Taphonomy and foraging behavior at SM1, a late Middle Stone Age site in NW Ethiopia

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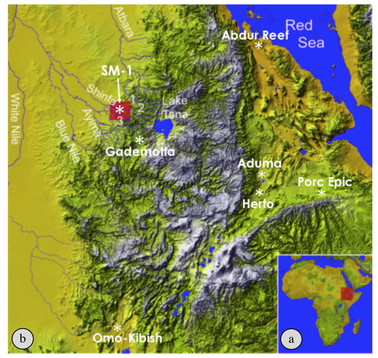
Introduction

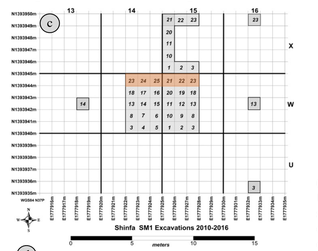
Excavations at SM1, a late MSA site (>50 ka) in NW Ethiopia, reveal stratified, open-air occupations with abundant chipped stone artifacts and faunal remains. SM1 is unusual for the MSA because the fauna include both terrestrial and abundant aquatic taxa. Taphonomic analyses suggest that fauna are largely human-collected, but also reveal a complex postdepositional history for the site. Faunal analyses indicate that MSA humans at SM1 focused hunting and foraging activities on smaller terrestrial mammals and birds, and also exploited fish and mollusks. This combination of riverine resource use and a restricted body-size focus may represent a seasonal facet of foraging behavior at SM1.

SM1

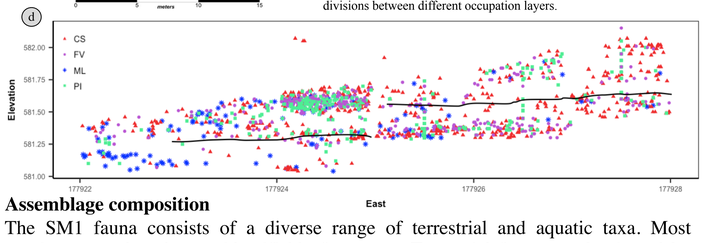
SM1 is located along the Shinfa River, a trunk tributary of the Blue Nile, in NW Ethiopia. Dating work is ongoing, but currently the best estimates derive from AMS ^{14}C dates on ostrich eggshell, which indicate that the oldest occupation layers are >50 ka.

Seven seasons of excavation have exposed 58 m^2, and document a rich record of MSA habitation that includes thousands of *in-situ* lithics and faunal remains. Fauna and artifacts are closely associated throughout the site, and the vertical distribution of material suggests multiple seasons of occupation.





(a & b) Map showing SM1 and other MSA sites in the Horn of Africa. (c) Excavation plan map of SM1 2010-2016 excavations, with units in cross-section highlighted in orange. (d) Partial cross-section of main excavation block at SM1 with black lines indicating stratigraphic divisions between different occupation layers.



Assemblage composition

The SM1 fauna consists of a diverse range of terrestrial and aquatic taxa. Most specimens are largely non-identifiable fragments. Terrestrial fauna are dominated by small/medium-sized animals, with birds and bovids accounting for 89% of those identified to taxon. Aquatic fauna are primarily catfish, with *Clarias* and *Synodontis* being the most abundant. Although body size estimates are not yet available, comparisons with modern fish suggest fossil fish range in size from a few centimeters to a meter or more in total length.

Terrestrial and aquatic taxa at SM1

cf. *Gazella granti*	Grant's gazelle
Antilopini size 1	Gazelle
cf. Reduncini size 2	Reduncine bovid
Phacochoerus sp.	Warthog
Carnivore size 1	Small carnivore
cf. *Cercopithecus*	Vervet monkey
Leporidae	Rabbit/hare
Hystrix sp.	Porcupine
Muridae	Gerbil
Numida meleagris	Guinea fowl
Struthio camelus	Ostrich
Serpentes	Snake
Squamata	Lizard
Crocodylus cf. *niloticus*	Nile crocodile
Anura	Frog
Bagrus docmak	Silver catfish
Clarias gariepinus	Sharptooth catfish
Heterobranchus longfilis	Vundu
Auchenoglanis biscutatus	Giraffe catfish
Synodontis schall/serratus	Wahrindi/Squeaker
Schilbe intermedius	Butter catfish
Labeo cf. *forskalii*	Carp
Etheria elliptica	Nile bivalve

Faunal remains from SM1: (a) Warthog molar, (b) small bovid mandible, (c) bird tibiotarsus, (d) *Clarias* and *Synodontis* pectoral spines, (e) *Bagrus* hyoid, (f) large *Clarias* mandible.

Terrestrial fauna skeletal element abundance

Element	AM	AV	BV	FV	LP	PR	RO	RP	SU	Total
Cranium/Horn core			0/12	1						**1/12**
Maxilla/Mandible			0/11	0/5	1/0		0/3			**1/19**
Tooth/Fragment			10/15	2/237		1/0	4/0		1/0	**18/252**
Scapula/Coracoid		0/6		5/0						**5/6**
Vertebra/Rib				23/34				2		**59**
Pelvis	2									**2**
Humerus/Femur		2/1	1/8	5/4		1/0	4/1			**13/14**
Radius/Ulna	5/0	0/3	1/1	0/1		1/0		1/0		**8/5**
Tibia		5	1	3						**10**
Metapodial/Phalanx		1/7	15/36	8/21				0/1		**24/65**
Compact bones			13	11			1			**25**
Long bone		111		1287			1			**1399**
Non-ID bone				1806*						**1806***
NISP	**7**	**138**	**124**	**1386**	**1**	**3**	**14**	**4**	**1**	**2019**
MNI	**3**	**5**	**5**	**-**	**1**	**1**	**2**	**2**	**1**	**21**

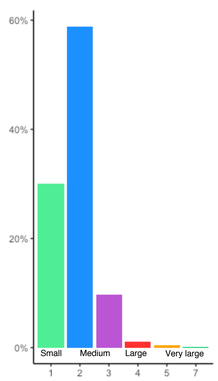
AM = amphibian; AV = bird; BV = bovid; FV = non-ID vert.; LP = leporid; PR = primate; RO = rodent; RP = reptile; SU = suid; *Not included in NISP

Fish element abundance

Element	NISP
Branchiostegal	31
Cleithrum	17
Fin/Rib	46/30
Hyoid/Urohyal	18/4
Mandible/Palatine	67/16
Neurocranium	60
Opercle	10
Spine	246
Suspensorium	26
Vertebra/Hypural	260/5
Headplate frag.	829
Non-ID bone	669
Total	**2434**

Fish taxonomic abundance

Genus	NISP	MNI
Auchenoglanis	2	1
Bagrus	17	5
Clarias	129	25
Heterobranchus	1	1
Labeo	1	1
Schilbe	7	4
Synodontis	30	10
Total	**188**	**43**



Body size class frequencies (%) based on long bone cortical thickness as a proxy for body size. Small = ~4.5-19 kg; Medium = ~18-299 kg; Large = ~367 – 900 kg; Very large = 900+ kg

The current study

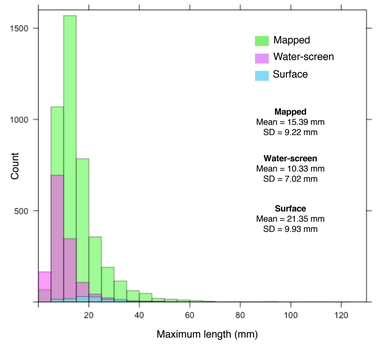
The goal of this study is to evaluate the role of humans and non-human agents/processes in the history of site formation at SM1. The faunal sample includes material collected over six field seasons from 2002-2016 that were classified and measured. Three classes of taphonomic data useful for identifying agents/processes of site formation were collected: fragmentation, surface modification, and postdepositional processes.

Provenience of faunal sample

Provenience	n	% total
Mapped	4455	72
Water-screen	1597	26
Surface	1561	2
Total	**6176**	

Taphonomic results

The SM1 fauna is heavily fragmented, with a preponderance of small fragments and limb bone samples that are dominated by shaft fragments with less than half of the original circumference of the shaft preserved. Fracture morphology patterns are generally similar to other MSA sites, and fractures with features indicative of fresh breaks (*i.e.,* oblique angles, curved/V-shaped outlines) are most common. However, frequencies of transverse outlines, which are characteristic of dry breaks, are also rather high at SM1.



Raw frequencies (#) of limb portion preserved and shaft completeness

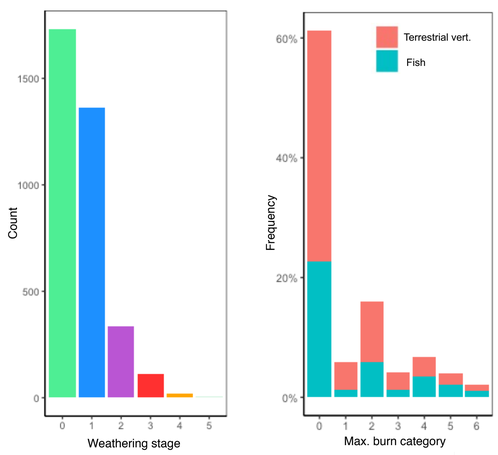
	Max. circumference of shaft			
Limb bone portion	**<50%**	**>50%**	**Complete**	**Total**
Epiphysis	6	2	11	**19**
Near epiphysis shaft	80	1	4	**85**
Shaft	1086	13	40	**1139**
Total	**1172**	**16**	**55**	**1243**

Fracture angle and outline frequencies (%) for SM1 and comparative MSA sites

Fracture angle	SM1	DK10	DK11	PE	BCM1	BCM2	BCM3	PP1*	PP2*	PP3*
oblique	**66.7**	71.8	74.2	96.0	69.3	63.7	81.1	75.0	77.3	76.3
right	**29.7**	18.0	20.0	3.7	27.2	33.5	17.2	23.6	20.2	21.0
oblique/right	**3.6**	10.2	5.7	0.3	3.5	2.8	1.7	1.4	2.5	2.7
Fracture outline										
curved/V-shaped	**40.5**	72.8	79.7	95.4	73.8	71.0	81.2	77.5	77.5	77.1
transverse	**36.1**	19.8	15.5	4.2	22.0	26.2	16.0	20.4	20.2	20.4
transverse/curved	**0.5**	1.7	1.3	>.1	3.2	2.5	2.4	1.4	2.1	2.1
intermediate	**22.9**	5.7	3.5	-	1.0	0.3	0.4	0.7	0.2	0.4

DK = Die Kelders 10/11; PE = Porc Epic; BC = Blombos Cave M1/M2/M3; PP = Pinnacle Point 1/2/3
*Pinnacle Point levels dating from 91-102 ka; shorthand unit numbers from Thompson (2009)

Less than 15% of specimens are weathered beyond Behrensmeyer's (1978) Stage 2, and other damage that can weaken bone and obscure cortical surfaces is also minimal. Most bones are unburned or locally-to-moderately carbonized, but it is worth noting that calcination occurs on both terrestrial fauna and fish. Finally, overall frequencies of both human cut/percussion and carnivore tooth marks are low, although human modification is only slightly more common. It is likely that the low observed frequencies of human and carnivore modification are due in part to the highly fragmented nature of the assemblage.



Frequencies (%) of postdepositional damage extent

	Extent of surface damage			
Damage type	**None**	**>50%**	**<50%**	**100%**
Dendritic etching	99	1	0	0
Exfoliation	86	12	2	0
Sheen	87	10	2	1
Smoothing	97	2	1	0

Frequencies of human and carnivore modification

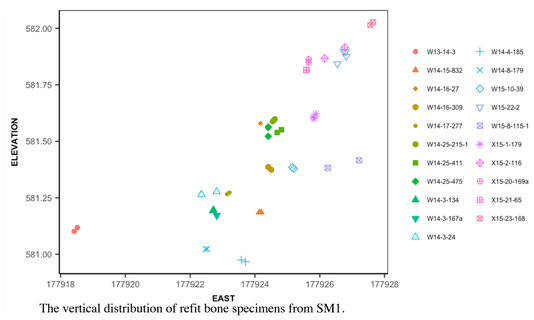
	# marks			% specimens		
Mark type	**HC**	**MC**	**Total**	**HC**	**MC**	**Total**
Cut mark	196	213	**409**	1.2	2.0	**3.2**
Percussion mark	32	67	**125**	0.7	1.4	**2.1**
Percussion notch	8	18	**24**	0.2	0.4	**0.6**
Total human mod.	***236***	***298***	***534***	***2.1***	***3.7***	***5.9***
Tooth mark	202	227	**429**	1.3	1.9	**3.3**
Tooth notch	31	68	**99**	0.5	1.1	**1.6**
Total carn. mod.	***233***	***295***	***528***	***1.8***	***3.0***	***4.9***

HC = high confidence marks; MC = medium confidence marks

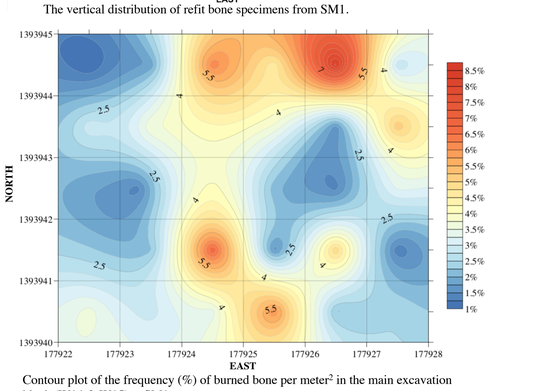
Human activity

Abundant chipped stone artifacts and flakes speak to human occupation of SM1 during the late MSA and the presence of cut/percussion marks on bones document human processing of faunal remains. The close spatial association of archaeological and faunal remains also suggests that these materials were deposited around the same time, and refit studies showing minimal movement of objects within the soil column support this conclusion.

Coupled with other evidence of human activity, the high frequency of fractures with green breaks suggests that many bones were broken by humans for marrow removal. Moreover, the fact that 9% of terrestrial vertebrate bones and 17% of fish bones are calcined suggests that humans were involved in burning bones, since natural fires typically do not get hot enough to cause calcination. Additionally, the spatial distribution of burned material suggests the presence of discrete clusters of thermally altered bone and chipped stone, which likely represent ancient hearth areas.



The vertical distribution of refit bone specimens from SM1.



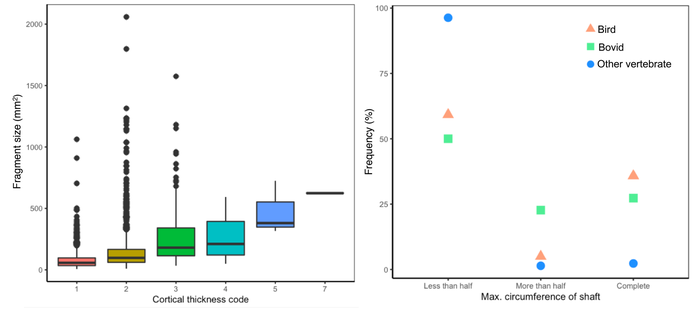
Contour plot of the frequency (%) of burned bone per meter^2 in the main excavation block (W14 & W15) at SM1.

Carnivores

The presence of tooth marks and notches on bones from SM1 attests to carnivore involvement in site formation or subsequent modification, and the lack of long bone epiphyses is also a potential indicator of carnivore activity. However, tooth marks are relatively rare, and evidence for other types of damage caused by carnivore consumption and digestion of bones (*e.g.,* sheen, gastric etching) and/or carnivore activity in general (*e.g.,* coprolites) is essentially non-existent. Furthermore, small compact bones, which are often swallowed whole by carnivores, are well-represented in the faunal assemblage, and account for 28% of almost/complete specimens at SM1.

Postdepositional attrition

The high frequency of transverse fracture outlines suggest a potentially significant amount of non-nutritive bone fragmentation at SM1. The predominance of smaller animals with thin cortical bone also raises the possibility that extensive fragmentation is partly natural. However, the relatively high representation of "low-survival" elements (*e.g.,* mandibles, vertebrae, ribs) and the lack of significant correlation between fragment size and cortical thickness (r = .18) indicate that bone fragmentation is not simply due to postdepositional attrition. The fact that bird bones, which have very thin cortical bone, retain complete shafts at higher rates than other fauna, and the recovery of numerous almost/complete microfaunal elements, further support these findings.



Agents of site formation

Taphonomic analyses document that carnivores played a limited role in assemblage formation/modification at SM1, and suggest a non-trivial amount of postdepositional bone destruction. Nonetheless, these analyses clearly indicate that humans were the primary agent of faunal accumulation and modification at SM1. As such, important aspects of the assemblage, including the taxonomic composition, spatial distribution of bones, and patterns of fragmentation and thermal alteration, are all likely to be largely the product of MSA human behavior.

MSA foraging behavior and ecology at SM1

Faunal analyses suggest that MSA humans at SM1 focused their hunting and foraging activities on small/medium-sized terrestrial animals, and regularly exploited fish and mollusks, making it one of only a handful of sites older than ~25 ka where systematic riverine resource use is well-documented. Additionally, the presence of aquatic fauna offers potentially important insight into the foraging ecology of the SM1 people.

The Shinfa River in the middle of the dry season.

The modern Shinfa River is a typical "temporary" river, with rapid, bank-full flows during the wet season that make aquatic foraging impractical. Conversely, during the dry season, the river is reduced to a series of increasingly disconnected waterholes that local populations visit regularly to catch fish and mollusks, and hunt terrestrial mammals that visit to drink. Stable isotope analyses indicate that climates were similar in the MSA, with possibly even more pronounced seasonal shifts in rainfall and river flow (*e.g.,* Nachman et al. 2015).

Given the similarity of ancient and modern environments, and the abundant fish and mollusks that are unlikely to have been regularly collected in the wet season, we hypothesize that SM1 was primarily occupied during the dry season. Thus, the combination of riverine resources and a restricted body size focus for terrestrial fauna may represent a seasonal facet of foraging strategies at SM1, in which dry season foraging centered heavily on exploitation of localized concentrations of fish and mollusks in isolated waterholes and populations moved away from the river and relied more heavily on terrestrial game during the wet season. Future research will focus on documenting seasonal resource use and occupation at SM1 in order to better understand how temporary river ecosystems in highly seasonal environments may have shaped important aspects of MSA foraging behavior at SM1 and other sites in similar settings.

Acknowledgments

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