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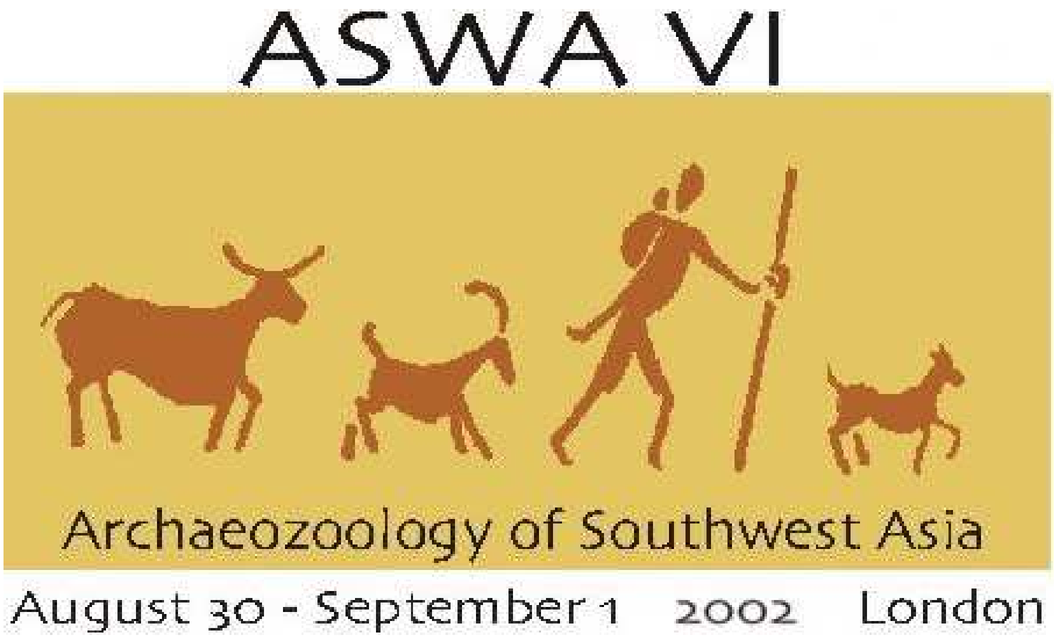

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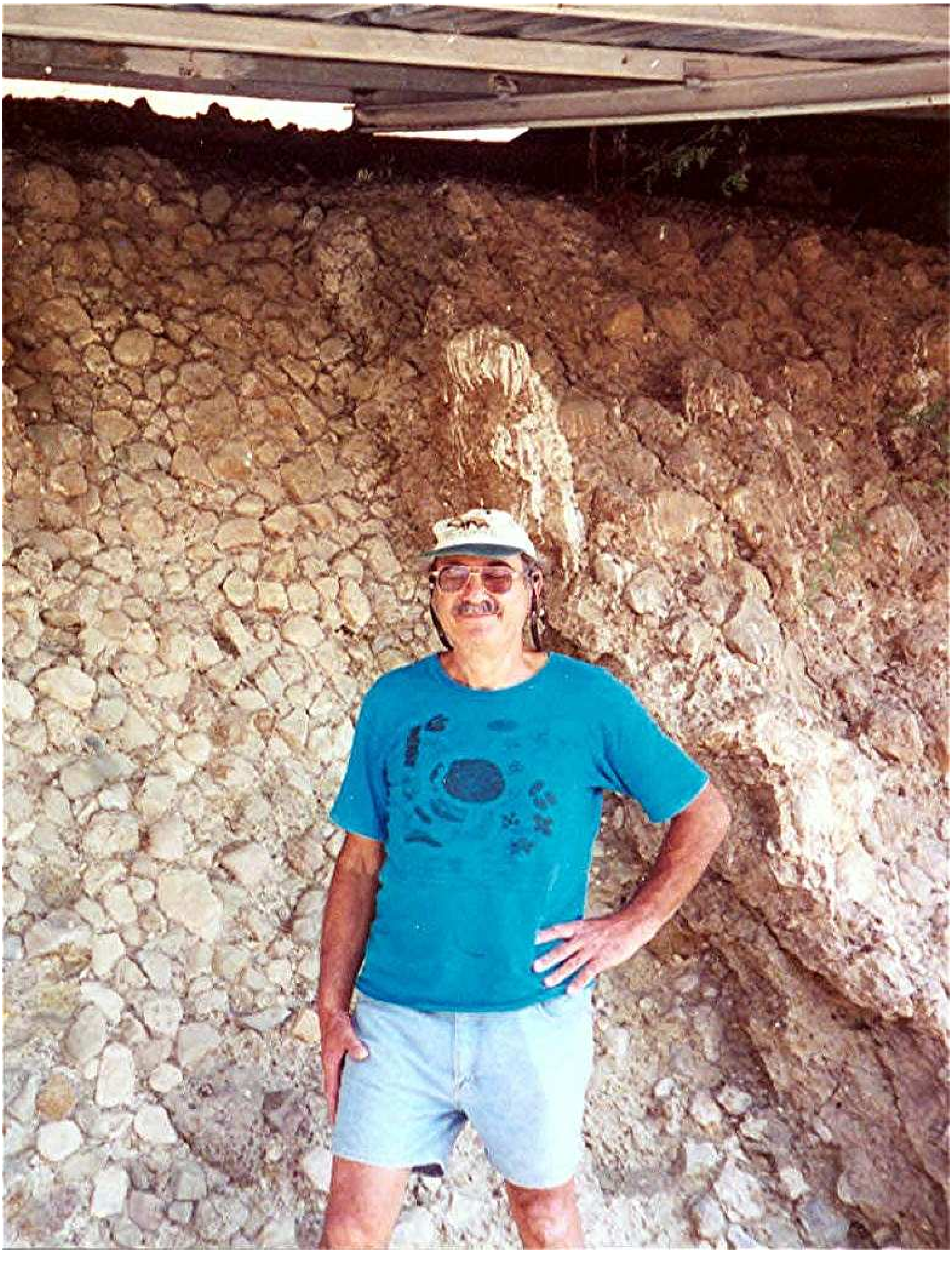

Prof.Dr. Eitan Tchernov

This volume is dedicated to the memory of Prof. Dr. Eitan Tchernov, in fond memory of his enthusiasm and support to many in the field of archaeozoology**.**

Preface

The ASWA VI meeting was held at the Institute of Archaeology, University College London, from 30th August-1st September 2002, timetabled to follow on the heels of the ICAZ meeting in Durham, UK. Over 55 participants attended the meeting, travelling from 13 countries, bringing the latest research results from our field. As usual, it was a pleasure to see so many doctoral students presenting their research – a sign for a very healthy future for zooarchaeology in south west Asia. It is still unfortunate, however, that colleagues from some Middle Eastern countries were unable to attend due to financial and political constraints.

Presentations were organized into the following six themes, which highlight the scope of the ASWA membership: Animals in Palaeolithic and Epipalaeolithic Levant; Neolithic Patterns of Animal Use; Animals in Neolithic Anatolia; Animals in the Chalcolithic and Bronze Ages; Iron Age, Nabatean and Roman Patterns of Animal Use; Animals in Ancient Egypt. There was also a poster session, and contributors were invited to submit papers to this volume.

As always with the ASWA forum, the meeting served to welcome new scholars to the group, but was also very much a reunion of old friends and colleagues who have been sharing new information and discussing issues of joint interest for many years now. In this vein, it is a great sadness that ASWA VI was the last international meeting attended by Prof. Eitan Tchernov, an original founder of the group and mentor and inspiration to so many. For many of us, it was the last time we saw Eitan, and experienced his usual incisive comment, unstoppable enthusiasm for the subject, and warm friendship. He will be greatly missed.

ASWA VI was supported by the Institute of Archaeology, UCL, who provided facilities and financial and administrative help. In particular, the organizing team was aided greatly by the administrative assistance of Jo Dullaghan at the Institute. ARC bv (Archaeological Research and Consultancy, Groningen, The Netherlands) once again shouldered the finances of the publication of the proceedings, and we are extremely grateful for their continuing support. Many thanks are also due to the postgraduate student helpers from the Institute of Archaeology who made the meeting run so smoothly: Banu Aydinoğlugil, Jenny Bredenberg, Chiori Kitagawa, Peter Popkin, and Chris Mosseri-Marlio (who also produced the logo reproduced on the frontispiece of this volume).

Many thanks to all the participants for making the meeting such a success!

Louise Martin
London 2005

Participants of the 6th ASWA Conference, held at the Institute of Archaeology, University College London.

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Preface

THE ORIGINS OF METALLURGY AT JERICHO (TEL ES-SULTAN): A PRELIMINARY REPORT ON DISTINGUISHING STONE FROM METAL CUT MARKS ON MAMMALIAN REMAINS

Haskel J. Greenfield[1]

Abstract

Metallurgy is considered to be a contributing factor to the development of social complexity in the Old World. Researchers studying early metallurgy have primarily confined investigations to the use of inferential models based on the relative decline of stone tool use. Relatively few metal tools have survived in the archaeological record, representing a bias in the data. Through experimental research, the author has explored and noted the morphological differences between cut marks made by stone tools and those made by metal tools on bone. The application of this methodology will allow for a re-evaluation of the spread of metallurgy and its impact on the development of complex societies. This paper discusses some of the results of the author's research on cut marks identified on the animal bone assemblage from the ancient tell of Jericho (Tel es-Sultan) and how they can be used to inform us of the adoption and spread of early metallurgy in the region.

Résumé

La métallurgie est considéré comme étant un facteur de développement des sociétés complexes dans l'ancien monde. Les chercheurs qui ont étudié les débuts de la métallurgie ont d'abord confinés leurs recherches à utiliser des modèles déductives fondée sur la baisse relative de l'utilisation de l'outillage lithique. Peu d'outils métalliques a survécu dans le matériel archéologique, ce qui représente un biais au sein des données. A travers une étude expérimentale, l'auteur a exploré et noté les différences morphologiques des traces de découpes laissées par des outils métalliques et par l'outillage lithiques sur les os. L'application de cette méthodologie va permettre de reconsidérer la diffusion de la métallurgie et son impact sur le développement des sociétés complexes. Cet article discute certains résultats issus de la recherche menée par l'auteur sur les traces de découpes identifiés sur les vestiges fauniques de l'ancien tell de Jericho (Tel es-Sultan), et comment ils peuvent être utilisés pour renseigner sur la mode d'adoption et la dispersion de la métallurgie dans la région.

Key Words: Origins, metallurgy, cut marks, scanning electron microscope, Jericho.

Mots Clés: Les origines, métallurgie, traces de découpe, scanning electron microscopie, Jericho.

Introduction

The Near East represents one of the earliest centres for the development of metallurgical technology and is therefore crucial to the investigation of issues related to the development of metallurgy (Muhley 1980, 1985, 1993; Tylecote 1992). Metallurgy in the Near East appears very early, with the recovery of cold-hammered copper artifacts from Late Pre-Pottery Neolithic contexts (Mellaart 1976; Redman 1978). With the development of smelting techniques, copper metallurgy spreads fairly quickly and widely during the Chalcolithic (ca. 4500 BCE - Levy and Shalev 1989; Mazar 1990). Metallurgy spreads even more rapidly when it was discovered that the properties of copper could be improved by alloying copper with other metals such as arsenic, lead or tin, to produce bronze. Bronze tools begin to be found in the later part of the Early Bronze Age (Early Bronze II in Israel – Genz 1999; Mazar 1990). By the Middle Bronze Age (ca. 1950 BCE in Israel), the use of bronze becomes more frequent. Concurrent to the introduction and spread of metallurgy were increases in social complexity and the rise of urbanism (Ben-Tor 1992; Ilan and Sebbane 1989; Mazar 1990; Rosen 1997).

In Israel, the origins of metallurgy has also been investigated through the analysis of lithics. Steve Rosen demonstrated that the first stage in the adoption of metallurgy did not involve the wholesale replacement of flint tools (as is commonly assumed). Functional chipped stone tool types gradually disappear between the end of the Chalcolithic and Iron Age. Some types disappear because of changes in subsistence (arrowheads), while others are replaced with metal types that had a corresponding func-

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tion (axes). Some stone tool types disappear quickly (e.g. arrowheads) at or prior to the beginning of the Bronze Age, others gradually through the Bronze Age (axes), and some continue to be used into the Iron Age (sickles – Rosen 1997). To explain the continued use of stone (in the face of available metal tools) into later periods, Rosen (1984: 504) has suggested that until a clear improvement in efficiency emerges, the economy would perpetuate the use of the traditional material. Thus, one would not expect the replacement of flint sickles until iron became readily available and cheap enough to supplant them in the Levant. Similarly, one would not expect the replacement of bronze axes with iron or steel axes until some factor, besides relative efficiency, intervened (Mathieu and Meyer 1997).

The objective of this paper is to investigate this issue from the perspective of zooarchaeology. Metal usually deteriorates or is recycled and there is little evidence left for the archaeologist to reconstruct ancient patterns of adoption and use. Instead, I will focus on cut marks on bones. Bones are ubiquitous on Near Eastern sites (Hesse and Wapnish 1985) and preserve much better than metal. By distinguishing whether cut marks on animal bones are made by metal or stone tools, an independent measure of the relative importance of the different raw materials used for butchering and cutting can be generated. The spread of metallurgy, as a result, can then be monitored.

The site

The remains discussed in this report were recovered during the 1950's excavation at the site of Jericho (Tel es-Sultan) conducted by Kathleen Kenyon. The site is located at the edge of the modern city of Jericho in the Palestinian Authority Area. The basic descriptive analysis of the entire zooarchaeological assemblage from Jericho was undertaken by Clutton-Brock (1971, 1979) and Clutton-Brock and Uerpmann (1974).

All bones from the site are stored in the Natural History Museum, London, and were examined by the author during visits in 2000 and 2002. Zooarchaeological remains were recovered from the site from a variety of periods. However, most bone remains did not yield any evidence of butchering marks. This report details only those periods from which remains were identified. At the conclusion of this research period, more remains were found that still await final analysis, and these will be reported on at a later date.

If the period is not mentioned but is present at the site, this means that no butchered remains were identified in the collection from that period (i.e. Byzantine). The periods with the best representation include the Protoneolithic, Pre-Pottery Neolithic A (PPNA) and B (PPNB), Pottery Neolithic, Early Bronze Age (EBA), and Middle Bronze Age (MBA).

Methodology

In order to identify bones with butchering marks on them, each bone fragment was individually examined. Most of the butchering marks were readily identifiable to the naked eye. A low power magnifying glass was used to survey each bone in order to enhance the potential for discovering butchering marks. Even though microscopic examination of the entire surface of each bone may have located a higher number of butchering marks, it was not deemed to be a realistic in terms of sample size, time, and finances. Also, it was also not possible to fit most bones comfortably beneath a microscope. Therefore, the entire assemblage was examined for macroscopic and not microscopic butchering marks.

Butchering marks are often relatively easy to distinguish from tooth and other marks (such as a result of weathering) in these periods. The nature of the activity leaves a relatively clear signature for even the naked eye – a relatively short straight incision in the bone. Many bones with possible cut marks were rejected when subjected to microscopic examination since they were deemed to be caused by non-butchering sources.

Once butchering marks were identified, the bone and the butchering marks were drawn to scale (1:1), and subjected to a detailed analysis (including taxon, state of domestication, symmetry, part of the element, etc.). The cut mark was then examined under a light optical microscope and a tentative identification of the nature of the raw material of the implement is made – stone or metal.

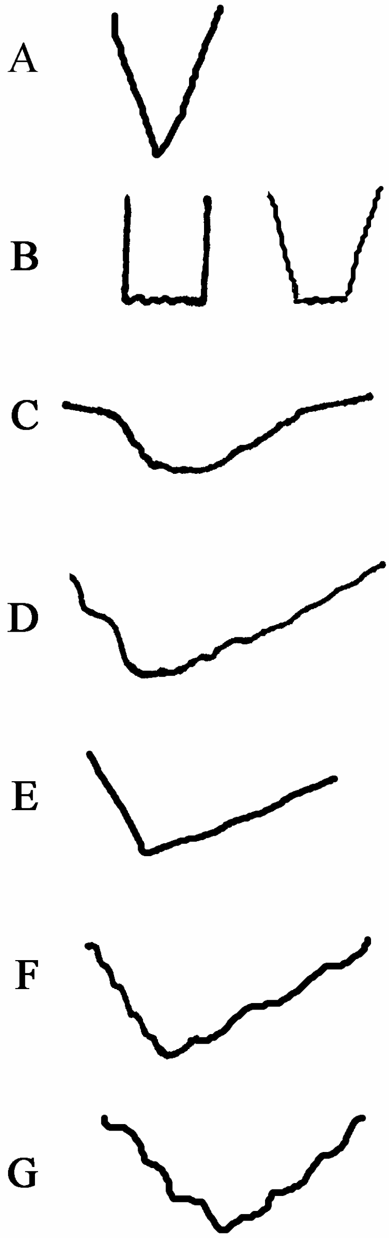

Fig. 1. Templates for distinguishing metal and stone tool cut marks:

A. profile of metal blade — sharp flat edge;
B. profile of metal blade — dulled flat edge;
C. profile of metal blade — serrated edge (saw-like);
D. profile of chipped stone scraper;
E. profile of chipped stone blade — unretouched;
F. profile of chipped stone blade — unifacial retouch;
G. profile of chipped stone blade — bifacial retouch.

Subsequently, a silicone mold of the incision was made in order to further study the mark in a Scanning Electron Microscope. The original bone was then returned to the curatorial facility (Natural History Museum, London) for long-term storage with the remainder of the faunal collection. Each mold was subjected to further examination by the author and an assistant in the lab at the University of Manitoba. In this way, each mold was separately and repeatedly examined to determine whether a stone or metal blade had been used during butchering. This ensured a level of accuracy and repeatability of results rarely encountered in such analyses.

The methodology for distinguishing between stone and metal cut marks is based on experimental research conducted by the author. This is discussed at length elsewhere (Greenfield 1999, 2000a, 2000b, 2002a, 2002b, n.d.) and is only briefly summarized here.

Metal knife blades produce a very uniform pattern, which can be summarized as follows:

1. Metal knives produce sharp V- or hard cornered |_|-shaped grooves that meet at a distinct apex at the bottom of the groove (Fig. 1a and b).
2. Metal tools make more uniform patterns on the bone, often removing material in the groove more effectively. They leave either no striations, or striations of a more uniform depth and spacing than when stone tools are used.
3. In general, metal knives produce a cleaner and more even slicing cut (except for serrated-edge blades – Fig. 1c).

By contrast, chipped stone tools have a different pattern, which can be summarized as follows:

1. Chipped tools (blades or flakes) create a groove with one side rising steeply and smoothly and the other side rising more gradually (Fig. 1e), except for scrapers (Fig. 1d).
2. The gradually rising side will have one or more striae that run parallel to the apex of the cut, depending on whether it is retouched or not.
3. Retouched tools may leave lateral striations on both sides of the apex, depending on whether they are unifacially or bifacially retouched (Fig. 1f and g).
4. Stone tools produce a shallower, less even cut mark.

Results

Size of the butchered assemblage

To date, a total of 271 bones from the sample have been identified as having evidence of butchery. This sample becomes the basis for the discussions below. The basic descriptive analysis of the entire zooarchaeological assemblage from Jericho was undertaken by Clutton-Brock (1971, 1979) and Clutton-Brock and Uerpmann (1974). Almost all of the bones (and fragments) with cutmarks were identified at least to genus (and usually to species) and to element. This is a larger than usual percentage amongst butchered fragments. In most cases, a relatively small percentage of bones with cut marks can be identified to a very specific taxonomic level. The major reason is that the entire assemblage was cleaned of calcium carbonate concretions after it was excavated. This made it much easier to identify cut marks that would otherwise have been covered over. Also, I suspect that only taxonomically identifiable bones were collected and kept by the excavators.

Butchered assemblage taphonomy

There were several major taphonomic issues that created problems in identifying the nature of the instrument that created the cut mark. Each is discussed below.

Weathering

The first problem was weathering. All of the bones were examined with respect to weathering patterns (Table 1). Generally, the sample from Jericho had a relatively good preservation. Most of the sample had a relatively low degree of weathering (83%). Very few were medium weathered (17%), and only one fragment was heavily weathered (0.5%). The most important reason that there was such a low degree of weathering was probably the fact that the sample came from deeply buried deposits. Most of the overlying or upper deposits at the site were removed by earlier excavators.

Table 1. Frequency of weathering patterns in butchered assemblage (NISP).

	Degree of weathering						
	Light		**Medium**		**Heavy**		**Total**
Period	***No.***	***%***	***No.***	***%***	***No.***	***%***	***No.***
Protoneolithic	4		0		0		4
PPNA	17		0		0		17
PPNB	16		1		0		17
Pottery Neolithic	1		0		0		1
EBA	17		0		0		17
Early-Middle BA	1		0		0		1
MBA	26		1		0		27
MBA tomb	142		44		1		187
Total	224	82.66%	46	16.97%	1	0.37%	271

Preservatives

In spite of the low weathering of most of the sample, an extremely large percentage of the sample was treated with preservatives (84% - Table 2). The unstable remains were dipped in a solution of 50% PVA (sometime after excavation). This leaves the surface of the bones covered in a greasy and/or waxy substance. The coating is thick and covered any cut marks on bones, making them difficult or impossible to see. In the worst cases, no observations could be made on the wax covered material.

The PVA stabilized the fragments and prevented further deterioration. However, it had the unfortunate effect of filling in many of the butchering impressions, especially the light slice marks. This af-

Table 2. Frequency of preservative treatment (NISP).

	Not treated	Treated			Treated	subtotal	Total
Period		**PVA**	**Wax-like PVA**	**Could not be determined**			
	No.	*No.*	*No.*	*No.*	*No.*	*%*	*No.*
Protoneolithic	0	4	0	0	4	100.00%	4
PPNA	1	16	0	0	16	94.12%	17
PPNB	2	15	0	0	15	88.24%	17
Pottery Neolithic	0	1	0	0	1	100.00%	1
EBA	0	17	0	0	17	100.00%	17
Early-Middle BA	0	1	0	0	1	100.00%	1
MBA	14	10	3	0	13	48.15%	27
MBA tomb	27	66	74	20	160	85.56%	187
Total	44	130	77	20	227	83.76%	271

Table 3. Frequency distribution of molds (NISP).

	Mold taken?				
Period	***No***		***Yes***		***Total***
	No.	*%*	*No.*	*%*	*No.*
Protoneolithic	0	0.00%	4	100.00%	4
PPNA	5	29.41%	12	70.59%	17
PPNB	5	29.41%	12	70.59%	17
Pottery Neolithic	0	0.00%	1	100.00%	1
EBA	8	47.06%	9	52.94%	17
Early-Middle BA	0	0.00%	1	100.00%	1
MBA	1	3.70%	26	96.30%	27
MBA tomb	49	26.20%	138	73.80%	187
total	68	25.09%	203	74.91%	271
EBA-MBA subtotal	10	25.64%	29	74.36%	39

fected the frequency of molds that could be taken of the various cut marks. Almost 25% of the identified cut marks could not be molded because of the preservative. This stands in strong contrast to other sites from the region, where the problem is that most of the material was not cleaned (75% - Table 3). The preservative also obscured somewhat my ability to identify the type of raw material (stone or metal) used in making the butchering instrument (knife) that was used to make the cut mark. In spite of the above problems, the preservative was sufficiently transparent in most cases to be able to see the cut mark pattern.

Analysis

Temporal distribution of butchered remains

Most of the bones with cut marks derive from a single period, and in fact a single context (Table 4). The bones from Jericho were laid out by context and period making it easy to assign them to a period. The vast majority (79%) are found in MBA deposits from the tell and 69% of all bones are associated with MBA tombs (Table 4). Very few come from the various other periods. The next largest, in descending order, come from EBA, PPNA and PPNB (6 %, respectively for each). The other periods are represented by less than 1% each.

Chop versus slice marks

The vast majority of butchering marks on the bones come from knife slice marks (96% - Table 4). Only a few chop marks were found (4%). Most of the chop marks (9 out of 10) came from the MBA tombs. Only one other chop mark was identified and it came from an EBA context.

Table 4. Frequency distribution of butchered bones by period and type of instrument (NISP).

	Butcher type					
Period	**Chop**		**Slice**		**Total**	
	No.	***%***	***No.***	***%***	***No.***	***%***
Protoneolithic	0	0.00%	4	100.00%	4	1.48%
PPNA	0	0.00%	17	100.00%	17	6.27%
PPNB	0	0.00%	17	100.00%	17	6.27%
Pottery Neolithic	0	0.00%	1	100.00%	1	0.37%
Early-Middle BA	0	0.00%	1	100.00%	1	0.37%
EBA	1	5.88%	16	94.12%	17	6.27%
MBA	0	0.00%	27	100.00%	27	9.96%
MBA tomb	9	4.81%	178	95.19%	187	69.00%
total	10	3.69%	261	96.31%	271	
MBA subtotal	9	4.21%	205	95.79%	214	78.97%

The paucity of chop marks should not be interpreted to mean that more slicing than chopping was done at the site. These data are not appropriate for this interpretation. The problem with chopping activities, either from an axe, adze, hammer, or other heavy implements, is that it usually fragments the bone. In effect, it destroys evidence of its own existence. All that is usually left are a variety of fragments, only some of which may preserve the impact mark. In contrast, slicing marks usually do not destroy or fragment the bone. As a result, there is better preservation of the distribution of slicing marks on bones.

Stone versus metal cut marks

Both stone and metal cut marks were found in the assemblage (Table 5). The vast majority of butchering marks were made by metal tools (77%). But the percentages shift dramatically over time. In the earliest periods, the ProtoNeolithic, Pre-pottery Neolithic, and Pottery Neolithic, metal tools are absent – with the exception of two metal cut mark types in the PPNB sample. These are probably intrusive or mislabeled. With the advent of the EBA, metal tool marks appear with increasing frequency. They are present in 41% of the EBA, but their frequency rises dramatically in the MBA to 85.19% in the tell deposits and to 95.19% in the tomb deposits.

This pattern parallels the data from other sites, such as Afridar near Ashkelon. In the EB I sample at Afridar, 89% belongs to stone tools and the remainder is identified as metal tool marks (Greenfield 2004).

Raw material by taxon

There is no perceived pattern of which taxa were butchered with the various types of raw material (Table 6). In the periods with metallurgy (EBA and MBA), both domestic and wild taxa are butchered with both metal and stone tools.

Table 5. Distribution of cut marks by type of instrument (NISP).

Period	**Metal total**		**Stone total**		**Total**
	No.	***%***	***No.***	***%***	***No.***
Protoneolithic	0	0.00%	4	100.00%	4
PPNA	0	0.00%	17	100.00%	17
PPNB	2	11.76%	15	88.24%	17
Pottery Neolithic	0	0.00%	1	100.00%	1
EBA	7	41.18%	10	58.82%	17
Early-Middle BA	0	0.00%	1	100.00%	1
MBA	23	85.19%	4	14.81%	27
MBA tomb	178	95.19%	9	4.81%	187
total	210	77.49%	61	22.51%	271
MBA total	201	93.93%	13	6.07%	214

Table 6. Distribution of cut marks by taxon and period (NISP).

Period	Domestication	Taxon	Metal	Stone	Total
			No.	*No.*	*No.*
Protoneolithic	Wild	*Gazella* sp.	0	4	4
PPNA	Wild	*Gazella* sp.	0	14	14
PPNA	Wild	*Sus scrofa ferus*	0	1	1
PPNA	Wild	*Vulpes vulpes*	0	1	1
PPNA	Wild	*Bos primigenius*	0	1	1
PPNB	Domestic	*Bos taurus*	1	1	2
PPNB	Wild	*Gazella* sp.	0	9	9
PPNB	Wild	*Sus scrofa ferus.*	0	1	1
PPNB	Wild	*Bos primigenius*	1	4	5
Pottery Neolithic	Domestic	*Ovis*	0	1	1
Early-Middle BA	Wild	*Gazella* sp.	0	1	1
EBA	Domestic	*Bos taurus*	3	4	7
EBA	Domestic	*Ovis*	2	3	5
EBA	Domestic	*Ovis/Capra*	2	2	4
EBA	Wild	*Ovis orientalis*	0	1	1
MBA	Domestic	*Equus caballus*	2	1	3
MBA	Domestic	*Ovis*	0	1	1
MBA	Domestic	*Ovis/Capra*	17	2	19
MBA	Domestic	*Sus scrofa* dom.	1	0	1
MBA	Domestic	*Sus scrofa ferus*	2	0	2
MBA	Wild	*Dama mesopotamica*	1	0	1
MBA tomb	Domestic	*Bos taurus*	3	1	4
MBA tomb	Domestic	*Capra*	14	0	14
MBA tomb	Domestic	*Capra hircus*	9	0	9
MBA tomb	Domestic	*Equus asinus*	4	0	4
MBA tomb	Domestic	*Ovis*	105	6	111
MBA tomb	Domestic	*Ovis aries*	19	1	20
MBA tomb	Domestic	*Ovis aries?*	2	0	2
MBA tomb	Domestic	*Ovis/Capra*	22	1	23
Total			210	61	271

Conclusions

While the data from Jericho are admittedly very small and were collected haphazardly in the field, the sample still represents a significant data set for many of the periods in the region. Few other sites have each of these periods represented.

Other problems that plague the analysis are that it is hard to obtain a statistically significant pattern from small sample sizes and it is always possible that some material from multi-period sites that is found in one or another stratum is either residual or intrusive, especially when the objects are small (such as animal bones). As a result, it is always possible that in a very small database, the effect of possible intrusions becomes statistically greater. It will only be from relatively large samples that we can have enough reliable data to draw definitive conclusions. Nonetheless, the data from Jericho allows us to draw some tentative conclusions.

The evidence from Jericho indicates changes in butchering technology over time. It was exclusively reliant upon stone tools in the Neolithic phases. Most tools were probably unmodified flakes, haphazardly made, or blades. In contrast, the data from the EBA and MBA indicate a substantial shift in butchering technology from stone to metal. Stone continues to play an important role in the EBA, but it is barely present in the MBA. This is not surprising given the nature of metallurgy in these two periods. Only copper or occasionally natural arsenical alloys (i.e. arsenical bronze) are in use until the very end of EB III when tin makes an appearance (Shalev 1994; Tylecote 1992). The evidence from the cut marks supports such a contention. A functional butchering bronze metallurgy is entirely or almost nonexistent and this is evident from the lower frequency of use of metal tools in the Early Bronze Age butchering process.

The data from Jericho are important for increasing our understanding of the spread and rate of adoption of a functional metallurgical butchering technology. It would appear to be adopted in spurts, similar to the process described for the abandonment of stone tools by Steve Rosen.

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