Foraging along Blue Highways

Preliminary faunal and taphonomic investigations at SM-1, a Middle Stone Age site in northwestern Ethiopia

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Introduction

SM-1 is a late MSA (>50 Ka) open-air site in Ethiopia that documents exploitation of riverine resources and suggests structured seasonal occupation and resource use. Both of these behaviors have important implications for the evolution of human adaptive strategies and social organization, and both have been argued to be rare or absent in the MSA. Ongoing excavations at SM-1 have produced a rich MSA record consisting of thousands of chipped stone artifacts and faunal remains. The faunal assemblage includes terrestrial mammals, birds, and reptiles, as well as fish and mollusks. Taphonomic analysis of a subset of the vertebrate fauna (n=748) documents good bone surface preservation and minimal weathering. High proportions of oblique fracture angles and curved/V-shaped fracture outlines suggest most bones were broken while fresh. Frequencies of human cut/percussion marks and carnivore toothmarks are both low, but human-induced damage is slightly more common and, notably, probable cutmarks were identified on several fish bones. These preliminary taphonomic data support the hypothesis that MSA humans were a primary agent of faunal accumulation and modification at SM-1, including terrestrial and aquatic fauna.

SM-1

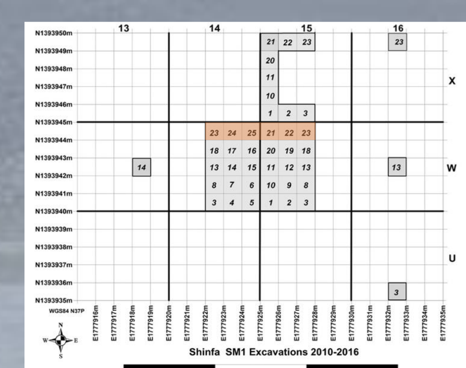
SM-1 is located along the Shinfa River, a trunk tributary of the Blue Nile, in the lowlands of NW Ethiopia. Currently, the most reliable age estimates come from AMS ^{14}C dates on ostrich eggshell, which indicate the oldest levels were occupied >50 ka. Dating work is ongoing, and the current approach combines U-series, AAR, and AMS ^{14}C techniques on OES fragments large enough for 3-way splits, in order to assess agreement and systematic errors, if any exist, so that U-series and AAR may be more confidently applied to the carbon infinite period (*e.g.*, Valdes et al. 2017).

Dating methods and age estimates

Method	Material	Age (ka)
OSL	Feldspar	27-36
ESR EU model	Enamel	39-57
ESR LU model	Enamel	70-103
AMS ^{14}C	*OES*	*27-53 Cal BP*
AAR	OES	Ongoing
U-series	OES	Ongoing

(a & b) Map showing SM-1 and other MSA sites in the Horn of Africa. (c) Enlargement highlighting the Shinfa River and the location of SM-1 within the project area. (d) Excavations at SM-1 during the 2016 field season.

Five seasons of excavation have exposed 43 m², and produced an MSA occupation that includes thousands of closely associated lithics and faunal remains that derive from a sealed context, as well as several thermal features that document hearth areas. The flake-based technology includes prismatic blades, scrapers, and unifacial, bifacial, and Levallois points, all of which are typical MSA.



Plan map of SM-1 excavation. Highlighted units depicted below.


Unifacial, bifacial, and Levallois points from SM-1.

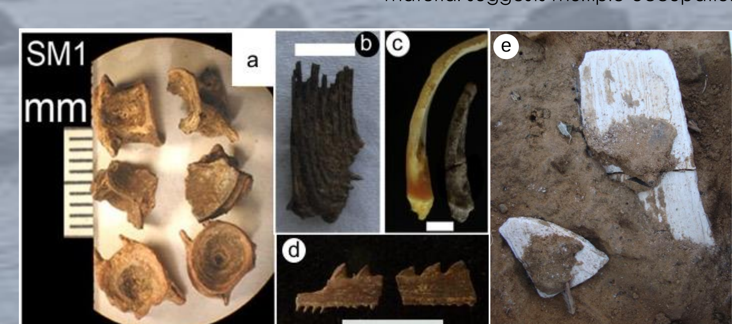
The SM-1 fauna includes diverse terrestrial and aquatic taxa. Of 5940 *in-situ* specimens, 3907 are from terrestrial mammals, birds, and reptiles, with an additional 1609 fish bones and 424 mollusk shell fragments. Additionally, there are many thousands more small fragments of bone and shell recovered through wet-sieving of sediment with 1.6 mm (1/16") mesh screens.

Faunal taxa identified at SM-1

Muridae	Gerbil
Hystrix sp.	Porcupine
Carnivora class 1	Small carnivore
cf. *Cercopithecus*	Vervet monkey
Phacochoerus cf. *africanus*	Warthog
Reduncini class 3/4	Med. reduncine bovid
Antilopini class 1/2	Sm. antilopine bovid
Numida meleagris	Guinea fowl
Struthio camelis	Ostrich
Crocodylus sp.	Crocodile
Squamata	Lizard
Serpentes	Snake
Anura	Frog
Clarias sp.	Catfish
Etheria elliptica	Nile bivalve mollusk

Partial cross-section of SM-1 excavation. Artifacts and faunal remains are closely associated throughout the site, and the spatial distribution of material suggests multiple occupations over a period of 20 ka or more.

Small (size I/II) bovid postcranial elements. (L astragalus, R radius, L femur)



Fish vertebrae (a), fin (b), dentary (c), & spines (d), & mollusk shell fragments (e) from SM-1.


Frog pelvis recovered from water-screened sediments.


Typical water-screened sample with numerous tiny fragments.

The ecological setting

The geomorphology of the modern Shinfa River and marked seasonality of rainfall in the region combine to produce powerful, bank-full flows during a brief and intense wet season. During the long and arid dry season the river is reduced to a series of nearly disconnected waterholes. Local human populations restrict riverine foraging largely to the dry season, when isolated waterholes contain localized concentrations of fish, mollusks, and aquatic reptiles, and are visited by terrestrial mammals daily for drinking water. Stable isotope data from fossil mollusks and bovid tooth enamel indicate similar climatic conditions in the past, and suggest that MSA humans were adapted to comparable hot, arid, and highly seasonal environments (*e.g.*, Nachman et al. 2015; Wyman et al. 2017).


During the dry season, isolated waterholes represent the only surface water and often contain high concentrations of fish, mollusks, and aquatic reptiles.

The current study

The ultimate goal of this project is to document MSA foraging behavior at SM-1 and to determine if the site provides evidence for systematic riverine resource use and/or seasonally-structured foraging in the MSA. As a first step towards that end, the current study presents results of initial faunal and taphonomic analyses from SM-1, aimed at answering three questions:

1. What skeletal elements and taxonomic groups are present and at what frequencies?
2. Are humans the primary agent of faunal accumulation and modification?
3. What are the effects of taphonomic processes that can bias behavioral interpretations?

Materials and methods

Analysis was limited to a subset of the vertebrate fauna (n=748). Four classes of taphonomic data were collected as multiple attribute variables:

1. Weathering (Behrensmeyer, 1978)
2. Thermal alteration (Stiner et al. 1995)
3. Fracture morphology (Villa and Mahieu 1991)
4. Surface modification (*e.g.*, Haynes 1983; Fisher 1995; Blumenschine et al. 1996)

Skeletal element and taxonomic representation

Of the 748 bones analyzed for this study, 635 (85%) could only be classified as belonging to unspecified vertebrates/terrestrial mammals. The other 108 bones (15%) are from bovids (10%), birds (4%), fish (1%), primates (<1%), and a snake (<1%). With respect to terrestrial mammals, some of the most common elements are small, compact bones (*e.g.*, phalanges, tarsals) that are often consumed by carnivores and therefore expected to be rare at carnivore sites. Likewise, several "low-survival" elements (*e.g.*, ribs, vertebrae), which are particularly vulnerable to destruction by post-depositional and/or density-mediated attrition, are also fairly common.

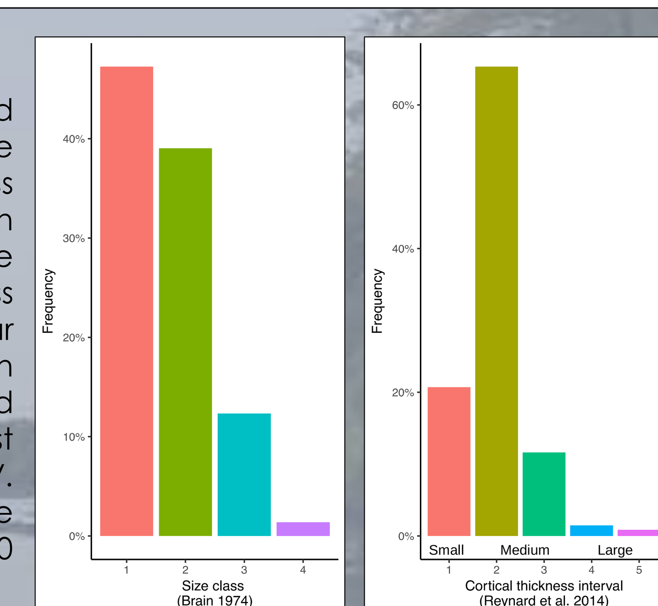
Faunal sample analyzed from SM-1 to date

Element	AV	BV	PR	SN	PI	FV	Total
Astragalus/Calcaneus	-	8/1	-	-	-	0/2	8/3
Horn core	-	9	-	-	-	-	9
Humerus/Femur	2/1	1/6	1/0	-	-	2/3	6/10
Maxilla/Mandible	-	0/7	-	-	1/1	0/1	1/9
Metapodial/Phalanx	1/0	8/30	-	-	-	4/7	13/37
Tooth fragment	-	-	1	-	-	1	2
Pectoral spine	-	-	-	-	3	-	3
Radius/Ulna	0/1	1/1	1/0	-	-	0/1	2/3
Rib/Vertebra	-	-	-	0/1	1/0	18/9	19/10
Scapula	-	-	-	-	-	2	2
Tibia/Tibiotarsus	1	-	-	-	-	2	2/1
Long bone shaft	21	-	-	-	-	471	492
Non-ID fragment	-	-	-	-	4	112	116
NISP/Total	27	72	3	1	10	635	748
MNI	2	5	1	1	3	-	12

AV = bird; BV = bovid; PR = primate; SN = snake; PI = fish; FV = non-ID vertebrate

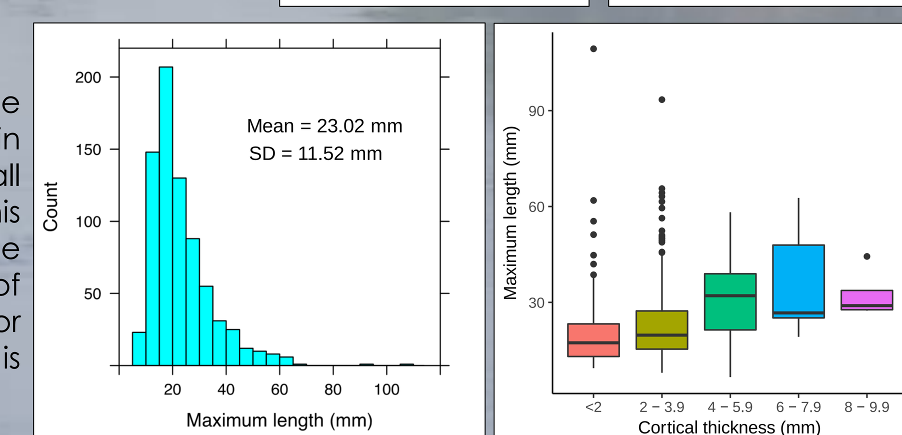
Size class frequencies

Data from the 140 identifiable specimens that could confidently be assigned to a body size class indicate that the SM-1 assemblage is dominated by size class I (*i.e.*, small) and II (*i.e.*, small-medium) animals (in that order), while size class III and IV animals are much less numerous. Analyses of cortical thickness as a proxy for animal body size paint a similar picture. However, in this case, fragments with cortical thickness measurements that correspond roughly to body size class II are by far the most abundant, followed by classes I, III, and IV. Moreover, based solely on cortical thickness, there does appear to be at least one very large (*i.e.*, >900 kg) animal represented in the collection.



Bone fragmentation

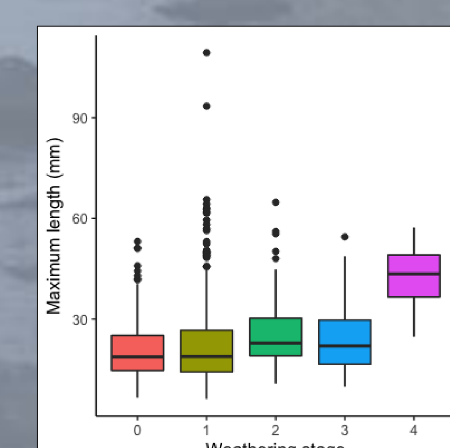
The SM-1 fauna has undergone extensive fragmentation, resulting in an assemblage dominated by small fragments. The extent to which this level of fragmentation is unique among MSA sites, and how much of it is attributable to human behavior and/or non-nutritive destruction, is not yet fully clear.



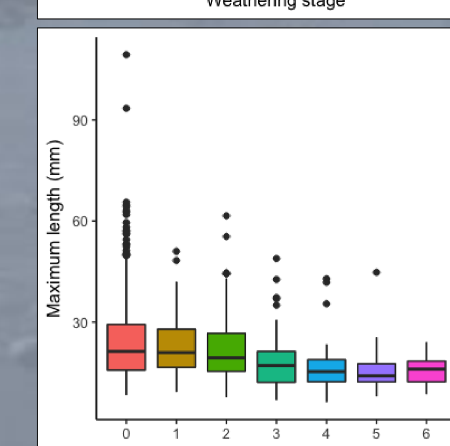
Given the prevalence of smaller animals in the assemblage, it is possible that the high degree of fragmentation is in part simply due to an abundance of relatively small and thin bone that is more susceptible to post-depositional attrition. However, although thicker fragments do tend to be larger on average, the correlation between bone cortical bone thickness and fragment size is not significant (r = .26). This suggests that extensive fragmentation is not merely a product of bone size/thickness and is likely due to human activity and/or other non-nutritive destructive processes.

Weathering and thermal alteration

Overall bone surface preservation is good, and the majority of bones display minimal surface weathering. Additionally, there is little difference in the severity of weathering between smaller and larger bones, although the few bones (n=4) weathered to Stage 4 are larger on average than those that are less weathered. This evidence indicates that the majority of bones were buried relatively rapidly after deposition on the surface, and that burial processes were similar for bones of all sizes.



Most bones are unburned, moderately carbonized, or carbonized, while any degree of calcination is relatively rare. Once again, the intensity of thermal alteration is relatively uniform across bones of all sizes, although there is a slight tendency for bones/fragments that are burned more heavily to be somewhat smaller.



Frequencies (%) of weathering stages and burning categories

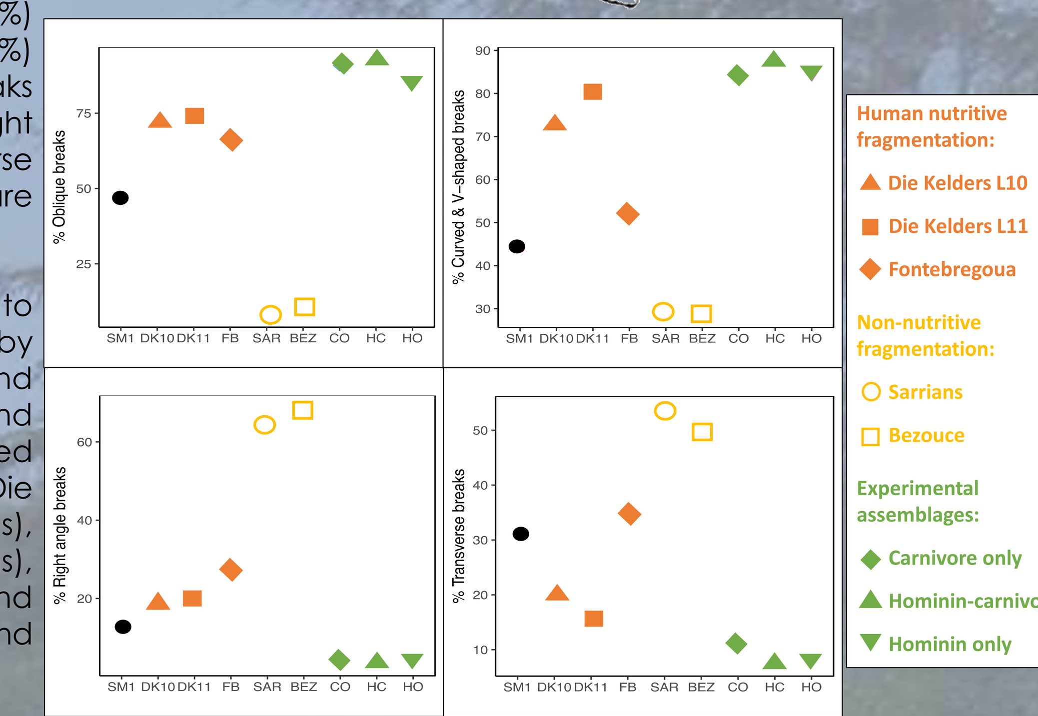
	Weathering stage/Burn category						
	0	**1**	**2**	**3**	**4**	**5**	**6**
Weathering	27	55	13	4	1	0	-
Thermal alteration	59	6	16	10	5	2	2

Weathering stages follow Behrensmeyer (1978). Burn categories: 0 = unburned, 1 = localized carbonization, 2 = moderate carbonization, 3 = carbonized, 4 = localized calcination, 5 = moderate calcination, 6 = calcined.

Fracture angles and outlines

Fractures with oblique angles (47%) and curved/V-shaped outlines (45%) characteristic of green bone breaks are most abundant at SM-1. Right angle breaks (12%) and transverse outlines (29%) typical of dry breaks are much less common.

Fracture data were compared to assemblages simulating fracture by hominins (HO), carnivores (CO), and hominins-then-carnivores (HC), and archaeological sites with inferred agents of fragmentation, including Die Kelders 1 (DK: MSA humans), Fontebregoua (FB: Neolithic humans), Sarrians (SAR: soil compaction), and Bezouce (BEZ: excavators) (Villa and Mahieu 1991; Marean et al. 2000).



Frequencies of oblique angle breaks and curved/V-shaped outlines are lower than all assemblages except SAR and BEZ, but are most similar to FB and, to a lesser extent, DK. SM-1 also has higher proportions of transverse breaks than all assemblages except SAR, BEZ, and FB, although the difference with FB is small (~6%). Conversely, SM-1 has the lowest frequency of right angle breaks of any archaeological site, but they are still higher than experimental assemblages; once again, SM-1 is most similar to DK and FB (in that order). Overall, SM-1 is quite similar to FB and comparable to DK, and is significantly different from all other assemblages. While fracture patterns cannot speak directly to agents of modification, high frequencies of oblique angle breaks and curved/V-shaped outlines on long bone shafts and shaft fragments indicate that most bones were broken while fresh. However, the relatively high frequencies of transverse outlines suggest that post-depositional processes may also have played an important role in assemblage formation that will need to be controlled for in future analyses.

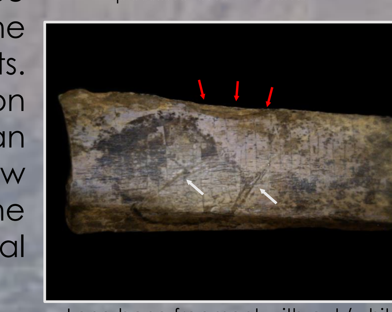
Surface modification

Rodent gnawing (.6%) and geochemical alteration (.8%) are exceedingly rare in the SM-1 assemblage, and root etching was not observed on any specimens analyzed for this study. Frequencies of human cut and percussion marks (6%), and carnivore tooth marks (4%), are also both low, but human-induced damage is somewhat more common, and it is notable that probable cutmarks were identified on several fish bones, including a dentary, three pectoral spines, and a rib.

Bird humerus with cut & possible chew marks.

Primate humerus with cutmarks.

Given the high degree of bone fragmentation at SM-1, it seems likely that the low frequencies of surface modification are due, at least in part, to the fact that the assemblage is dominated by very small fragments. Regardless, the presence of cut and percussion marks on terrestrial, and likely aquatic, fauna documents human involvement in assemblage formation, and low frequencies of carnivore damage are consistent with the hypothesis that humans were the primary agent of faunal accumulation and modification.


Long bone fragment with cut (white arrows) & percussion marks (red arrows)

Fish jaw with probable cutmarks.

Discussion and conclusions

These analyses allow us to draw several preliminary conclusions about the SM-1 faunal assemblage, including that:

1. The assemblage is heavily fragmented, consists largely of small fragments that can only be classified into broad skeletal element and/or taxonomic categories, and is dominated by small-medium sized animals, many of which are likely to be bovids.
2. Weathering and thermal alteration are minimal and fairly uniform across all bones, suggesting that most were buried rapidly (probably by ancient over-bank deposits during seasonal flooding) and that these processes likely did not play a significant role in producing observed patterns of bone modification.
3. Fracture angle and outline frequencies most closely match those observed at other human-produced archaeological sites and indicate that most bones were broken while fresh.
4. Frequencies of human and carnivore damage are low, likely due in part to the small average size of bone fragments. Nonetheless, human damage is more common and the presence of cut and percussion marks documents that humans fragmented and butchered at least some of the bones.

Particularly when coupled with abundant other evidence for repeated human occupation, these data support the hypothesis that MSA humans were a primary agent of faunal accumulation and modification at SM-1. Future research will focus on better understanding the taphonomic history of the site, producing a detailed reconstruction of overall foraging behavior at SM-1, and determining whether or not the site provides evidence for early riverine adaptations and structured seasonal foraging in the MSA

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