two new species to the MIA crop package: *Eleusine coracana* (finger millet) and *Vigna radiata* (mung bean). At present, the known MIA crop package includes these five crops, plus *Citrullus lanatus* (tsamma melon/wild watermelon), which is a possibly cultivated non-domesticated species. Research has also identified significant wild species that were used. These include *Sclerocarya birrea* (marula), *Adansonia digitata* (baobab), *Xanthocercis zambesiaca* (nyala berry), *Vangueria infausta* (African medlar), and *Syzygium cordatum* (water berry) (Antonites et al., 2024; Eloff, 1979; Schoeman, 2006). However, poor preservation and the absence of systematic sampling generally means that these likely represent only a tiny fraction of the wild plants used in the past. Despite the gains that have been made in understanding MIA agriculture, some issues remain. For one, our knowledge of the variability and spatial distribution of agricultural practices are still limited. Other than Mutamba, MIA macrobotanical data have been confined to elite or large settlements, leaving a gap in our understanding of everyday agricultural practices across the region and across diverse social contexts. Macrobotanical data as used here refers primarily to carpological material, i.e., seeds and fruit/fruiting structures. In addition, studies with botanical data tend to be at a site level—both as dedicated archaeobotanical studies (Antonites et al., 2024; Steyn & Antonites, 2019) or as appendices to site reports or dissertations (Eloff, 1979; Fouché, 1937; Hanisch, 1980; Schoeman, 2006)—and therefore a regional perspective is lacking. As a result, questions such as how communities managed agricultural resources, responded to environmental constraints, and integrated wild plants into their economies are poorly understood (but see Schoeman, 2006 for a discussion of plants in MIA rain making rituals).

This article presents the macrobotanical assemblages from six thirteenth-century AD archaeological sites in northern South Africa. This is the first study to compare assemblages from different regions on the Mapungubwe landscape and from communities that occupied different sociopolitical strata. Below, we present the results of this analysis, with information on key crops, their agronomic characteristics, environmental adaptability, associated harvesting and processing practices, and associated social significance. The results contribute to a better understanding of plant use and agricultural practices during the MIA.

The Archaeological Context

Agricultural communities first entered the Limpopo Valley during the early first millennium AD; however, settlements were seemingly transient and short-lived, with communities not opting to settle in the region on a permanent basis. It is not until the tenth century that more permanent villages were settled by communities associated with the Zhizo ceramic facies. Isotopic data shows that when Zhizo communities entered the region, rainfall patterns were largely similar to the present—ranging between 350 and 500 mm per annum, and therefore of marginal agricultural suitability (Huffman, 1996; Smith et al., 2007). Archaeologists have hypothesized that elephant ivory and the associated trade therein, rather than agricultural suitability, was likely the reason behind settlement of the Valley (Chirikure et al., 2014; Forssman et al., 2014; Huffman, 2000, 2008; Smith, 2005). Evidence for this is seen at Schroda, the largest Zhizo settlement in the Limpopo Valley, where the amount and diversity of imported goods indicate the rapid expansion of a trade that connected the societies of the Limpopo Valley to the wider Indian Ocean rim (cf. Chirikure, 2014; Moffett & Chirikure, 2016).

By the twelfth century, new communities had moved into the Limpopo Valley, particularly around the Shashe and Limpopo Rivers Confluence Area (SLCA). These newcomers are associated with the pottery from the wider Leopard's Kopje style grouping (Huffman, 2000). The settlement K2—located 6 km southwest of Schroda—is regarded as a Leopards Kopje capital in the SLCA between 1030 and 1220 AD. Its occupation coincides with higher rainfall (Smith et al., 2007; Vogel, 2000), which likely enabled agricultural intensification—evidenced by the rapid increase in settlements on better-suited agricultural lands along the Limpopo River floodplains and associated wetlands (Du Piesani, 2008).

Around 1220 AD, the settlement at K2 was abandoned and relocated to the nearby (~2 km) Mapungubwe Hill (Vogel, 2000). At Mapungubwe, there were significant changes to the spatial organization of the settlement compared to K2. The most notable is the spatial separation of elite and commoner segments of society (Huffman, 2009). The Mapungubwe ruler and his extended household lived on the inaccessible hilltop, with the rest of the community residing around the base. This spatial separation of elites were further emphasized by stone walls, terracing, and palisades on the summit as well as lavish royal burials—all hallmarks of an elite settlement pattern that emerged across the wider region during this time (Chirikure et al., 2014; Huffman, 2009; Meyer & Cloete, 2010).

The widely accepted view, particularly associated with Huffman (1982, 1986, 2007, 2009), is that class distinction at Mapungubwe is linked to wealth accumulation through the control over long-distance trade that augmented earlier cattle-based systems. This was believed to have been legitimated by an ideological shift in which Leopards Kopje elites appropriated control over community-wide rainmaking rituals, which, in turn, legitimized their elevated status. However, recent research suggests that class distinction and sacred leadership may have been present in other sites that predate Mapungubwe (Chirikure et al., 2014). As such, the idea of a single point of origin for social complexity has been questioned in favor of a model that sees Mapungubwe as a reflection of social developments that were taking place more broadly in the region (Chirikure et al., 2013, 2014; Moffett & Chirikure, 2016). Regardless of the origins of this elite pattern, the Mapungubwe royal settlement was in decline by 1280 AD and abandoned by 1300 AD. The reasons for this remain unclear and is likely due to a complex interplay of sociopolitical and environmental factors rather than a monocausal event (Huffman, 2007; Manyanga, 2001; Meyer, 2000; O'Connor & Kiker, 2004; Smith et al., 2007).

Mapungubwe's Hinterland

Regardless of ongoing debate that surrounds the primacy of Mapungubwe in the rise of regional social complexity and the reasons for its decline, it is well accepted that during the thirteenth century, Mapungubwe was the apex site in a regional political hierarchy across northern South Africa. The sites included in this study are all located outside the Mapungubwe heartland (broadly conceived as the SLCA), but with clear social, political, and economic ties to the Mapungubwe center (Ashley & Antonites, 2020). Elsewhere, these communities outside Mapungubwe's direct control but with clear socioeconomic links to the center have been referred to as Mapungubwe's hinterland (Antonites, 2019b). Research has demonstrated that these communities participated in the regional political economy by extracting raw materials such as gold and ivory and producing finished items such as cloth and shell beads. This enabled small, seemingly unimportant hinterland communities to obtain and use high-status goods, whose circulation in the Mapungubwe heartland was restricted to elite segments of society (Antonites, 2019b).

The six research sites in this study (Fig. 1)—Mutamba (MUT), Frampton 1 (MNR74), Frampton 2 (MNR78), Vryheid (MNR04), Evelyn (EV01), and Klein Bolayi (EV02)—were excavated between 2010 and 2018. They all date to the thirteenth century and the height of Mapungubwe's influence and with the exception of Vryheid and Mutamba is single-phase occupations (Antonites et al., 2016; Antonites, 2019b; Fletcher, 2021; Kraljević, 2017; Lippert, 2019). Ceramics are all from the Mapungubwe facies, signaling a mid to late thirteenth century date, which, together with exotic trade goods on the sites, speaks to participation in exchange networks with the SLCA.

The largest site in the study is Vryheid. It has some spatial elements typical of higher-status sites, including a distinct elevated elite area with a cattle kraal

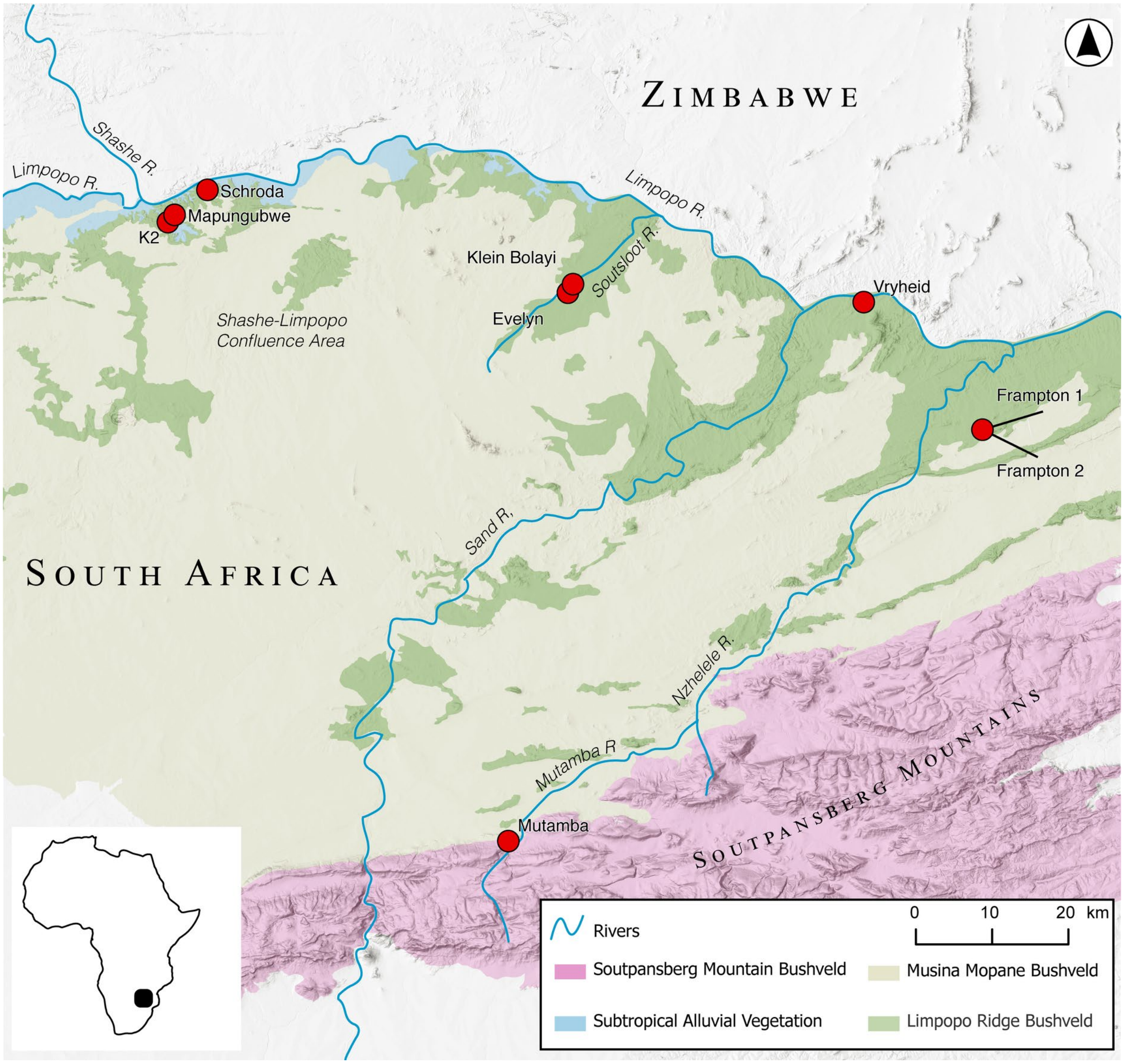

Fig. 1 Map indicating sites and rivers mentioned in the text, with major vegetation zones of the study area (South African National Biodiversity Institute, 2018)

(livestock pen/corral) located away from the rest of the settlement's inhabitants. As such, it likely represents the settlement of a petty chief (cf. Huffman & Hanisch, 1987). Mutamba, Evelyn, and Klein Bolayi share a consistent layout of a centrally placed kraal surrounded by a domestic space—a pattern typical of lower-status settlements such as those of family heads and ward headmen (cf. Huffman, 2007; Huffman & Hanisch, 1987). Frampton 1 and 2 are closely located sites that represent two small homesteads or short-term or seasonal encampments, potentially as part of a transhumant pastoral cycle.

Proxy evidence for agricultural activities in the form of granary foundations or supports was present on all sites except Mutamba. The absence of granary foundations at the site may be due to the use of grain storage methods less likely to be preserved archaeologically—such as large baskets, storage pits, or clay granaries without stone foundations (cf. Maggs, 1976, Mabgwe and Manyanga 2017, Moifatswane, 1993, Nwaigwe, 2019). The foundations of all granaries at the other sites were identifiable as circular arrangements of stones, typically between 0.75 and 1 m in diameter (Fig. 2). The stone base served to raise the granary off the ground, allowing air to circulate and keeping it away from moisture and pests. The granary superstructure was likely made from daga (clay or mud daub), plastered over a cylindrical frame of posts with a thatch roof (cf. Frescura, 1981, p. 216; Meyer & Cloete, 2010).

Environmental Setting

The site locations can be divided into three distinct locales, each with its own unique environmental characteristics (Fig. 3). The furthest eastern locale is Maremani and includes the sites Vryheid, Frampton 1, and Frampton 2. All three are located in the Maremani Nature Reserve. The Klein Bolayi locale includes the sites Evelyn and Klein Bolayi—both located in the Klein Bolayi Game Reserve. The Mutamba locale is represented by the eponymous site and is located on the northern slopes of the Soutpansberg Mountains.

Maremani

The Maremani locale is characterized by a combination of irregular plains, hills, rocky outcrops, and high mountains. There are three major rivers: the Limpopo, Sand, and Nzhelele. However, many non-perennial rivers form during the rainy season (Nel, 2001). Frampton 1 and 2 are located on the transition between Musina Mopane Bushveld and Limpopo Ridge Bushveld vegetation zones (Rutherford et al., 2006). The former is dominated by *Colophospermum mopane* on sandy soils, while the latter is dominated by *Kirkia acuminata* and *Adansonia digitata* on shallow calcareous gravel. Vryheid is located on Limpopo Ridge Bushveld, with *C. mopane* dominant around the site.

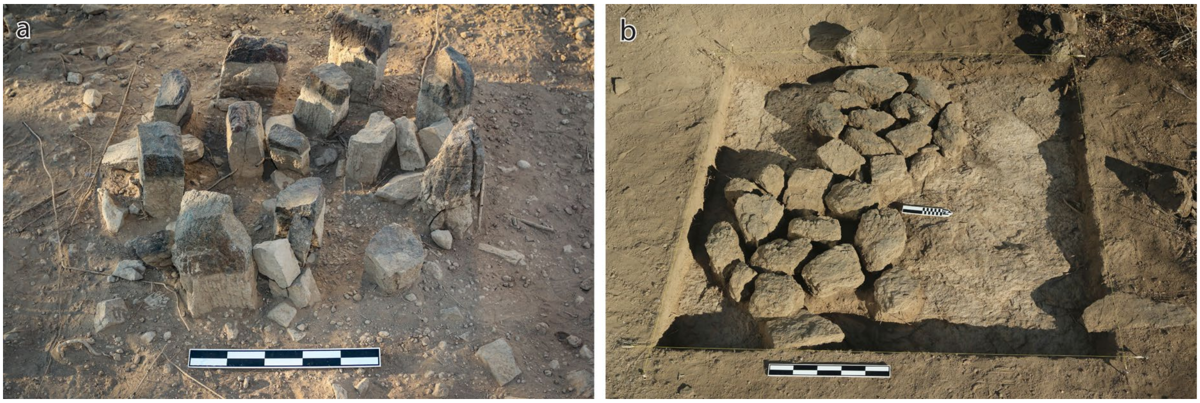

Fig. 2 Example of stone granary foundations on **a** Vryheid and **b** Evelyn; scale is 0.5 m

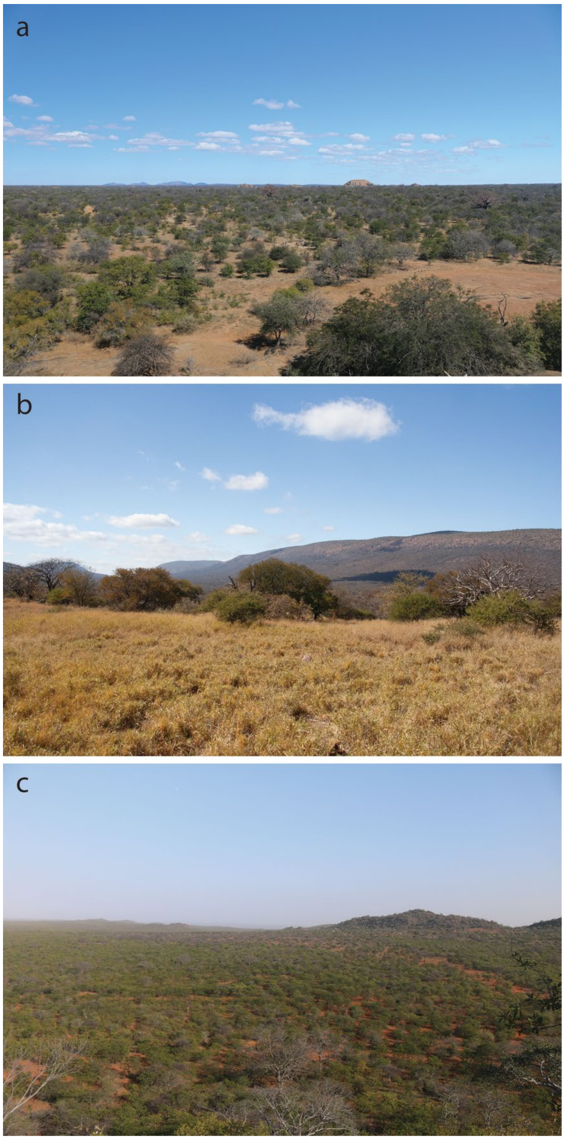

Fig. 3 General views of research locales at **a** Klein Bolayi, **b** Mutamba, and **c** Maremani

Klein Bolayi

In close proximity to Evelyn is Klein Bolayi whose location is characterized by flat to slightly undulating plains, interspersed with granitic hills and is part of the open woodland of the Musina Mopane Bushveld vegetation area with *C. mopane*, *Terminalia sericea*, *Grewia flava*, and *Combretum apiculatum* being dominant (Rutherford et al., 2006). Two perennial rivers, the Mzingwane and the Soutsloot, flow through the locale and into the Limpopo, just over 10 km north of the sites, and a fountain draining into a small wetland is also present.

Mutamba

Mutamba is located on the northern foothills of the Soutpansberg Mountains on the transition from the Soutpansberg Mountain Bushveld to the Musina Mopane Bushveld vegetation types (Rutherford et al., 2006). Soutpansberg Mountain Bushveld is a complex mosaic of sharply contrasting vegetation zones, and at Mutamba, it is dominated by *Senegalia nigrescens* and *A. digitata* (Rutherford et al., 2006). Because the area is situated on the northern slopes of the Soutpansberg, it experiences an extreme rain-shadow effect due to the high levels of precipitation on the southern slope. The perennial Mutamba River passes within 300 m of the site.

Sampling and Methods

The macrobotanical material used in this study was retrieved from flotation samples collected during controlled stratigraphic excavations. All samples are from secure contexts and definitive association with Mapungubwe ceramics. Flotation samples were standard 10 L bulk samples from the center of each locus—the discrete excavated context defined by the archaeologist during excavation—with water flotation taking place off-site. The sample volume was increased in deposits rich in carbonized material or visible botanical remains.

Macrobotanical material was recovered via a modified SMAP-style (Shell Mound Archaeological Project) flotation machine. SMAP machines are comprised of two parts: an outer barrel body and a barrel insert with a rigid screen (Pearsall, 2016; Watson, 1976). The machine used in this study is a modified 200-L steel barrel with a 2-mm brass mesh for the insert. The body of the barrel functions akin to a water reservoir for the flotation, during which a continuous flow of pressurized water washes the soil, releasing material trapped in the soil. Non-buoyant matter sinks to the mesh bottom of the insert, while lighter buoyant matter—such as botanical material—floats to the top (the light fraction). The light fraction is carried out via a sluiceway attached to the insert into a waiting fine-mesh container.

During the flotation process, soil from each locus was added to the flotation machine and slowly agitated by hand. Any buoyant material was passed out the sluiceway into a removable fine net bag suspended beneath the sluiceway. Once complete, the net bag with light fraction was placed in a shady area to air-dry. The non-buoyant heavy fraction that remained in the barrel insert was scooped into a dense cotton fabric bag and also left to air dry. Once all material was completely dry, sorting and identification of the light fractions took place in the Archaeology Laboratory of the University of Pretoria.

The dried light-fraction material was screened through nested geological sieves with the mesh sizes varying between 1.25 and 9.5 mm. Each sieve's content was examined under a stereo microscope with a magnification between × 0.65 and × 4. Any macrobotanical material (e.g., carbonized or desiccated material) was collected for identification. Botanical material was identified through the combined use of the botanical reference collection at the University of Pretoria's Archaeology Laboratory and published morphological criteria from reference literature (Table 3).

The minimum number of individuals (MNI) was calculated using seed part preservation. For Poaceae, MNI was calculated using the methods developed by Antolín and Buxó (2011) for the numerical description of carbonized caryopses. Each seed was described in terms of preserved part and type of fragmentation (complete caryopsis, transversal apical, transversal medial, transversal embryonal, longitudinal ventral-dorsal, longitudinal ventral, and longitudinal dorsal). MNI counts were calculated by considering both the highest number of transversal fragments (apical, medial, or embryonal) and the highest number of longitudinal parts (dorsal and longitudinal ventral) since a seed can only have one of each. In the case of longitudinal ventral-dorsal fragments, the total was divided by half as each grain can potentially break into two such pieces.

For legumes, the MNI was determined based on the preservation of cotyledon parts. A whole seed, with both cotyledons intact, was counted as one individual. Two detached but complete cotyledons were likewise considered equivalent to one seed. In instances where only partial cotyledons were preserved, four quarter cotyledon fragments were counted as one individual. For *Sclerocarya birrea*, MNI was calculated on the basis of either one whole endocarp or three opercula, following Steyn and Antonites (2019). The MNI for all other taxa was estimated by the presence of whole seeds or, in the case of endocarps, by counting four fragments as equivalent to one individual. Any material that could not be quantified was marked as non-quantifiable fragment/s (NQF).

Results

For this study, a total of 310 flotation samples, with a total soil volume of 4083 L, were analyzed (Table 1). Samples for analysis were only selected from well-preserved, stratified contexts with minimal evidence for post-depositional disturbances. Surface contexts were not considered. Of the 310 samples analyzed, 161 (51%) contained macrobotanical material. The preservation and amount of material varied greatly between the sites, with most of the material preserved in a carbonized form, with desiccated material recovered only at Mutamba. The latter was included in the analysis because it originated from below the surface in a sealed context, with no evidence to suggest that it was intrusive.

Seventeen taxa were identified using identifiable morphological criteria (Tables 2 and 3). Five of the taxa were domestic (Fig. 4), and 12 taxa were wild (Figs. 5 and 6). The most common crop taxa were *S. bicolor*, *C. americanus*, and *V. unguiculata*, followed by *V. radiata* and *E. coracana*. Wild taxa were also

Table 1 Flot volume, number of flotation samples and number of samples that contained macrobotanical remains

Site	Analyzed flot volume (l)	Number of flotation samples	Samples with macrobotanicals	
			(*n*)	%
Mutamba	1875	100	100	100
Klein Bolayi	410	41	17	41.4
Evelyn	783	66	21	31.8
Frampton 1	335	34	5	14.7
Frampton 2	150	15	4	26.6
Vryheid	530	54	14	25.9
Total	4083	310	161	

Table 2 The minimum number of individuals (MNI) for identified taxa from the six archaeological sites in this study. Non-identifiable seed remains are denoted as NQF (non-quantifiable fragment). Calculated totals exclude NQF values

Taxon Category	Family	Genus	Species	Mutamba	Vryheid	Frampton 1	Frampton 2	Evelyn	Klein Bolayi	Row total (excl. NQF)
Domestic taxa	Fabaceae	*Vigna*	*radiata*	19				1		20
	Fabaceae	*Vigna*	*unguiculata*	32				1		33
	Poaceae	*Cenchrus*	*americanus*	150	7			7	2	166
	Poaceae	*Eleusine*	*coracana*	4						4
	Poaceae	*Sorghum*	*bicolor*	173			2	6		181
Wild taxa	Amaranthaceae	*Chenopodium*	—		2	2	3	2		9
	Anacardiaceae	*Sclerocarya*	*birrea*	71		1		1	2	75
	Cucurbitaceae	*Citrullus*	—			1				1
	Cyperaceae	—	—						1	1
	Fabaceae	*Vachellia/Senegalia*	—	5	NQF		1	1	NQF	7
	Malvaceae	*Adansonia*	*digitata*	1				3	NQF	4
	Malvaceae	*Gossypium*	*herbaceum*	11						11
	Malvaceae	*Gossypium*	—		1	4		3	1	9
	Malvaceae	*Grewia*	—	19	1			2	2	24
	Poaceae	*Brachiaria*	*deflexa*	7						7
	Poaceae	*Brachiaria*	*nigropedata*	3						3
	Rhamnaceae	*Ziziphus*	*zeyheriana*	17						17
	Rhamnaceae	*Ziziphus*	—					1	NQF	1
	Solanaceae	*Solanum*	*retroflexum*			3				3
Unknown	Fabaceae	—	—		1		1	1		3
	Poaceae	—	—		NQF			NQF	NQF	—
	Unknown	—	—	11	NQF	1 (+NQF)	NQF			12
Site total (excl. NQF)				523	12	12	7	29	8	567

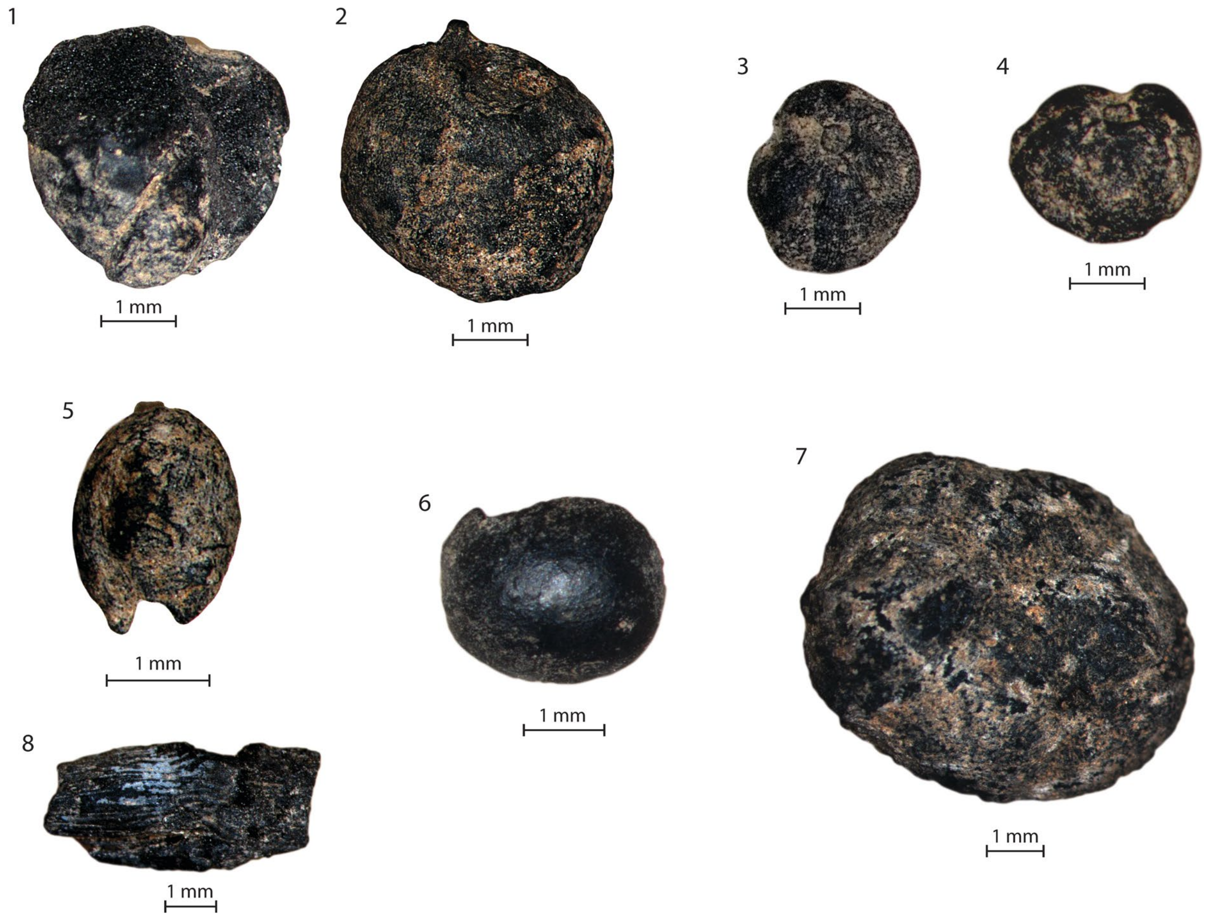

Fig. 4 Examples of carbonised macro remains of domesticated species; **1**, **2** *Sorghum bicolor*, **3** *Eleusine coracana* with hilum visible, **4** *E. coracana* viewed from front, **5** *Cenchrus americanus*, **6** *Vigna radiata* cotyledon, **7** *Vigna unguiculata* cotyledon, **8** culm fragment as possible evidence of crop processing; scale bar is 1 mm

present with *S. birrea* and *Vachellia/Senegalia* sp. being the most common. Prior to 2011, *Senegalia* sp. and *Vachellia* sp. were all members of the *Acacia* genus, and identified samples which would have been classified as *Acacia* are here referred to collectively as *Vachellia/Senegalia* sp.

Mutamba

Mutamba had the richest and best-preserved macrobotanical sample in the study (MNI = 523). Analysis was conducted on 100 flotation samples with a combined volume of 1875 L. Every analyzed sample contained botanical remains spread across 13 taxa (Table 4). The Mutamba material (previously reported in Steyn & Antonites, 2019) was preserved in carbonized and desiccated forms. Eleven taxa were identified at the species level and two taxa at the genus level. The most commonly observed family was Poaceae, which included three crop taxa (*C. americanus*, *S. bicolor*, *E. coracana*) and two wild taxa (*Brachiaria deflexa* and *Brachiaria nigropedata*). The second most common family was Fabaceae, with three species. Two of these—*V. unguiculata* and *V. radiata*—were cultivated as crops. *V. unguiculata* is indigenous, while *V. radiata* originates from India (Fuller, 2007; Fuller & Harvey, 2006). The single wild Fabaceae was a *Vachellia/Senegalia* sp. Other taxa identified include those from the Malvaceae, Rhamnaceae, and Anacardiaceae families—all of these taxa were wild species. There were also 11 seeds

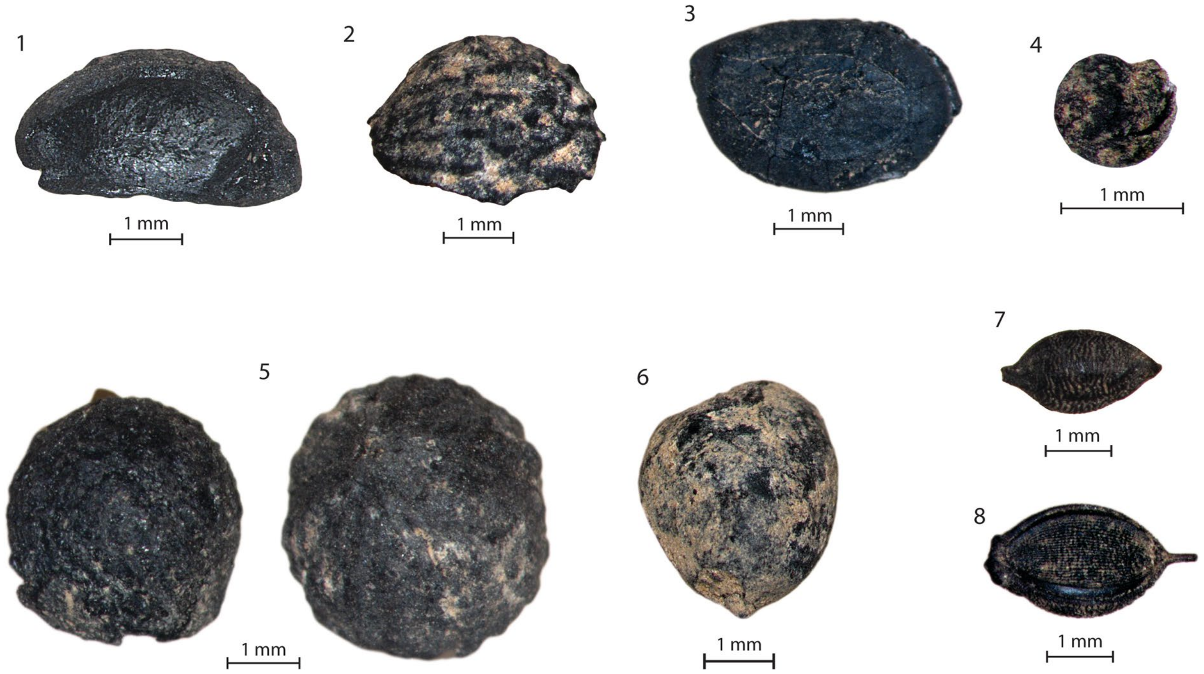

Fig. 5 Examples of carbonised macro remains of wild species. **1** Interior of *Ziziphus* sp. endocarp, **2** exterior of *Ziziphus* sp. endocarp, **3** *Vachellia/Senegalia* sp., **4** *Chenopodium* sp., **5** *Grewia* sp., **6** *Gossypium* sp., **7** *Brachiaria nigropedata*, **8** *Brachiaria deflexa*; scale bar is 1 mm

that could not be identified to any taxonomic level. No crop processing by-products or weed taxa were identified.

Crop taxa are the most prevalent of the Mutamba taxa in terms of MNI (*n* = 378). *S. bicolor* was the most dominant cultivated species, composing 33% of all seeds found at the site. *C. americanus* occurs in slightly lower quantities (MNI = 150), accounting for almost 29% of the total material and is present in over half of the samples (*n* = 64). *E. coracana* was the least common grain (four samples, MNI = 4). Of the two cultivated legumes, *V. unguiculata* comprises approximately 6% of the Mutamba sample and *V. radiata* almost 4%. The latter legume was identified in 16 flotation samples (MNI = 19) and *V. unguiculata* in 18 (MNI = 32).

Wild taxa were present in 84 of the Mutamba samples. Two of the taxa are grasses, and the remainder are either trees or shrubs. The most dominant wild species is *S. birrea*, which accounts for approximately 13% of the total sample from Mutamba (68 samples, MNI = 71). This species is primarily found in the form of either endocarp fragments or opercula and is the only species preserved in both carbonized and desiccated forms.

Vryheid

For Vryheid, 54 flotation samples with a volume of 530 L were analyzed. The macrobotanical assemblage includes six taxa identified from eight of the flotation samples (Table 5). One taxon was identified to species level, four to genus, and one to family. A greater diversity of wild taxa is present compared to domesticates, with *Cenchrus americanus* being the only identified crop species. Wild taxa are from the Malvaceae (*Gossypium* sp. and *Grewia* sp.), Amaranthaceae (*Chenopodium* sp.), and Fabaceae (*Vachellia*/*Senegalia* sp. and unknown Fabaceae) families.

C. americanus accounts for roughly 67% of the identified material at the site (eight samples, MNI = 8). It is present in both grain form (caryopsis or represented seed parts) and non-fruiting structures (e.g., glumes, rachis fragments). Two samples (MNI = 2) of the potential arable weed taxon,

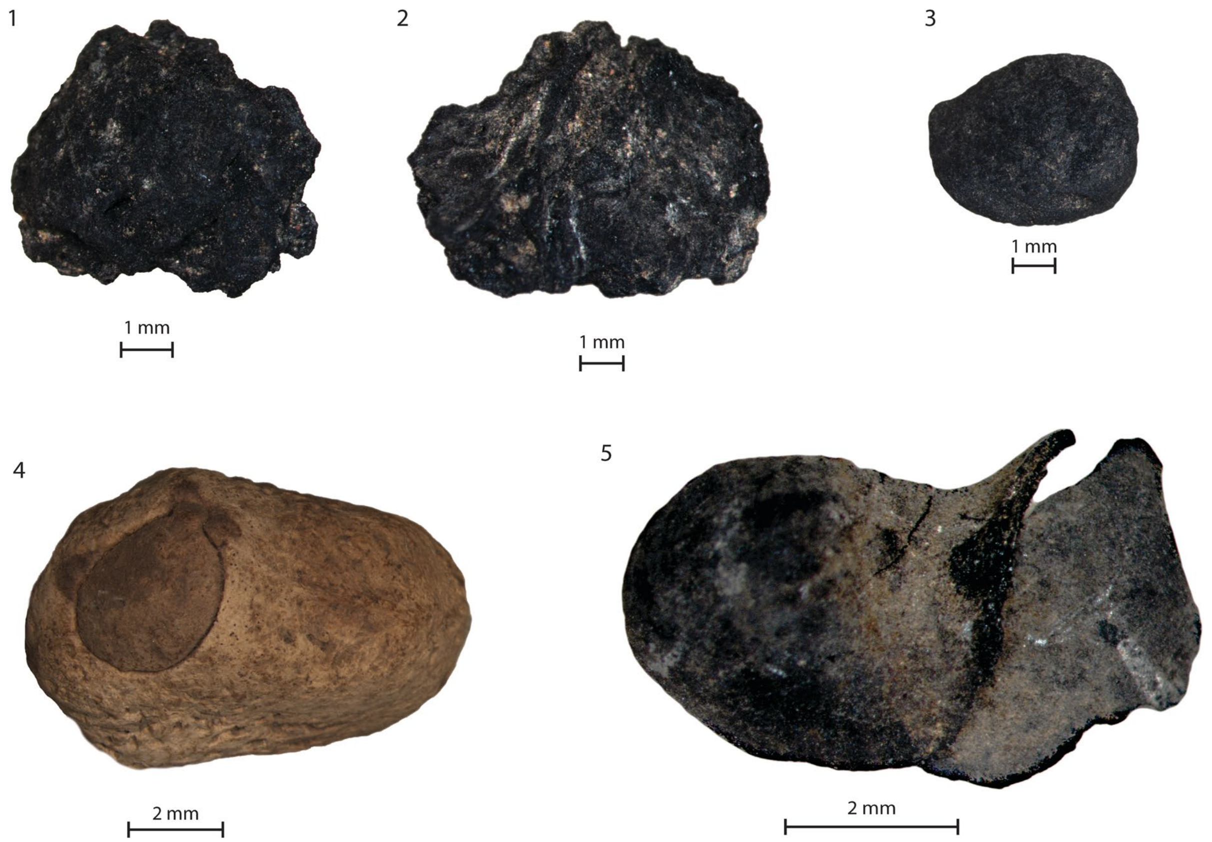

Fig. 6 Examples of **1** *Sclerocarya birrea* endocarp exterior, **2** *S. birrea* endocarp interior, **3** *S. birrea* operculum, **4** desiccated complete *S. birrea* endocarp with operculum present, **5** *Adansonia digitata* endocarp fragment; **1–3** scale bar is 1 mm; **4–5** scale bar is 2 mm

Chenopodium sp., were also identified. The remaining taxa—*Gossypium* sp. (two samples, MNI = 1), *Grewia* sp. (one sample, MNI = 1), and an unknown Fabaceae (one sample, MNI = 1)—accounted for 8% of the assemblage at the site. The *Vachellia/Senegalia* sp. was identified from distinctive testa fragments and, therefore, its MNI could not be calculated.

Frampton 1 and Frampton 2

Frampton 1 (MNI = 12) and Frampton 2 (MNI = 7) only had a small number of macrobotanical remains. At Frampton 1, 34 flotation samples with a volume of 335 L were analyzed and at Frampton 2, 15 flotation samples with a total volume of 150 L. At Frampton 1, two species (*Solanum retroflexum* and *Sclerocarya birrea*) and three genera (*Chenopodium* sp., *Citrullus* sp. and *Gossypium* sp.) were identified (Table 6). At Frampton 2, the botanical material was limited to one species (*S bicolor*), two genera (*Vachellia/Senegalia* sp. and *Chenopodium* sp.), and one family level identification (Fabaceae) (Table 7).

Evelyn

For Evelyn, 66 flotation samples with a volume of 783 L were analyzed. Twenty-nine carbonized seeds were recovered from 21 samples (Table 8). Six of the taxa were identified to species level (*S. bicolor*, *C. americanus*, *S. birrea*, *A. digitata*, *V. unguiculata*, and *V. radiata*), five to genus (*Ziziphus* sp., *Vachellia/Senegalia* sp., *Chenopodium* sp., *Grewia* sp., and *Gossypium* sp.) and two to family level (unknown Poaceae and Fabaceae). The Fabaceae and Malvaceae families were each represented by three taxa. There were three positively identified

Table 3 Seed morphology criteria used in identification and reference literature

Taxon	Seed morphology	Reference literature
Adansonia digitata	Seed reniform in shape; length up to 15 mm	Moll (2012); Coates Palgrave (2002)
Brachiaria deflexa	Seed is rather elliptically shaped; spikelets are between 2.5 and 3.5 mm	Ibrahim et al. (2018)
Brachiaria nigropedata	No technical data found for seed characteristics but it has an inflorescence of racemes along a central filiform or ribbon-like rachis; lower glume tends to be shorter than the spikelet and the upper lemma is obtuse to acute or mucronate	Renvoize et al. (1996)
Cenchrus americanus	Seed is ovate in plan with a deep projecting scutellum (3/4 of scutellum length); hilum projects; seed sizes tend to vary	Brunken et al. (1977); Fuller (2006)
Chenopodium sp.	Seeds are orbicular; Sides are convex and with keeled margins; testa is smooth to striate with raised reticulum	Williams (1963)
Cucurbitaceae	Seeds are oval to spherical; testa is smooth; size varies	Ajuru and Okoli (2013)
Cyperaceae	Seeds are found in a range of shapes but tend to be ovoid, fusiform or ellipsoid. Size ranges from 0.3 to 6 mm; raphe and chalaza are prominent; hilum is punctate and the seed coat is thin and smooth in texture	Gordon-Gray et al. (2009); Koekemoer et al. (2015); Baskin and Baskin (2021)
Eleusine coracana	The seed (caryopsis) is globose shaped; scutellum is only 1/3 of the seed; Surface decoration is pusticulate; size up to 2 mm	Fuller (2006); Hilu et al. (1979)
Gossypium herbaceum/Gossypium sp.	The seed is ovoid with a point	Bouchaud et al. (2019); Chowdhury and Buth (1971)
Grewia sp.	The seed's shape, size and reticulation depend on the species	Cappers et al. (2009)
Sclerocarya birrea	Possesses different parts—a oval shaped stone (endocarp) with two to four (sometimes only one) locule/s containing nuts and operculum covering the locule	von Teichman, 1988; von Teichman et al. (1986)
Solanum retroflexum	Seeds are < 2 mm in length and width; shape is a flattened lacrimal sub-apical hilum; Testa minutely pitted	Särkinen et al. (2018)
Sorghum bicolor	Seed (caryopsis) is round to ovate dorso-ventrally compressed with a projecting concave hilum; scutellum is shallow, long and wide, comprising 1/2 to 2/3 of the seed's length	Fuller (2006)
Vachellia/Senegalia sp.	Seed size and shape tend to vary, based on species; noted feature on seeds are obovate areole	Al-Gohary and Mohamed (2007)
Vigna radiata	Seeds are oblong or globular shaped with flattened ends; length up to 4 or 5 mm	Kay (1979)
Vigna unguiculata	There is some variation present with size and shape; shape tends towards reniform or globular; length up to 12 mm	Kay (1979)
Ziziphus zeyheriana/Ziziphus sp.	The seed is small (up to 5 mm); elliptical in shape	Cappers et al. (2009)

Table 4 MNI of Mutamba macrobotanical remains

	Family	Genus	Species	Part/s rep	MNI
Domestic taxa					
	Poaceae	*Cenchrus*	*americanus*	Caryopsis/represented seed parts	150
	Poaceae	*Eleusine*	*coracana*	Caryopsis	4
	Poaceae	*Sorghum*	*bicolor*	Caryopsis/represented seed parts	173
	Fabaceae	*Vigna*	*radiata*	Cotyledon/seed	19
	Fabaceae	*Vigna*	*unguiculata*	Cotyledon/seed	32
Wild taxa					
	Anacardiaceae	*Sclerocarya*	*birrea*	Operculum/endocarp	71
	Fabaceae	*Vachellia/Senegalia*	—	Seed/testa	5
	Malvaceae	*Gossypium*	*herbaceum*	Seed/testa	11
	Malvaceae	*Grewia*	—	Endocarp/endocarp fragments	19
	Malvaceae	*Adansonia*	*digitata*	Seed/testa	1
	Poaceae	*Brachiaria*	*deflexa*	Caryopsis	7
	Poaceae	*Brachiaria*	*nigropedata*	Caryopsis	3
	Rhamnaceae	*Ziziphus*	*zeyheriana*	Endocarp/endocarp fragments	17
Unknown					
	Unknown	—	—	Seed/represented seed parts	11

Table 5 MNI of Vryheid macrobotanical remains

	Family	Genus	Species	Part/s rep	MNI
Domestic taxa					
	Poaceae	*Cenchrus*	*americanus*	Caryopsis/LVD fragment	7
Wild taxa					
	Amaranthaceae	*Chenopodium*	—	Seed	2
	Fabaceae	*Vachellia/Senegalia*	—	Testa fragments	NQF
	Malvaceae	*Grewia*	—	Seed	1
	Malvaceae	*Gossypium*	—	Seed/testa fragments	1
Unknown					
	Fabaceae	—	—	Seed	1
	Poaceae	—	—	Non-fruiting structure	NQF
	Unknown	—	—	Seed/arboreal fragment	NQF

Table 6 MNI of Frampton 1 macrobotanical remains

	Family	Genus	Species	Part/s rep	MNI
Wild taxa					
	Amaranthaceae	*Chenopodium*	—	Seed	2
	Anacardiaceae	*Sclerocarya*	*birrea*	Endocarp	1
	Cucurbitaceae	*Citrullus*	—	Seed	1
	Malvaceae	*Gossypium*	—	Seed	4
	Solanaceae	*Solanum*	*retroflexum*	Seed	3
Unknown					
	Unknown	—	—	Arboreal	NQF
	Unknown	—	—	Nutlet/achene	1

Table 7 MNI of Frampton 2 macrobotanical remains

	Family	Genus	Species	Part/s rep	MNI
Domestic taxa					
	Poaceae	*Sorghum*	*bicolor*	Caryopsis	2
Wild taxa					
	Amaranthaceae	*Chenopodium*	—	Seed	3
	Fabaceae	*Vachellia/Senegalia*	—	Seed	1
Unknown					
	Fabaceae	—	—	Cotyledon	1
	Unknown	—	—	Arboreal	NQF

Table 8 MNI of Evelyn macrobotanical remains

	Family	Genus	Species	Part/s rep	MNI
Domestic taxa					
	Poaceae	*Cenchrus*	*americanus*	Caryopsis	7
	Poaceae	*Sorghum*	*bicolor*	Caryopsis	6
	Fabaceae	*Vigna*	*radiata*	Seed/cotyledons	1
	Fabaceae	*Vigna*	*unguiculata*	Seed/cotyledons	1
Wild taxa					
	Amaranthaceae	*Chenopodium*	—	Seed	2
	Anacardiaceae	*Sclerocarya*	*birrea*	Operculum/endocarp	1
	Fabaceae	*Vachellia/Senegalia*	—	Seed/testa	1
	Malvaceae	*Gossypium*	—	Seed/testa	3
	Malvaceae	*Grewia*	—	Seed	2
	Malvaceae	*Adansonia*	*digitata*	Seed/testa/endosperm	3
	Rhamnaceae	*Ziziphus*	—	Seed	1
Unknown					
	Fabaceae	—	—	Cotyledon	1
	Poaceae	—	—	Non-fruiting structure/s	NQF

Fabaceae taxa (*Vachellia/Senegalia* sp., *V. unguiculata*, and *V. radiata*), of which two were crop taxa, one was wild, and one was an unidentified cotyledon. Malvaceae was represented with three wild taxa (*A. digitata*, *Grewia* sp., and *Gossypium* sp.). Poaceae was the third most represented family with two crop species (*S. bicolor* and *C. americanus).* The remaining families of Amaranthaceae, Anacardiaceae, and Rhamnaceae had a single wild taxon each. Probable evidence of crop processing on site was found in the form of culm fragments.

Klein Bolayi

Klein Bolayi had eight carbonized seeds observed in 17 of the 41 analyzed flotation samples—these had a combined volume of 410 L (Table 9). The material at Klein Bolayi was significantly more fragmented than the material from the nearby Evelyn. One taxon was identified to family level (Cyperaceae), four to genus level (*Vachellia/Senegalia* sp., *Gossypium* sp., *Grewia* sp., and *Ziziphus* sp.) and three to species (*C. americanus*, *S. birrea*, and *A. digitata*). Most taxa identified at the site were wild with only one crop taxon (*C. americanus*) identified. A total of six families were present, with the leading family at the site being Malvaceae with three attributed taxa (Table 9). Probable evidence for crop processing was identified in the form of non-fruiting structures.

Table 9 MNI of Klein Bolayi macrobotanical remains

	Family	Genus	Species	Part/s rep	MNI
Domestic taxa					
	Poaceae	*Cenchrus*	*americanus*	Caryopsis	2
Wild taxa					
	Anacardiaceae	*Sclerocarya*	*birrea*	Operculum	2
	Cyperaceae			Achene	1
	Rhamnaceae	*Ziziphus*	—	Seed	NQF
	Malvaceae	*Grewia*	—	Seed	2
	Fabaceae	*Vachellia/Senegalia*	—	Seed/testa	NQF
	Malvaceae	*Adansonia*	*digitata*	Seed/testa/endosperm	NQF
	Malvaceae	*Gossypium*	—	Seed/testa	1
Unknown					
	Poaceae	—	—	Non-fruiting structure/s	NQF

Discussion

A major impediment to archaeobotanical research in the area is the relatively poor preservation of material. Therefore, the absence of a crop at a particular site is not an accurate indication of its lack of cultivation. Regardless, the macrobotanical material from the study does indicate that, as a minimum, the general crop package cultivated by MIA farmers in the study area consisted of grains (*S. bicolor*, *C. americanus*, and *E. coracana*) and legumes (*V. radiata* and, more commonly, *V. unguiculata*).

The most widely identified grain was *C. americanus*, which was present at all the sites except at Frampton 1 and 2, with *S. bicolor* found at Mutamba, Evelyn, and Frampton 2. Both *S. bicolor* and *C. americanus* are hardy and drought-resistant and require as little as 250–300 mm of annual rainfall, which makes them well suited to dryland agriculture even in marginal regions such as the Limpopo River Valley (National Research Council, 1996). *C. americanus* has a short growing season, capable of withstanding high temperatures and very low rainfall, offering reliable food security under dryland conditions and, depending on the variety, can mature in as little as 80 days (Biagetti et al., 2018; Van Wyk & Gericke, 2018). It is known to be relatively resistant to disease and pests, and its deep root system allows it to produce consistent yields, even in areas with as little as 150 mm of annual rainfall—conditions where other significant crops like *S. bicolor* often fail (Biagetti et al., 2021; National Research Council, 1996; Van Wyk & Gericke, 2018).

Mutamba is the only site where *E. coracana* was identified. While its absence at other sites may be due to its tiny seeds that make handling, preservation, retrieval, and identification difficult, we believe that it is more likely a reflection of Mutamba's location in a slightly higher rainfall zone (Soutpansberg). *E. coracana* needs rainfall of 500 to 1000 mm, and it is therefore likely to be found at sites such as Mutamba, which is in a comparably higher rainfall zone to the other sites in the study. In addition, the microenvironment around the site—with its proximity to the perennial Mutamba River and associated floodplain—may also have presented favorable growing conditions for its cultivation. Although not drought-resistant, *E. coracana* offers benefits such as pest resistance, as its small grains are impenetrable to weevils. However, it requires meticulous weeding and has a long maturation period of 6 months (Chandra et al., 2016; National Research Council, 1996; Van Wyk & Gericke, 2018).

Of the two legumes cultivated, *V. unguiculata* is indigenous to Africa and well-adapted to semi-arid conditions. It is a hardy, frost-sensitive annual that grows in a variety of soil types (Barros et al., 2020; Pienaar & van Wyk, 1992; Slabbert et al., 2004). *V. radiata*, found only at Mutamba and Evelyn, was likely introduced into southern Africa via Indian Ocean trade networks (Fuller & Harvey, 2006) and the presence in assemblages from at least two sites suggests that it was cultivated in a wide area by the thirteenth century. A probable *V. radiata* seed has also recently been identified at Schroda in the SLCA, which indicates that its introduction into the region may have been as early as the eleventh century AD (Antonites et al., 2024).

The botanical material from the six hinterland sites in this study serves as important comparative samples to capital sites like Mapungubwe, K2, and Schroda. Unfortunately, the sampling from these sites poses challenges, as the material collected from older excavations often lacks contextual information and a dedicated recovery strategy for botanical remains such as flotation. Here, the absence of a plant taxon does not automatically signal its non-use since preservation, sampling, and recovery techniques vary. Nonetheless, some general trends are still evident. The three sites within the SLCA exhibit identical crops: *S. bicolor*, *C. americanum*, *V. unguiculata*—the only exception is a possible find of *V. radiata* at Schroda. This crop package is well suited to dryland agriculture and the comparatively marginal environment of the Limpopo Valley. Compared to the regional assemblages in this study, there seems to be no real differentiation between higher and lower status settlements in terms of cultivated crops (Fig. 7).

The limited presence of domesticated plants at Frampton 1 and 2 does, however, contrast with the other sites. This difference is a result of their status as transhumant settlements. It is perhaps telling that the only domesticated plant at these two sites was *S. bicolor*. While this may be due to differential preservation, it could also reflect the preference for sorghum on temporary or mobile sites due to storage, transport, seasonal availability, or even preference for specific dishes.

Cultivation and Processing

Very little is known about the cultivation practices of Iron Age farmers in southern Africa. As with subsistence farmers in the region today, it is likely that they employed mixed agricultural strategies. This involved both monocropping—where different crops were cultivated in separate fields or sections—and polyculture, in which various crops were grown together in the same space, such as household gardens. Dryland farming, which relies primarily on rainfall, was the predominant method and is still practiced by subsistence farmers in the region today. Similarly, as is still the case in areas near rivers or streams, floodplain

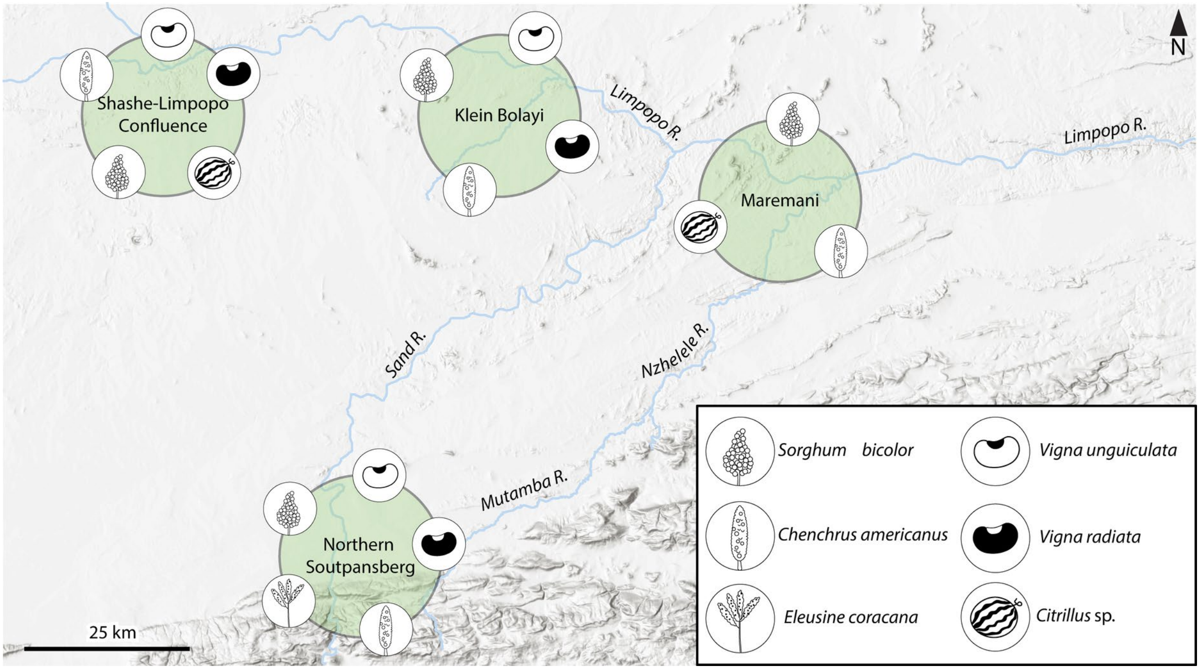

Fig. 7 Distribution of thirteenth-century crops in the Limpopo Valley

agriculture was likely also practiced. Unfortunately, the locations of ancient fields and gardens remain difficult to identify archaeologically. Elsewhere, Greenfield et al. (2005) have proposed that cultivation during the Early Iron Age (c. AD 200–900) likely took place both within villages and in adjacent fields. Although this pattern has yet to be demonstrated for the Mapungubwe World, it is a likely possibility.

Crop processing refers to the process that takes place after cultivation and harvesting, whereby contaminants such as weeds and chaff are separated from grains. This generally involves two main activities: breaking apart the crop plant and separating its components. This processing can occur in bulk during harvest time or in smaller batches throughout the year. Bulk processing is often performed in the field once or twice annually, while routine processing occurs multiple times a year within the settlement (Fuller et al., 2014). These actions shape the macrobotanical assemblages with early stages of processing yield rich in chaff and weed seeds, while the final stages contain mostly grain (Fuller et al., 2014).

Archaeological evidence for crop processing in our sample occurs through crop by-products and a weed taxon (*Chenopodium* sp.) at Evelyn, Klein Bolayi, Frampton 1, and Frampton 2. While *Chenopodium* sp. has historically been collected as a wild food source, often known as "marog" or wild spinach, it has also been harvested as an arable weed alongside cultivated crops (Mabogo, 1990; Singo, 1996). This plant thrives in disturbed soils, making it common in agricultural contexts (Van Wyk & Gericke, 2018).

Assemblages from semi-cleaned crops stored for later processing typically contain a mix of grain, chaff, and tiny weed seeds like *Chenopodium* sp. (Fuller et al., 2014). Labor availability significantly influenced processing strategies. At the smaller settlements such as Frampton 1 and Frampton 2, limited labor availability likely made large-scale, in-field processing difficult. As a result, crops may have been stored in a less processed state, with routine, small-batch processing carried out as needed throughout the year which would lead their presence on the smaller sites (cf. Fuller et al., 2014).

Wild Taxa and Their Uses

The presence of wild taxa at all six sites highlights the role of non-domesticates in the repertoire of MIA communities. Twelve different wild taxa were identified, with the largest variety found at Mutamba and Evelyn. However, the complexity of discerning plant use in the archaeological record is highlighted in a study of present-day plant use in the study area, where researchers identified 574 plant species that are still being utilized on a regular basis—a list that includes 189 trees, 143 shrubs, 170 herbs, 44 climbers, 21 grasses, 4 sedges, 1 parasite, and 2 epiphytes (Magwede et al., 2019). The primary recorded uses include medicinal, food and beverages, magico-ritual uses, fuel, construction, crafting, and diverse uses such as poisons, leather tanning, and dyes. While this highlights the impossibility of discerning the full spectrum of wild plant use in the past, ethnobotanical studies such as this do provide some use case examples to consider in the archaeological record.

Gossypium sp. (wild cotton) was identified at Mutamba, Vryheid, Frampton 1, Evelyn, and Klein Bolayi. Both *G. herbaceum* and *G. arboreum* are known to occur in the wider Limpopo Valley. However, only *G. herbaceum* occurs in the Soutpansberg around Mutamba and is therefore the likely species at that site (Mostert, 2006; Mostert et al., 2008, 2009). *Gossypium* sp., belonging to the Malvaceae family, thrives in tropical and subtropical environments and is often found in savanna, scrubland, and forest edge habitats (Koekemoer et al., 2015). In the past, fibers from *Gossypium* sp. were processed into cloth (Davison & Harries, 1980; Du Toit, 1968; Van Warmelo, 1940)—attested archaeologically by the presence of ceramic spindle whorls (Antonites, 2019a; Huffman, 1971). The presence of *Gossypium* sp. at sites serves as an additional line of evidence for the widespread occurrence of spinning in the MIA. Spindle whorls were found at all the study sites except Klein Bolayi (Antonites, 2019a; Lippert, 2019), but the presence of *Gossypium* sp. suggests that fiber spinning may indeed have taken place here. This is supported by the observation that, other than spinning, none of the ethnobotanical studies in the region recorded additional uses of *Gossypium* sp. (e.g., Magwede et al., 2019).

Grewia species were identified at Mutamba, Vryheid, Evelyn, and Klein Bolayi and was also one of the species identified by early researchers at Mapungubwe (Pole-Evens, 1937). Depending on the species, these plants are either shrubs or small trees (Koekemoer et al., 2015). Several *Grewia* species occur in the study area. Contemporary studies have recorded 19 *Grewia* taxa in the Soutpansberg region (Hahn, 2006) and nine within the Maremani Nature Reserve (Van Rooyen, 2002). These plants typically flower in spring and summer, occasionally extending into winter, with fruiting occurring from summer through winter (Coates Palgrave, 2002). The fruit is generally spherical, containing bilobed seeds. Ethnographic records suggest that *Grewia* fruits are edible, while other parts of the plant have diverse practical and medicinal uses (Mabogo, 1990; Magwede et al., 2019; Coates Palgrave, 2002; Rankoana, 2022).

Z. zeyheriana/Ziziphus sp. belongs to the Rhamnaceae family and was identified at Mutamba, Evelyn, and Klein Bolayi. The plant thrives in various habitats, including open woodlands and grasslands, and often grows on termite mounds (Coates Palgrave, 2002). The fruit of this species is spherical, featuring a thin layer of dry, meal-like pulp around the seed. Although edible, today it is generally considered unpalatable and is primarily used for its magico-medical uses, fuel, construction, and craftwork (Mabogo, 1990; Magwede et al., 2019).

Chenopodium sp. was identified at Vryheid, Frampton 1, Frampton 2, and Evelyn. Although generally regarded as an agriculturally associated weed, it is also recognized as a naturally occurring wild plant found in many arable fields in South Africa (Van Wyk & Gericke, 2018). Its competitive advantage lies in its early emergence, rapid growth, and prolific seed production and seeds that remain viable for extended periods. These traits allow it to outcompete many crop plants. Several *Chenopodium* varieties grow in South Africa, including *C. thunbergii*, *C. paniculatus*, and *C. spinosus*. However, *C. album* is the most recognized and widely used species in the regions where these sites are located (Koekemoer et al., 2015; Quin, 1959). Young leaves are frequently boiled and consumed as a spinach-like vegetable, either on their own or mixed with other greens. Beyond its culinary uses, some *Chenopodium* sp. also have diverse medicinal applications (Mabogo, 1990; Quin, 1959; Van Wyk & Gericke, 2018).

Vachellia/Senegalia sp. was identified at Mutamba, Vryheid, Frampton 2, Evelyn, and Klein Bolayi. The trees grow in various climates such as scrub, wooded grasslands, open bush, dunes, and woodlands (Coates Palgrave, 2002). In addition to fuel, different species have several recorded uses ranging from wood for fencing and construction material to magical and medicinal uses (Mabogo, 1990; Magwede et al., 2019).

Seeds of *A. digitata* were identified at Mutamba, Evelyn, and Klein Bolayi. This is a comparatively short but distortedly fat tree of 10 to 15 m in height, which grows in low altitude areas in dry hot woodlands and produces a hard woody shelled indehiscent fruit roughly 12 cm in length. The fruit contains a brittle and crumbly white pulp and kidney-shaped seeds, and both the powdery pulp and seeds are edible (Magwede et al., 2019; Coates Palgrave, 2002; Quin, 1959; Van Wyk & Gericke, 2018). The seeds are nutritious and can be roasted and eaten as nuts. The pulp is used as a condiment and made into a beverage or powdered. Historically, the bark was used as a source of fiber for cordage, beer sieves, fiber, floor mats, bags, and snares, while medicinal uses have also been documented (Mabogo, 1990; Magwede et al., 2019).

S. birrea was identified at all six sites. It is a medium-sized tree of 7–17 m that fruits from mid to late summer and grows across large portions of northeast South Africa (Coates Palgrave, 2002; Van Wyk & Gericke, 2018). The fruits are a fleshy drupe covering a hard woody stone containing two or three nuts (Coates Palgrave, 2002). This taxon counts among the most highly valued indigenous trees as the richly scented fruit is made into a popular beverage, in both alcoholic and non-alcoholic varieties (Krige, 1937; Mabogo, 1990; Van Wyk & Gericke, 2018). The nuts are also eaten, and the bark is known to have medicinal applications (Magwede et al., 2019; Van Wyk & Gericke, 2018).

Citrullus sp., which is part of the Cucurbitaceae family, was identified only at Frampton 1. Many important food plants are found in this family, including pumpkin, melon, watermelon, gourds, and cucumber. However, the exact species found at Frampton 1 is unknown, but two species are frequently mentioned in ethnographic literature: *C. lanatus* and *Lagenaria vulgaris* (refer to Antonites et al., 2024). The primary use for the former is culinary. The leaves can be eaten as a potherb, the pulp is eaten in porridge, and the seeds are used as a relish. The plant is also considered to be a good stock feed (Quin, 1959). *L. vulgaris* serves the dual purpose of food and being used as a container (Van Wyk & Gericke, 2018).

Possible *S. retroflexum* was present only at Frampton 1. It is a widespread endemic drought-tolerant species and is often found growing in natural veld areas and on disturbed soils (Koekemoer et al., 2015; Sivakumar et al., 2020). It is a short-growing perennial herbaceous plant which produces small black berries. The species is a popular leafy vegetable eaten as a potherb but is not usually consumed fresh as it is considered too bitter (Maanda & Bhat, 2010). Some medicinal uses have also been documented (Mokganya & Tshisikhawe, 2019).

B. deflexa and *B. nigropedata* are grasses, and these were identified at Mutamba (Steyn & Antonites, 2019). *B. deflexa* grows in the area surrounding the site, as well as in other parts of the Soutpansberg. Today, *B. nigropedata* does not grow in the site's immediate vicinity but is found on the highest crests and plateaus of the Soutpansberg Mountain (Mostert, 2006). This grass usually favors undisturbed veld and loamy or sandy soils and can grow in an assortment of environments (Fish et al., 2015; van Oudtshoorn, 2012). The seeds could reflect the use of grass as fuel, tinder, or building materials (e.g., thatching or as a binder in plaster). Alternatively, the seeds could have been introduced via animal dung or as windblown scatter, in which case they would reflect the background vegetation of the site.

Cyperaceae, or the sedge family, includes annuals and perennials and was only identified at Klein Bolayi. Cyperaceae sedges tend to grow along water courses, although some species prefer the shallow, poor soils found on hilltops (Gordon-Gray et al., 2009). The small, lightweight, one-seeded fruit is generally referred to as achene, or sometimes as a nutlet, and is often distributed by wind and birds, which can account for the taxon's presence at the site. Depending on the species, the plant is utilized for food and for weaving (Magwede et al., 2019; Van Wyk & Gericke, 2018). The sedges likely originate from water bodies close to Klein Bolayi such as the Soutsloot and Limpopo. *Cyperus* species are traditionally widely used for making sitting and sleeping mats as well as hand brooms (Van Wyk & Gericke, (2018)).

Conclusion

The analysis of the macrobotanical remains across the six MIA sites in this paper indicates a diverse representation of both cultivated and wild species during the thirteenth century AD. At sites with good preservation (e.g., Mutamba), domesticated plant remains far exceed those of wild plants. The core crop package of pearl millet, sorghum, and cowpea was generally consistent across the region. However, there are some indications of regional variations, such as the utilization of locally available wild plants, the adoption of crops like mung beans, and finger millet in areas with higher rainfall. Mutamba and Evelyn demonstrate the most extensive agricultural evidence, with evidence of up to five different crop species cultivated through both dryland and possibly floodplain agriculture—although this relies on indirect evidence at present. This pattern suggests an adaptive strategy to optimize crop yields in arid conditions, consistent with modern studies of sorghum and millet cultivation in similar environments (Biagetti et al., 2021).

Frampton 1 and Frampton 2 present a divergence in the regional pattern, showing limited evidence of agriculture despite granaries and grinding stones at the sites. These sites are also the smallest and are regarded as short-term or seasonal settlements (Antonites & Ashley, 2016; Antonites et al., 2016). This diversity in agricultural intensity and strategies across sites underscores a flexible and localized approach to resource management, likely shaped by environmental constraints and community needs (Ekblom, 2012; cf. Manyanga, 2001, 2018).

This complements existing research in the wider region that has highlighted community adaptation to environmental risks in marginal environments such as the Limpopo Valley. In nearby southern Zimbabwe, Nyamushosho and colleagues (2018) have found that these strategies include adaptive practices such as varying between different soil types depending on the timing of rains, water management, such as water harvesting and exploiting flood plains, and social acts such as rain petitioning—and it is likely that these were implemented in the study area as well.

Despite challenges like poor preservation, this study highlights the urgent need for more archaeobotanical research across the MIA political and economic spectrum, and from sites located in various environmental mosaics. Ultimately, this endeavor will provide a more complete picture of agricultural practices during the development, height, and decline of Mapungubwe.

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Author Contribution Bianca Steyn conducted the flotation analysis, identified macrobotanical remains, and compiled the quantitative data. She led the writing of the initial manuscript draft and was responsible for the interpretation of botanical results. Alexander Antonites supervised the archaeological fieldwork, provided regional and cultural context, and contributed to the interpretation of archaeological and environmental data. He coordinated the integration of archaeobotanical and archaeological findings, was a main contributor to the discussion section, and critically revised the manuscript for intellectual content.

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Data Availability The datasets generated and analyzed during the current study are curated by the Department of Anthropology and Archaeology, University of Pretoria and consent for publication is available from the corresponding author on reasonable request.

Code Availability Not applicable.

Declarations

Ethics Approval The research was conducted in an ethical manner and all relevant permissions were obtained from the University of Pretoria, Department of Anthropology and Archaeology, to study the material included in this research. No human or animal subjects formed part of this study. This material is the authors' own original work, which has not been previously published elsewhere. It reflects the authors' own research and analysis in a truthful and complete manner.

Competing interests The authors declare no competing interests.

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