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An ethnoarchaeological comparison of observed butchery actions to bone surface modifications of the Dobe !Kung San

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ABSTRACT

The Dobe !Kung were a group of foragers living in northern Botswana in the Kalahari Desert. In the second half of the twentieth century, their butchery actions on animal prey were recorded (1968–1975) and their abandoned camps from 1944–1976 were excavated to retrieve faunal remains from butchered prey animals. Here we test the hypothesis that bone surface modifications on these excavated faunal remains accurately reflect these butchery observations. We find that despite a few exceptions, the observed bone surface modifications follow the expectations derived from observations of butchery of different sized animals. This supports the idea that past butchery actions, based on the location and presence of bone surface modifications on modern bones, can be confidently linked to past butchery behaviours. We also suggest that bone surface modifications can provide information about past hunter-gatherer processing behaviours, cooking styles, and use of hides.

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Ethnoarchaeology; actualism; butchery; bone surface modification; taphonomy

Introduction

Ethnoarchaeological study of butchery actions and resultant traces

Butchery creates bone surface modifications (BSMs) on faunal remains. Marks on bone are often 'accidents' made by a butcher, in that creating BSMs is presumably not the goal of butchery. The frequency and locations of cut marks can vary based on the experience and skill of butchers, butchery action, butchery tool type, and tool raw material (e.g. Domínguez-Rodrigo and Yravedra 2009; Pobiner et al. 2018; Escosteguy 2020). The location of butchery marks on bone are thought to be linked to different butchery actions. For instance, for experimental butchery with larger animals for consumption, skinning and defleshing actions create cut marks, often in clusters (e.g, Merritt 2017). Disarticulation can create cut marks along the epiphyses of bones, but usually results in fewer clusters of cut marks than skinning (Galán and Domínguez-Rodrigo 2013; Merritt 2017). During skinning, phalanges are often disarticulated and cut marked by the cutting implement as a result of removing the feet to complete skinning or releasing the claws from the animal (Cunningham et al. 2008). When experienced taxidermists were tasked with skinning a variety of carnivores, they created the highest number of skinning-related marks on phalanges (Val and Mallye 2013).

Butchery actions and butchery traces have been recorded in many different groups of hunter-gatherers for ethnoarchaeological comparisons (e.g., White 1953; Zierhut 1967; Binford 1978, 1984; O'Connell et al. 1988; O'Connell and Marshall 1989; Bartram et al. 1991; Marshall 1994; Rybczynski 1996; Lupo and O'Connell 2002; Martínez 2007; Pickering et al. 2013). Butchery serves important functions for hunter-gatherers: it creates smaller packages of meat that are easier to transport, it allows the meat to be divided amongst a population, and it divides animals into pieces to fit in pots (O'Connell et al. 1988; O'Connell and Marshall 1989). Butchery techniques used by foragers tend to reflect the culture and the limitations of the group. For example, in West Greenland, Inuit peoples in one town (Kapisillit) break down their prey into comparatively smaller pieces than in a nearby town (Atammik) because they carry their meat by foot rather than boat (Domínguez-Solera 2012).

Butchery traces on bony prey remains left behind by modern foragers are studied by ethnoarchaeologists to compare with butchery traces observed on prey remains at archaeological sites (Yellen 1991a, 1991b; Lupo 1995). Yet studies that directly link ethnographic observations of specific butchery activities to observed butchery traces on bony prey remains are uncommon; exceptions are Binford's (1978) among the Nunamiut and Martínez (2007) among the Nunak. We aim here to test the hypothesis that butchery actions observed during ethnographic studies of the modern !Kung San foragers will result in predictable bone surface modifications resulting from the observed butchery activities. To our knowledge, this is the first study that created predictions for the detailed locations of butchery traces based on observed butchery actions, rather than immediately directly linking butchery traces to observed butchery actions without the intermediate step of creating these predictions. If this hypothesis is supported, it implies that bone surface modifications resulting from butchery activities accurately reflect butchery actions observed during ethnographic studies. This in turn would mean that zooarchaeologists and taphonomists can more confidently link specific butchery traces to specific butchery actions in the past.

!Kung san cultural lifeways and food procurement

The broad 'San' group encompasses many different individual ethnolinguistic groups who speak click languages (Yellen 1990). The San and their ancestors may have been living in southern Africa for at least 77,000 years (Brooks and Yellen 1987) and genetic

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Table 1. Dobe Base Camp (DBC) occupancy timing, duration, and volume of excavation.

DBC ID Number	Year of Occupation (Midpoint)	# of Months of Occupation	# of Squares Excavated
32	1944	3	3
33	1947	6	3
34	1949	4	2
5	1953	4	4
8	1962	1	3
11–29	1963	6	4
12	1964	17	6
14	1965	18	4
15	1967	14	3
16	1967	1	4
17	1968	6	4
18	1968	14	7
19	1970	13	3
20	1970	2	5
27	1971	8	3
28	1972	21	4
22	1973	22	6
23	1974	6	4
26	1975	22	12

Table 2. NISP of taxa represented in the Dobe base camp (DBC) faunal collection. Fauna were identified to the most specific taxonomic level possible; for example, for specimens in 'Bovidae', secure genus and species identifications were not possible.

Taxon	NISP isolated teeth	NISP bones (with butchery marks)	NISP total
Indeterminate	1	17 (0)	18
Mammalia	21	2205 (53)	2226
Giraffa camelopardalis	0	2 (0)	2
Bovidae	139	310 (19)	449
Bos taurus	1	7 (0)	8
Syncerus caffer	1	13 (1)	14
Taurotragus oryx	1	0 (0)	1
Tragelaphus strepsiceros	3	12 (2)	15
cf. *Oryx gazella*	0	2 (0)	2
cf. *Connochaetes taurinus*	0	1 (1)	1
Capra hircus	9	20 (2)	29
Raphicerus campestris	32	28 (5)	60
Raphicerus campestris/Sylvicapra grimmia	0	31 (5)	31
Sylvicapra grimmia	6	3 (0)	9
cf. Equidae	0	1 (0)	1
Phacochoerus africanus	107	67 (9)	174
cf. Suidae	0	1 (0)	1
cf. Carnivora	0	1 (0)	1
Vulpes chama	0	1 (0)	1
Lagomorpha	0	2 (0)	2
Lepus saxatilis	0	38 (0)	38
Pedetes capensis	53	127 (6)	180
Hystrix africaeaustralis	19	30 (3)	49
cf. *Hystrix africaeaustralis*	3	0 (0)	3
Aves	0	24 (0)	24
Testudinae	0	367 (0)	367
cf. Varanidae	0	22 (0)	22

studies indicate they diverged from other modern human groups between 100,000–300,000 years ago (e.g. Veeramah et al. 2012; Kim et al. 2014; Schlebusch et al. 2020). The San previously occupied almost the entirety of southern Africa prior to Dutch colonisation. During this time those San living south of the Orange River "were almost entirely wiped out as a result of a systematic Dutch extermination campaign" (Lee in Lee and DeVore 1998, p. 5). It has been estimated that there were 150,000 to 300,000 San in the 1600s; by the 1970s only around 50,000 San remained due to the combination of genocide and further assimilation with neighbouring Bantu tribes. Around 60% of the remaining San live in Botswana. Previously, the San relied solely on hunting and gathering for subsistence, but at the time of this study, only around five percent of the entire group were reliant on hunting and gathering.

The focus of this study are faunal remains from hunting activities excavated from the Dobe Base Camps (DBC) occupied between 1944–1975 (Yellen 1991a, 1991b; Tables 1 and 2) and related ethnographic observations of butchery actions (Appendix 1) of the San-speaking Ju/'hoansi (which translates to 'real people'). The term '!Kung' has been used preferentially in literature about these peoples as it is the broad term that refers to the entire ethnolinguistic group (Lee 1979; Yellen 1986, 1990, 1991b; Lee and DeVore 1998). The study of the !Kung of the Dobe region of Botswana by the Harvard Kalahari Project team and other affiliated researchers began in 1963 (Brooks and Yellen 1987; Yellen 1990; Lee and DeVore 1998). The Dobe region is an area in the northwest portion of the Kalahari Desert (Lee 1979; Lee and DeVore 1998); the Kalahari is categorised as a shrubby savanna-region with five distinct seasons including spring rains (very dry, October–November), summer rains (December–March), autumn (April), winter (dry, May–August), and early spring (August–September) (Yellen and Lee 1976; Yellen 1977, 1986). There is a dry summer and a cool winter, with the highest temperatures occurring in October. The rainy season usually lasts 3 to 4 months, with the earliest recorded precipitation occurring in October and the latest in May (Yellen 1977).

From 1963 to 1969, 840 people were recognised as Dobe !Kung culturally and linguistically (Lee and DeVore 1998). At this time, Dobe !Kung groups were organised into bands that all searched for food in separate but overlapping areas. In the dry season, bands congregated and established a base camp (DBC) near the Dobe water hole which was marked as those bands' territory. When not in the dry season, bands moved around more without restrictions and rarely stayed in one location. The bands were fluid, with members of the group being able to swap bands freely. Having kinship ties or a child that marries into another band would have also given an individual access to other bands' territories. Sharing was common amongst the !Kung in order to enforce food equity. Hunted animals made up about 40% of the !Kung's daily caloric intake; large hunts were shared outside of a family unit, with the intention to have the favour reciprocated (Lee 1979; Yellen 1990). Larger (size class 3) animals which the !Kung hunted include *Tragelaphus strepsiceros* (greater kudu), *Oryx gazella* (gemsbok) and *Connochaetes taurinus* (blue wildebeest) (Yellen 1986; size classes following; Bunn 1982). Smaller animals (size class 1) include *Raphicerus campestris* (steenbok), *Sylvicapra grimmia* (common duiker), *Hystrix africaeaustralis* (Cape porcupine), and *Pedetes capensis* (springhare). Although the !Kung did not consider themselves small mammal specialists, small mammals contributed substantially to their diets. The !Kung hunted fewer size class 2 animals, with *Phacochoerus africanus* (common warthog) being the major hunted size class 2 species. Yellen (1991) previously reported on the butchery sequence for small mammals at Dobe: steenbok/duiker, porcupine, and springhare. This previous study described the faunal elements that remained after the butchering process and which skeletal elements were complete or fragmentary, but the resulting bone surface modifications (BSMs) were not reported.

In the earlier ethnographic studies of the !Kung, hunting and gathering were the primary form of subsistence, and animal skins were the primary form of clothing. By 1975, many of the !Kung had adopted pastoralist activities such as owning goats and planting gardens, and they were wearing some mass-manufactured clothing rather than animal skins (Yellen 1986). This was reflected in the bones that were excavated from the DBC: very few domesticated animals were represented in the faunal collection of the 1950 DBCs, with an increasing prevalence of goats and cattle into the 1960s and 1970s (Yellen 1990). As the number of hunted large mammals decreased, the number of domesticated large mammals (cows) increased; simultaneously, as the number of hunted small mammals decreased, there was a domesticated replacement for steenbok and duiker (goats), but no direct replacement for the springhare (Yellen 1986).

We hypothesise that the BSMs on the DBC bone collection of both larger and smaller mammals will accurately reflect the ethnographically recorded butchery actions of the !Kung. The DBC bones were buried for up to 30 years at some of the DBCs and the entire animal may not be represented in the record since there were no controls on what faunal remains the !Kung were discarding that subsequently became buried; the preservation of these faunal remains has been outlined in prior literature (Yellen 1991a, 1991b). This limitation may impact the potential of the faunal remains to accurately reflect the ethnographic observations of butchery actions to be compared with the faunal remains, but allows our results to more realistically reflect the archaeological record.

Materials and methods

The Dobe base camp study

Notes on observations of butchery actions of the !Kung were taken predominantly during the 1960s and 1970s by John Yellen, Richard B. Lee, and Irven Devore, who witnessed the !Kung butchering prey animals. The ethnographic notes were a result of the Harvard Kalahari Project, in which a team of anthropologists observed and published on the lives of the !Kung. Butchery action descriptions of both small animals and gemsbok have been published (Lee 1979; Yellen 1991a, 1991b). For this study, Yellen's unpublished notes were converted into digital records for analysis (Appendix 1). Yellen took ethnographic notes for butchery of animals of different species and size classes, with some butchery actions pertaining to all animals of a certain size class. While these notes contain information on the butchery of internal organs and soft tissues of animals, these parts of his notes were omitted from this study to focus solely on the butchery actions that could likely result in BSMs. Predictions of the locations of bone surface modifications were made based on these notes and then compared to the DBC bone collection (Table 3).

Bones were collected by John Yellen in 1975 and 1976 from a total of 19 camps that were inhabited sometime between 1944 and 1975 (Yellen 1986). These 19 camps were inhabited during the dry seasons and known in the published literature as the 'Dobe Base Camp series'. There was another set of 'rainy season camps' that were excavated between 1968 and 1969, but those faunal remains were lost (Yellen 1977, 1986). Animals were thought to have been butchered in the same way during both the rainy season and dry season (Yellen, pers. comm.). Yellen initiated this study with excavations of recent camps, and then subsequently asked whether members of his team could be taken to locations where they remembered living and butchering animals further back in the past. A !Kung informant, Kopela Maswe, was responsible for directing the anthropologists to the abandoned camps and providing the locations where the hearths associated with each house were. Maswe and others also provided what turned out to be quite accurate accounts of what animals were caught and eaten at each hearth. Each hearth included the remains from the butchery of a single prey animal. Excavations occurred at these camps and each camp, hearth, and level of the excavation were given a number so the remains could be grouped by locality. Hearths were excavated in 2 centimetre (cm) levels and sieved through ¼ inch mesh sieves. Dobe !Kung helped with the analysis of the faunal species based on their memory of the occupation at the camp (Yellen, 1991). The bones were buried for a length of time between 1 and 32 years, which was enough time to show signs of root marking and weathering on some of them. The camps that were represented in the faunal collection were Camps 12, 18, 20, 23, 28, and 34. Camp 34 was occupied in 1949 for 4 months, Camp 12 was occupied in 1964 for 17 months, Camp 18 was occupied in 1968 for 14 months, Camp 20 was occupied in 1970 for 2 months, and Camp 23 was occupied in 1974 for 6 months (Table 1 in Yellen 1986). The faunal remains are labelled first with this camp number; then with the number of the hearth that was being excavated which Yellen (1986) writes as 'number of squares excavated'; then with the level of the excavation, with each level equating to 2 cm in depth; and finally, a faunal specimen number (e.g. 12.1.3.79) (Table 1).

Taphonomic data collection

Taphonomic data collection on the excavated fauna began in 2008 by Tyler Faith and was completed in 2021 by Suzanne Kunitz with assistance from Briana Pobiner. Information recorded from each bone included specimen number, taxon, animal size class, skeletal element, bone portion, side of the body, age of the animal, and any BSMs present – including cut marks, tooth marks, percussion marks, and charring from being burned. BSMs were found by studying each bone with a 10× hand lens under a high incident light, following the protocols in Blumenschine et al. (1996).

The DBC faunal collection consists of 3,734 total bones (Appendix 2). A total of 806 (21.6%) of those bones displayed some form of BSMs including charring, and 123 (3.3%) had either cut marks, tooth marks, or percussion marks (Tables 2, 3). Of the 123 bones with BSMs, 53 were identifiable to taxon and skeletal element. Because there was no ethnographic data for butchery of goats or Size 2 bovids, those remains were not considered in this study and omitted from the set of 53 bones, resulting in a total of 41 bones with BSMs which were used for the present study, described in Table 3.

Ethnographic observations of butchery actions and predicted resultant butchery marks

The following section draws on relevant examples of Yellen's ethnographic observations of butchery among the !Kung San (a full transcription of his field notes are in Appendix 1) and outlines specific predictions of butchery marks resulting from those butchery behaviours (summarised in Table 4).

Size 3: Kudu, Gemsbok, and Wildebeest

Kudu, gemsbok, and wildebeest are all size 3 bovids hunted by the !Kung. The butchering of a gemsbok was described by Lee (1979) in minimal detail, but the butchering of kudu and wildebeest was described in great detail by Yellen, and the rest of the butchering process is similar for all three species with only one deviation in the kudu butchery practice. Wildebeest and gemsbok radius epiphyses were split to access the marrow, but kudu radius epiphyses were not because 'there is no food in the heads of the kudu radius' (Lee 1979; Appendix 1).

Table 3. List of specimens with bone surface modifications from the DBC faunal collection. Assumed butcher action that is likely to have produced each mark is listed; these assumptions are based on the experimental butchery studies cited in the text. Size classes are following Bunn (1982).

Specimen #	Taxon	Size	Skeletal Element	Side	Age	Cut Marks?	Percussion Marks?	Charring?	# of Cut Marks	Location of Marks	Mark Types(s)	Assumed Butcher Action
12.1.1.3	Kudu	3	1st Phalanx	Left	Adult	Yes	No	No	2	Proximal	Cut	Disarticulation
18.2.1.90	Kudu	3	1st Phalanx	Right	Adult	No	Yes	No	2	1 each side of shaft	Percussions	Marrow Extraction
18.2.1.57	Kudu/ Wildebeest/ Gemsbok	3	Calcaneus	Right	Indet	Yes	No	No	6	Posterior Aspect	Cut and Scrape	Disarticulation and Defleshing/ Skinning
18.4.3.1	Kudu/ Wildebeest/ Gemsbok	3	Cervical vertebra	N/A	Indet	Yes	No	No	2	Caudal Aspect	Cut/Hack	Separation for Carrying Packages
28.1.2.5	Kudu/ Wildebeest/ Gemsbok	3	Rib	Indet	Indet	Yes	No	No	1	Shaft	Cut/Hack	Marrow Extraction
18.2.1.11	Kudu/ Wildebeest/ Gemsbok	3	Rib	Indet	Indet	Yes	No	No	1	Caudal Aspect	Cut	Disarticulation
12.1.3.79	Kudu/ Wildebeest/ Gemsbok	3	Tibia	Right	Indet	Yes	No	No	1	Shaft	Scrape and Cut/Hack	Marrow Extraction and Defleshing/ Skinning
20.1.1.1	Kudu/ Wildebeest/ Gemsbok	3	Tibia	Right	Indet	Yes	No	No	2	Shaft, on break	Scrape and Cut/Hack	Marrow Extraction and Defleshing/ Skinning
20.2.1.7	Kudu/ Wildebeest/ Gemsbok	3	Tibia	Indet	Indet	Yes	No	No	1	Shaft	Cut/Hack	Marrow Extraction
20.2.1.32	Warthog	2	Metatarsal	Indet	Indet	Yes	No	No	1	Shaft	Cut	Marrow Extraction
20.2.1.33	Warthog	2	Metatarsal	Indet	Indet	Yes	No	No	1	Shaft	Cut	Marrow Extraction
20.5.1.10	Warthog	2	Metacarpal	Right	Adult	Yes	No	No	7	Distal Epiphysis	Cut	Disarticulation
20.5.2.142	Warthog	2	Metapodial	Indet	Indet	Yes	No	No	2	Shaft	Cut/Hack	Marrow Extraction
20.5.2.278	Warthog	2	Humerus	Right	Indet	Yes	No	No	21	Shaft	Unknown	Unknown
20.5.3.14	Warthog	2	Radius	Right	Adult	Yes	No	Yes	1	Proximal Epiphysis	Cut	Disarticulation
20.5.3.3	Warthog	2	Radius	Right	Adult	Yes	No	Yes	1	Proximal Epiphysis	Cut	Disarticulation
20.5.3.49	Warthog	2	Radius	Left	Adult	Yes	No	Yes	1	Proximal Epiphysis	Cut	Disarticulation
20.5.3.60	Warthog	2	Radius	Right	Adult	Yes	No	Yes	1	Proximal Epiphysis	Cut	Disarticulation
20.5.3.86	Warthog	2	Radius	Left	Adult	Yes	No	Yes	1	Proximal Epiphysis	Cut	Disarticulation
12.3.1.4	Steenbok/ Duiker	1	Navicular-cuboid	Right	Adult	Yes	No	No	1	Metatarsal Facet	Cut	Disarticulation
12.3.4.3	Steenbok/ Duiker	1	Navicular-cuboid	Right	Adult	Yes	No	Yes	2	Metatarsal Facet	Cut	Disarticulation
12.1.4.1	Steenbok/ Duiker	1	Metatarsal	Left	Indet	Yes	No	No	1	Proximal Epiphysis	Cut	Disarticulation
12.1.4.3	Steenbok/ Duiker	1	Astragalus	Right	Adult	Yes	No	No	5	On Opposite Sides of Bone, Near Lateral Process and Tibial Stop	Cut	Disarticulation
12.1.4.4	Steenbok/ Duiker	1	Metatarsal	Left	Adult	Yes	No	No	4	Proximal Epiphysis	Cut	Disarticulation
12.2.1.4	Steenbok/ Duiker	1	Radius	Left	Adult	Yes	No	No	4	Distal Epiphysis	Cut	Disarticulation
12.2.2.8	Steenbok/ Duiker	1	2nd Phalanx	Right	Adult	Yes	No	No	1	Proximal Aspect	Cut	Disarticulation
12.6.1.1	Steenbok/ Duiker	1	Navicular-cuboid	Left	Adult	Yes	No	Yes	2	Metatarsal Facet	Cut	Disarticulation
18.3.3.6	Steenbok/ Duiker	1	Radius	Left	Adult	Yes	No	No	2	Proximal Epiphysis	Cut	Disarticulation
20.2.1.9	Steenbok/ Duiker	1	2nd Phalanx	Right	Adult	Yes	No	No	1	Distal Aspect	Cut	Disarticulation
12.2.3.4	Steenbok/ Duiker	1	Lumbar Vertebra	N/A	Juvenile	Yes	No	No	1	Caudal Aspect	Cut/Hack	Disarticulation
12.5.2.25	Steenbok/ Duiker	1	Radius	Right	Adult	Yes	No	No	2	Proximal Epiphysis	Cut	Disarticulation
34.1.3.7	Steenbok/ Duiker	1	Metatarsal	Right	Adult	Yes	No	No	3	Proximal Epiphysis	Cut	Disarticulation
12.0.5.10	Porcupine	1	Scapula	Left	Adult	Yes	No	No	3	Glenoid	Cut	Disarticulation
12.0.5.3	Porcupine	1	Ulna	Right	Adult	Yes	No	No	2	Distal Epiphysis	Cut	Disarticulation
23.2.1.6	Porcupine	1	Rib	Left	Juvenile	Yes	No	No	1	Shaft	Cut	Chopping for Pot Sizing
12.0.5.11	Springhare	1	Innominate	Right	Adult	Yes	No	No	1	Acetabulum	Cut	Disarticulation

(*Continued*)

Table 3. (Continued).

Specimen #	Taxon	Size	Skeletal Element	Side	Age	Cut Marks?	Percussion Marks?	Charring?	# of Cut Marks	Location of Marks	Mark Types(s)	Assumed Butcher Action
12.0.5.5	Springhare	1	Humerus	Left	Adult	Yes	No	No	3	Near Proximal Epiphysis	Cut	Marrow Extraction
12.1.4.28	Springhare	1	Tibia	Right	Indet	Yes	No	No	4	Shaft	Cut/Scrape	Defleshing/ Skinning
12.1.4.29	Springhare	1	Tibia	Left	Indet	Yes	No	No	many	Shaft	Scrape	Defleshing/ Skinning
12.1.4.80	Springhare	1	Tibia	Right	Adult	Yes	No	No	3	Distal Epiphysis	Cut	Disarticulation
12.5.4.2	Springhare	1	Femur	Left	Adult	Yes	No	No	1	Shaft	Cut/Hack	Marrow Extraction

To butcher the abdomen of a Size 3 animal, first a 'slit [is] made down center of belly, passing to side of udder and down the inner portion of leg' then, 'the chest, including the foremost ribs from both right and left sides is separated from the spinal column, first by breaking dorsal portions of ribs with axe and then cutting through with a knife. The uppermost 10 or so remaining vertebrae are separated from the vertebral column, using a knife to make the separations. These this [sic] upper chain is then split lengthwise, using axe, to yield two carrying size parcels' (Appendix 1). The butchery process yields '2 packages, each with 8 or 9 ribs attached-each of these battered, smashing vertebrae and ribs, but not breaking up the package' (Appendix 1). From this butchery process, the expected BSMs would be hack marks (deep, possibly wide cut marks) on the vertebrae and potential cut marks on the dorsal portions of the ribs (Table 4). Although the skinning of these animals was not detailed in Yellen's notes, the initial butchering action of removing the meat from the inner portion of the legs could lead to scrape marks on the limb bones, particularly lower limb bones like tibiae and metapodials (Table 4). It is possible that there would be cut or hack marks on the inner portion of four ribs because they were split between to yield carrying-sized parcels (Table 4). During the wildebeest butchering, 5 ribs were left at the kill site when they were roasted over a fire and eaten, so it is possible that fewer ribs would be recovered to actually inspect for BSMs. The pelvis is 'separated from the spinal column, using both a knife and axe' (Appendix 1). Some cut or hack marks would be expected on the pelvis where it attaches to the spinal column (Table 4).

The hindlimbs were removed by 'cutting through muscle to expose head of the femur, and ligaments which hold head of femur to acetabulum, [which is] then cut. Again, no bones are broken, and rear limb contains the femur and tibia-fibula' (Appendix 1). Then, to split the bones, 'with a knife the femur separated from the tibia-fibula by cutting away the cartilage which joins the two. Using a metal hatchet, both bones [are] smashed by splitting lengthwise along each of the heads, thus destroying them, and then hacking across the shafts in several spots' (Appendix 1). From these butchery actions, disarticulation-related cut marks would be expected on the acetabulum and femur proximal epiphysis (Table 4). When the femur and tibia were separated, the resulting marks would be cut marks on the femur distal epiphysis and tibia proximal epiphysis, and hacking of the bone shafts for marrow extraction may also be visible (Table 4). Although cut marks would be possible on these epiphyses, the smashing of the heads and hacking of the shafts may destroy the bones beyond the point where BSMs could be recognised.

Prior to the removal of the forelimbs, 'using a knife, the four cannon bones are removed by severing connective tissue. The articulations remain intact. In a similar way the cannon bones are separated from the phalanges' (Appendix 1). According to Yellen, the cannon bones (metapodials) are always broken for marrow and consumed at the kill site, and therefore these bones are always left behind. The forelimbs are 'removed by cutting attachments between the scapula and the ribs using a knife. The limb then contains the scapula, humerus, and radius-ulna, all intact' (Appendix 1). Because the forelimbs are not disarticulated, other than at the scapula, it is likely that there will be a lack of disarticulation related BSMs on the forelimb bones. The humerus in all Size 3 bovids is split for marrow, but the radius is only split in the gemsbok and wildebeest, so there may only be some percussion marks on forelimb bones (Table 4).

Size 2: Warthog

Reporting on Size 2 animal butchery actions is limited, as there were no notes taken on the butchery of any Size 2 bovids. The one reported Size 2 animal that was butchered was a warthog. The warthogs are 'treated like large animal[s] and the long bones [are] split lengthwise, resulting in cracking and loss of long bone heads. Ribs [are] split as with large animals' (Appendix 1). Warthogs are therefore predicted to have many of the same BSMs as the Size 3 animals (Table 4).

Size 1: Steenbok, Duiker, Springhare, Porcupine

Size 1 animals hunted and butchered by the !Kung included steenbok, duiker, springhare, and porcupine. A major difference between processing of larger and smaller animals is that larger animals were butchered at the kill site to create carrying parcels, while smaller animals were brought directly back to camp intact. Also, the majority of sections of larger animals were roasted over the fire, while the smaller animals were disarticulated to fit into pots. Small animal butchery sequences were reported by Yellen (1991).

The steenbok and duiker are both size class 1 bovids that were butchered in the same way by the !Kung. The animal is first skinned and the skin 'is dried, cured, and made into clothing or carrying bags' (Yellen 1991). To remove the skin, the !Kung 'slit ventral midline- front of forelegs- up neck ventral to mid mandible – then remove by pulling and a bit of cutting- slit down rear of hindlegs- cut above fore and hind hooves' (Appendix 1). The process of skinning could lead to some markings on the anterior side of the forelimbs or the posterior side of the hindlimbs and disarticulation marks could be present on the phalanges from this skin removal (Table 4).

To butcher the abdomen, the 'animal lain on right side and [a] slit [is] made up [the] left side with ax, passing through dorsal portion of ribs and through the pelvis which is split in two (thus the two halves held together only at belly)' (Appendix 1). Then, 'the

Table 4. Expected butchery marks and descriptions of butchery traces for each animal.

Species	Size Class	Butchery Observation	Expected Butchery Trace	Specimen #(s) and Descriptions of Specimen(s) with Butchery Traces
Kudu/ Wildebeest/ Gemsbok	3	Skinning	Skinning scrape marks on anterior side of limbs, especially lower limb bones	18.2.1.57: Calcaneus with disarticulation and defleshing/ skinning cut marks on posterior aspect 12.1.3.79: Tibia with marrow extraction cut/hack mark and defleshing/skinning scrape marks on shaft 12.1.3.79: Tibia with marrow extraction cut/hack mark and defleshing/skinning scrape marks on shaft
Kudu/ Wildebeest/ Gemsbok	3	Butchery of abdomen	Cut/hack marks on vertebrae and dorsal portion of ribs; fewer ribs present due to leaving at kill site; cut/hack marks on pelvis at sacroiliac joint	18.4.3.1: Cervical vertebra with disarticulation cut mark on caudal aspect 28.1.2.5: Rib with marrow extraction cut/hack mark on shaft 18.2.1.11: Rib with disarticulation cut mark on caudal aspect
Kudu/ Wildebeest/ Gemsbok	3	Butchery of hindlimbs	Disarticulation cut marks on the acetabulum, femur distal and proximal epiphyses, and tibia proximal epiphysis; some marrow extraction (percussion) and cut/hack marks on bone shafts; metapodials left behind at kill site	12.1.1.3: 1st Phalanx with disarticulation cut marks on the proximal end 18.2.1.90: 1st Phalanx with percussion marks on shaft 18.2.1.57: Calcaneus with disarticulation and defleshing/ skinning scrape marks on posterior aspect 12.1.3.79: Tibia with marrow extraction cut/hack mark and defleshing/skinning scrape marks on shaft 20.1.1.1: Tibia with marrow extraction cut/hack mark and defleshing/skinning scrape marks on break of shaft 20.2.1.7: Tibia with marrow extraction cut/hack mark on shaft
Kudu/ Wildebeest/ Gemsbok	3	Butchery of forelimbs	No disarticulation marks on forelimbs; metapodials left behind at kill site; marrow extraction (percussion) and cut/ hack marks on some humerii and radii	No forelimbs with butchery marks
Warthog	2	Skinning	Skinning scrape marks on anterior side of limbs	No forelimbs with butchery marks
Warthog	2	Butchery of abdomen	Cut/hack marks on vertebrae and dorsal portion of ribs; fewer ribs present due to leaving at kill site; cut/hack marks on pelvis at sacroiliac joint	No abdominal area bones with butchery marks
Warthog	2	Butchery of hindlimbs	Disarticulation cut marks on the acetabulum, femur distal and proximal epiphyses, and tibia proximal epiphysis; some marrow extraction (percussion) and cut/hack marks on bone shafts; metapodials left behind at kill site	20.2.1.32: Metatarsal with marrow extraction cut mark on shaft 20.2.1.33: Metatarsal with marrow extraction cut mark on shaft 20.2.1.33: Metatarsal with marrow extraction cut mark on shaft
Warthog	2	Butchery of forelimbs	No disarticulation marks on forelimbs; metapodials left behind at kill site; marrow extraction (percussion) and cut/ hack marks on some humerii and radii	20.5.1.10: Metacarpal with disarticulation cut mark on distal epiphysis 20.5.2.278: Humerus with unknown marks on shaft 20.5.3.14: Radius with disarticulation cut mark on proximal epiphysis 20.5.3.3: Radius with disarticulation cut mark on proximal epiphysis 20.5.3.49: Radius with disarticulation cut mark on proximal epiphysis 20.5.3.60: Radius with disarticulation cut mark on proximal epiphysis 20.5.3.86: Radius with disarticulation cut mark on proximal epiphysis
Steenbok/ Duiker	1	Skinning	Skinning scrape marks on anterior side of forelimbs and/or posterior side of hindlimbs; disarticulation cut marks on phalanges	No remains with skinning related marks
Steenbok/ Duiker	1	Butchery of abdomen	Chop or cut marks at the dorsal portions of the ribs and on the innominate	12.2.3.4: Lumbar vertebra with disarticulation cut/hack mark on the caudal aspect

(*Continued*)

Table 4. (Continued).

Species	Size Class	Butchery Observation	Expected Butchery Trace	Specimen #(s) and Descriptions of Specimen(s) with Butchery Traces
Steenbok/ Duiker	1	Butchery of hindlimbs and forelimbs	Disarticulation cut marks on all epiphyses and marrow extraction (percussion) and cut or hack marks on femur and occasionally on the humerus and radius	12.3.1.4: Navicular-cuboid with disarticulation cut mark on metatarsal facet 12.3.4.3: Navicular-cuboid with disarticulation cut marks on metatarsal facet 12.6.1.1: Navicular-cuboid with disarticulation cut marks on metatarsal facet 12.1.4.3: Astragalus with disarticulation cut marks near lateral process and tibial stop 12.1.4.4: Metatarsal with disarticulation cut mark on proximal epiphysis 12.1.4.1: Metatarsal with disarticulation cut marks on proximal epiphysis 34.1.3.7: Metatarsal with disarticulation cut marks on proximal epiphysis 18.3.3.6: Radius with disarticulation cut marks on proximal epiphysis 12.5.2.25: Radius with disarticulation cut marks on proximal epiphysis 12.2.1.4: Radius with disarticulation cut marks on distal epiphysis 20.2.1.9: 2nd Phalanx with disarticulation cut mark on distal aspect 12.2.2.8: 2nd Phalanx with disarticulation cut mark on proximal aspect
Porcupine	1	Butchery of abdomen	Cut/hack marks on dorsal portion of ribs; vertebrae entirely shattered and unidentifiable	23.2.1.6: Rib with cut mark on shaft – chopped to fit into a pot
Porcupine	1	Butchery of hindlimbs and forelimbs	Cut/hack marks on dorsal portion of ribs; vertebrae entirely shattered and unidentifiable	12.0.5.10: Scapula with disarticulation cut marks on the glenoid 12.0.5.3: Ulna with disarticulation cut marks on the distal epiphysis
Springhare	1	Skinning	Scrape marks on ventral portions of limbs and especially present on the tibia-fibula	12.1.4.28: Tibia with defleshing/skinning cut/scrape marks on the shaft 12.1.4.29: Tibia with defleshing/skinning scrape marks on the shaft
Springhare	1	Butchery of hindlimbs	Disarticulation cut marks on acetabulum and all epiphyses and marrow extraction (percussion) and cut/hack marks on femur and tibia, or no disarticulation marks present and marrow extraction marks on femur	12.0.5.11: Innominate with disarticulation cut mark on acetabulum 12.1.4.80: Tibia with disarticulation cut marks on distal epiphysis 12.1.4.80: Tibia with disarticulation cut marks on distal epiphysis
Springhare	1	Butchery of forelimbs	No marks expected	12.0.5.5: Humerus with marrow extraction cut marks near proximal epiphysis

Figure 1. Specimen 18.2.1.11, a kudu/gemsbok/wildebeest thoracic vertebral spine with a slicing cut mark. Scale bar is 1 centimeter.

animal [is] turned on [the] other side, and the right ribs [are] separated from the spinal column in the same way, (thus separating the body, from the head and spine.) The head with several cervical vertebrae attached cut from rest of spine' (Appendix 1). From this butchery sequence, cut marks would be expected at the dorsal portions of the ribs and on the pelvis (Table 4). To further break down a steenbok or duiker, 'the rib cages are separated into small packages by cutting between the bones and thus individual ribs survive nearly intact. The spinal column is chopped crosswise to yield portions which fit easily into a pot (since the column is not first chopped lengthwise most vertebrae survive intact.) The pelvis is cut from the spinal column and the two innominates separated. These are either left intact or chopped crosswise at acetabulum level' (Yellen 1991). Thus, most portions of the abdomen should be mainly intact with limited BSMs except for those between the ribs or at the innominate bone disarticulations (Table 4).

The steenbok/duiker forelimb is 'cut off between scapula and ribs, while the hindlimbs are removed at pubis joint' (Appendix 1). Once both the fore- and hindlimbs are removed, they are disarticulated at all joints to fit into a small pot. To access marrow, 'The humerus may be left unbroken, be cracked with an axe across midshaft, or be split lengthwise by a blow through the proximal head. The radius, if processed, may also be cracked across the midshaft or split with blows on both proximal and distal ends. The femur is always broken and may be chopped either across the midshaft or lengthwise through both proximal and distal heads. The tibia likewise is always processed and broken either crosswise or lengthwise through the proximal head' (Yellen, 1991). Although the humerus and radius are only occasionally split, in one of Yellen's observations of steenbok butchery, 'the humerus [was] first split lengthwise and then chopped crosswise' (Appendix 1). Disarticulation marks would be expected at all the epiphyses, both proximal and distal (Table 4). The potential for cut marks to be preserved would be contingent upon the state of the bones after they are smashed for marrow. The humerus and radius, which are only occasionally split, may retain their epiphyses and therefore have visible disarticulation cut marks, though the humerus has occasionally been observed to be split (Table 4).

!Kung butchery of a porcupine began with skinning, which was typically accomplished at the kill site for immediate consumption, while butchery of the rest of the animal took place back at camp. The !Kung began butchering the limbs prior to butchering the abdomen. The forelimbs were 'removed with [the] scapula by separating the scapula from the rib cage', while the hindlimbs are 'removed by separating the femur from the pelvis, leaving both intact' (Appendix 1). To get marrow out of the bones, 'all four limbs are then hit with an ax crosswise (perpendicular to the length of the bones) hard enough to shatter the bone. The bones are then separated at their articulations cleanly with knife. Each bone then cut through at point of axe marks. Thus, the femur is divided into 2 pieces and other bones into [the] same number' (Appendix 1). Yellen (1991) notes that the radius, ulna, and fibula were typically not broken as they do not contain much marrow and they are small enough to fit inside of the pot; the tibia could be broken or left intact. From these butchery actions, cut marks would be expected at the acetabulum and the articulations of the long bones (Table 4). Similar to the duiker and steenbok, it is unclear if the cut marks would be visible on the long bones due to the smashing of the bones for marrow extraction. The radius, ulna, and tibia would be the most likely to have marks that are visible because they remain intact (Table 4). Because 'the humerus and femur are usually each divided into three pieces: one with bone shaft fragment only and the other two with shaft fragments and either the proximal or distal head, complete or nearly so', then there may be an occasional proximal or distal head unaffected by smashing that would have cut marks, but it is less likely than that of the radius, ulna, or tibia (Yellen 1991; Table 4).

The !Kung butchered the abdomen of a porcupine 'using an axe, all ribs on one side are hacked from body. This rib package then separated into 3–4 pieces by cutting with knife between the ribs. The same is done to the ribs on the other side as well. [The] spine [is] then hacked a few times along its length with an axe to split and shatter the vertebrae. [The] shattered spinal column [is] then hit crosswise 3 times with axe to give 4 pieces' (Appendix 1). This could result in cut or hack marks on the portion of ribs near the vertebral column (Table 4). The ribs are typically cut crosswise to fit into the pot, but this would not impact the area near the vertebral column. The vertebrae are shattered in this process, so it is unlikely that they would be identifiable enough to use for the present study.

The !Kung butchery of a springhare was outlined by Yellen (1991b) and notes were taken on the butchery process of one springhare in 1976. Although the notes taken on the butchery of the

Figure 2. Specimen 12.1.3.79, a kudu/gemsbok/wildebeest tibia with scrape marks on the shaft. Scale bar is 1 centimeter.

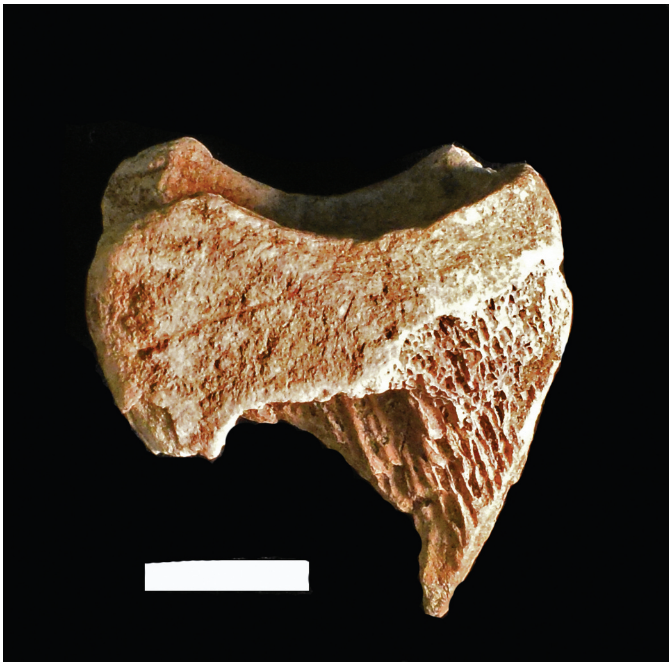

Figure 3. Specimen 12.1.1.3, a kudu 1st phalanx with a slice mark on the proximal end. Scale bar is 1 centimeter.

aforementioned small animals (steenbok, duiker, and porcupine) matched the published description of the butchery practice, the springhare has a few deviations between both recorded butchery sequences. To skin a springhare, the 'skin [is] slit down breast and stomach midline with knife. [Skin is] cut free down sides and down ventral surface of arms and legs. [Then] pulled free around body. [The skin is] cut at base of tibia-fibula, and remains on hands and on tail, [and] hand and tail come off with skin' (Appendix 1). Skinning marks would be expected on the ventral portions of the limbs (Table 4). There may be some extra skinning-related marks on the tibia-fibula due to removing the skin (Table 4). As described in Yellen (1991), the hindlimbs were then disarticulated at the acetabulum and all other joints, whereas in another instance they were chopped off with innominate bones and all joints remain intact (Appendix 1). Yellen (1991) stated that the femur is smashed along with the tibia to extract marrow, whereas the other springhare femur is smashed but the tibia remains intact. There may be the potential for disarticulation marks on the acetabulum and epiphyses of the hindlimb long bones if the butchery of the springhare follows the process described by Yellen (1991; Table 4). There will be no evidence of disarticulation marks if the bones are not separated. Also, the smashing of the bones in Yellen (1991) would likely impact the visibility of the cut marks and the identifiability of the bones. The forelimbs were treated the same way in both butchery instances, 'The scapulae and forelimbs are removed

Figure 4. Specimen 20.5.3.86, a warthog radius with cut marks on the proximal epiphysis and shaft. Scale bar is 1 centimeter.

Figure 5. Specimen 20.5.1.10, a warthog metacarpal with cut marks on the distal epiphysis. Scale bar is 1 centimeter.

from the body and boiled and the meat is eaten from the bones. None are broken for marrow' (Yellen 1991). No marks are expected on any of the forelimb bones.

Results

Butchery marks on different sized animals

Size 3: kudu, Gemsbok, and Wildebeest

Of the 41 identifiable butchered bones, both by animal species and skeletal element, 9 can be attributed to one of the size 3 bovids (Table 3; Table 4). There were no forelimb portions with BSMs attributed to a size 3 animal, which matches the butchery description in which no forelimbs were disarticulated (Table 4). There are cut/hack marks on a cervical vertebra, thoracic vertebra, and a rib as a result of separating the abdomen into specific carrying packages (Table 4; Figure 1). The most common skeletal element of size 3 bovids with BSMs is the tibia; three tibiae have cut/hack marks present on the shafts, presumably a result of attempting to hack across the shaft to extract marrow and also to skin or deflesh the animal (Figure 2). Perhaps the most surprising skeletal element that had BSMs were two 1st phalanges, one of which had percussion marks and one had disarticulation marks (Table 4; Figure 3). There is

Figure 6. Specimen 12.1.4.4, a steenbok/duiker metatarsal with cut marks on the proximal epiphysis and shaft. Scale bar is 1 centimeter.

Figure 7. Specimen 12.2.1.4, a steenbok/duiker radius with cut marks on the distal shaft and epiphysis. Scale bar is 1 centimeter.

no direct mention of the phalanges in the butchery notes, but there is evidence that they are cracked for marrow in other ethnoarchaeological contexts (e.g., Lupo 1998, Jin and Mills 2011).

Size 2: warthog

Although the warthog was reported to be butchered in the same way as large animals, the pattern of BSMs on warthog skeletal elements is different from the pattern of BSMs on size 3 bovid skeletal elements (Table 4). Ten of 67 warthog bones displayed butchery marks. The most common warthog skeletal element with BSMs is the radius; all five radii have disarticulation related cut marks on the proximal epiphysis (Table 4; Figure 4). Four metapodials are present in the warthog assemblage; three of them exhibit cut/hack marks related to marrow extraction and one has evidence of disarticulation cut marks on the distal epiphysis (Table 4; Figure 5). As none of these marks are reflective of the butchery process of size 3 animals, we suggest that the !Kung may have divided their warthog kills into even smaller parts than anticipated to be carried back to camp or to fit into a pot.

Size 1: Steenbok, Duiker, Porcupine, Springhare

Based on the location of cut marks on the steenbok and duiker skeletal elements, these cut marks are due to disarticulation only (Table 4). Disarticulation marks appear on the three metatarsal facets of navicular-cuboids and three proximal epiphyses of metatarsals of steenboks/duikers (Table 4; Figure 6). This pattern suggests that the disarticulation in this region of the hindlimbs is perhaps more difficult for the !Kung, and there are issues in finding the joint in this region without cutting the bone accidentally. Three radii have disarticulation marks, two at the proximal epiphysis and one at the distal epiphysis, which also matches the description that all long bones were

Figure 8. Specimen 12.0.5.3, a porcupine ulna with cut marks on the proximal epiphysis. Scale bar is 1 centimeter.

Figure 9. Specimen 12.1.4.28, a springhare tibia with cut marks on the shaft. Scale bar is 1 centimeter.

Figure 10. Specimen 12.1.4.29, a springhare tibia with scrape marks on the shaft. Scale bar is 1 centimeter.

disarticulated (Table 4; Figure 7). Two intermediate phalanges have disarticulation marks on the proximal and distal side of each bone, respectively, and one astragalus is cut marked on both sides with disarticulation marks (Table 4). The steenbok/duiker had the greatest number of identifiable bones and the greatest number of disarticulation marks, despite evidence that some of the bones were broken for marrow extraction.

Only three of 30 porcupine bones had BSMs: a scapula, an ulna, and a rib (Table 4). The scapula and ulna both have disarticulation marks, which aligns with the expectations from the butchery actions (Table 4; Figure 8). The rib that has a cut/hack mark in the middle is due to making it smaller to fit into a pot, which is also consistent with the description of porcupine butchery (Table 4).

Six of 127 springhare skeletal elements had BSMs; five out of six are hindlimbs, including one innominate, that are associated with the hindlimb butchery process for springhares (Table 4). Three bones with BSMs are tibias; two have skinning marks and one has disarticulation marks (Table 4; Figures 9–10). Springhares are skinned for their hides to become small loincloths or pouches, so the presence of skinning marks on their bones affirms these observed butchery actions. There are cut/hack marks on one femur that are consistent with marrow extraction, which matches Yellen's (1991) butchery description of springhare; the disarticulation mark on one innominate bone would also match this description (Table 4). The other account of butchery does not mention actions that would result in marks in these spots (Appendix 1). The one surprising BSM is a cut/hack mark on a springhare humerus that would be related to marrow extraction, even though both butchery accounts do not mention forelimb marrow extraction or disarticulation.

Discussion

This study uses observations of butchery actions of modern foragers to make predictions of where resultant bone surface modifications would be expected. Ethnoarchaeologists often study modern forager butchery and transport behaviour, or assemblage-wide bone surface modifications resulting from butchery, or both; few studies include detailed butchery behaviour observations and studies of resultant bone surface modifications (e.g., Binford 1978; Martínez 2007). This study joins those few in making specific predictions of the locations of butchery marks from observed butchery actions, and is especially rare in providing detailed ethnographic butchery behaviour observations.

With the exception of marks on two size 3 bovid phalanges, one springhare humerus, and the warthog bones, the rest of BSMs on the DBC assemblage follow the expected butchery actions for each animal. It is possible that these marks, which were not predicted by observed butchery actions, were simply the result of butchery behaviours which had not been observed.

Comparatively, there were more disarticulation-related marks on bones that were from size class 1 animals than size class 3 animals, which was related to the specific cooking method that is utilised for small mammals, which here refers to animals weighing 50 pounds/~23 kilograms (Bunn 1982). For small mammals, the marrow will escape if the bones are roasted over the fire; rather, the bones are made into a stew in a '1 foot wide' pot (Appendix 1). The butchering decisions largely stay the same amongst the !Kung across small mammals, though Yellen (1991) notes that butchery decisions can change based on the size of the cooking vessel or the marrow content of the animal species. As an example of this, the innominate bones of size class 1 animals can either remain intact or be smashed depending on the pot size, with the latter occurring in situations where the pot that is available is very small. Alternatively, the butchery of size class 3 animals depends on the carrying capacity of the hunters. The !Kung hunters can only carry approximately 80 pounds (~36 kilograms), which necessitates breaking the animal down into smaller pieces. The butchery process also can vary based on the number of !Kung present to carry the animal and the distance back to camp (Appendix 1). Also, more marrow extraction marks were both expected and observed on size class 3 bones due to the meat being roasted directly over the fire and not in the pot where marrow could escape in the broth. Distinctive skinning marks were present on both small and large animals, as the hides were subsequently processed by the !Kung to be used for a variety of purposes including clothing and carrying satchels.

The present study emphasises the importance of studying BSMs, specifically to predict and interpret the cooking method and the hide utilisation of specific small animal carcasses. Distinctive skinning marks, which are usually clumped together on the shaft of a bone, can be indicative of hide utilisation, especially on mammals such as a springhare, where defleshing marks are unlikely due to the limited amount of flesh on bones and the lack of ethnoarchaeological evidence for this behaviour (Yellen 1991). The presence of disarticulation marks on the bones of small mammals can be a good indicator that a group had a cooking vessel, as these animals can be carried back to camp without the need to disarticulate them. If size 1 animals were roasted over an open fire, disarticulation marks are less likely to be present – in part because disarticulation and roasting could have occurred simultaneously.

The conditions in which the fauna analysed in this study were discarded, buried, and recovered are a reasonable model for how bones might be incorporated into the archaeological record as fossils and then retrieved for analysis. Some of the bones were buried for 30 years and still had visible BSMs. The !Kung, who at the time represented by this study were mainly obligate hunter-gatherers, were experienced butchers and still created BSMs, despite the knowledge of the location of joints. Although some archaeological sites might experience higher levels of degradation of bone and therefore decreased visibility of BSMs, there is potential to utilise the BSMs to reconstruct butchery actions. Determining butchery actions can then help reconstruct behaviours of specific groups, such as tanning hides and cooking in vessels.

Disclosure statement

No potential conflict of interest was reported by the authors.

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