

Macro- and Microscopic Aspects of Bone Tool Manufacture and Technology in the Levantine Iron Age: A 9th Century BCE Workshop from Tell es-Safi/Gath, Israel

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INTRODUCTION

Human utilization, and alteration, of animal bone is evident from the earliest prehistoric periods (e.g., Villa and d'Errico 2001; Vincent 1993), and continued to be a dominant facet of human material culture, even following the advent of metal technology. Needless to say, the attraction of bone in antiquity probably lay in its common availability and cheapness, since any animal consumed could provide suitable raw material. Moreover, its innate natural properties, being soft but strong, made it suitable for the production of a wide range of utilitarian as well as luxury items (Christensen 2004; MacGregor 1985). Thus, in almost all archaeological contexts in the Ancient Near East, there is extensive evidence for bones modified to form ornaments, tools and utensils.

From a perusal of the archaeological literature of the Near East, it is apparent that the vast majority of studies of bone artefacts have focused on their typology (e.g. Ayalon 2005a; Stordeur 1977), although a few studies have paid attention to the technologies involved in the production of these "mundane" items so common in the archaeological repertoire (e.g. Campana 1989; Christidou 1999; Le Dosseur 2006; Newcomer 1987). This imbalance may be attributed to:

- 1) The fact that only a limited number of 'bone workshops' have been excavated in this region. Exceptions are Middle Bronze Age production contexts at Umm el-Mara, Syria (Nichols and Weber 2006), an Iron Age workshop from Stratum K-4 (=VIA) in Megiddo, Israel (Gadot and Yasur-Landau 2006: 591) and extensive Roman period bone-working debris (if not a workshop *per se*) at Caesarea, Israel (Ayalon 2005a).

- 2) The mobility of craftsmen and the temporary nature of their workshops (Barnett 1982: 11, 46; Zaccagnini 1983).

- 3) Poor retrieval techniques during excavations that have resulted in animal bone collections that are severely biased. This is due to the fact that in most excavations, bones in general have either not been systematically collected or not recovered in a sufficiently robust manner (i.e. sediments fine-sieved), so that waste products related to bone tool production may well have been missed.

- 4) The traditional concentration in Near Eastern archaeology on artifacts having aesthetic value has resulted in only complete pieces being collected. Only relatively recently have non-worked bones and debitage been systematically saved. A series of workshops discovered in the Late Bronze Age palace at Kamid el-Loz (Mansfeld 1985) may be such a case: although the publication presents detailed descriptions and technical analyses of metal slag and other materials found therein. It lists only very brief catalogue entries for modified bones, and then only items recognizable as tools. If there was any debitage recovered, it is not reported. Such data are often separately listed, in the general zooarchaeological reports, rather than in the bone tool studies (e.g. Greenfield and Fowler 2005).

For these reasons, the recent discovery at Tell es-Safi/Gath of a bone tool workshop dating to the 9th century BCE (late Iron Age IIA) offers an important addition to our knowledge of this common, but little known, aspect of past human technology. It provides an opportunity to study the context, methods and technology of bone tool production in this period.

The Workshop

The excavations at Tell es-Safi/Gath have provided a wealth of information regarding a wide range of periods and cultures, ranging from the proto-historic through modern periods (Maier 2003; 2008). Of particular importance are the remains relating to the various stages of the Iron Age, when the site was one of the main cities of the Philistines, “Gath of the Philistines” (Fig. 1). As such, impressive evidence of most of the developmental stages of the Philistine culture have come to light, from the early Iron Age (ca. 1200 BCE), until the 8th century BCE. Within this archaeological/stratigraphic sequence, the remains from the late 9th century BCE are noteworthy. Throughout the site, a well-preserved destruction level dating to the end of the 9th century BCE has been discovered. This destruction level affords a unique opportunity to study the material culture of a less-known stage of the Philistine culture. The excellent preservation of the remains, as well as the uniquely diverse and rich nature of the archaeological finds therein, offers unique opportunities to study diverse aspects of the daily life of the Philistines at Gath during the late 9th century BCE (e.g., Ben-Shlomo, Shai and Maier 2004; Maier and Shai 2005; Shai and Maier 2003; Zukerman et al. 2007; Ben-Shlomo et al. 2008). In general, it is believed that the destruction of the site as represented in this level (along with a related siege system surrounding the site) is to be connected with the conquest of Gath by Hazael of Aram Damascus, as mentioned in II Kings 12:18 (e.g., Maier 2004; Maier, Ackermann and Bruins 2006).



Fig. 1 : Map showing location of Tell es-Safi/Gath, selected Philistine sites and Megiddo where another bone workshop was found.

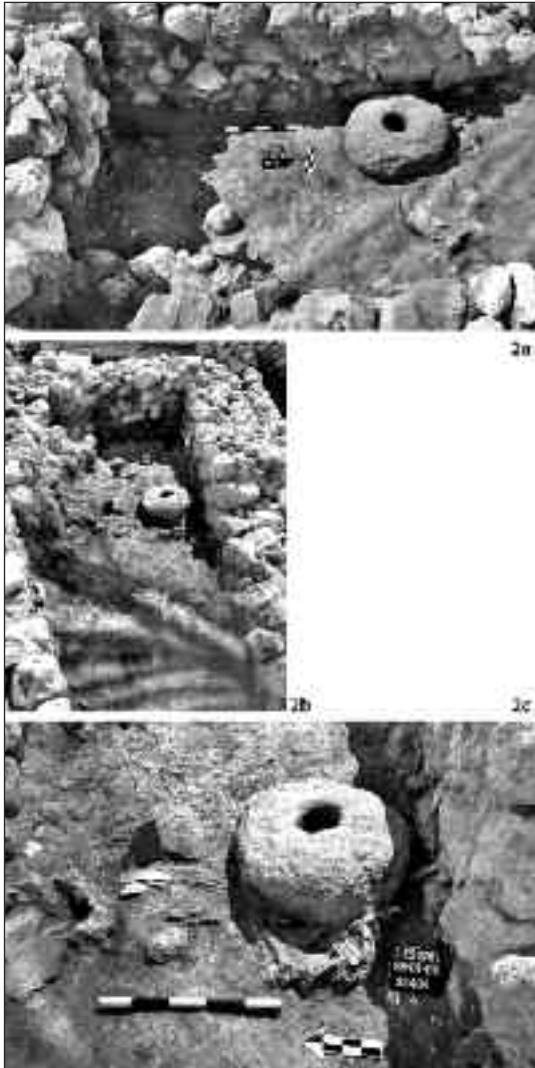


Fig. 2: Views of the workshop and its vicinity in Locus 95404/95405 (Tell es-Safi/Gath, Area F).

(a-b) General view, looking south (a) and east (b), of Locus 95404/95405 – showing the excavated room and doughnut-shaped stone around which the worked bones were found;

(c): Close up view, looking east, of the doughnut-shaped stone and the concentration of worked bones in Locus 95404.

The bone workshop is located in Area F, Locus 95404, an excavation area situated to the north west of the summit of the site (Fig. 2a-b).¹ This context represents portions of a partially excavated room within an apparently multi-roomed structure (at present, not completely excavated) which was destroyed in the late 9th century BCE along with the contemporary stratum throughout the rest of the site. The area of the workshop and its immediate environs contained a large assortment of finds mainly of a domestic nature, including different types of pottery characteristic of this period, all destroyed in a collapse. In the center of the excavated room, there was a large (ca. 50 cm in diameter), doughnut-shaped stone (Fig. 2a-c). Around the stone, a total of 141 fragments of worked bone and some 120 small unworked bone splinters ca. 1-3 cm in length were recovered.

Archaeozoological analysis of the bones by two of us (JL and LKH) showed that all 141 worked bones derive from the lower forelimb (metacarpal) and hindlimb (metatarsal) of adult domestic cattle (*Bos taurus*) (Fig. 3a-b). An estimate of the minimum number of elements (MNE) represented by these modified long bones was 14 since they comprised 6 metatarsals, 4 metacarpals and 4 indeterminate metapodial fragments (Fig. 4) – the latter may represent either the lower forelimb or hindlimb. This estimate was based on the reoccurrence of the same distal portion of the bone, with the side of the bone (left or right) not taken into account due to the difficulty in determining the side from the

1. The Tell es-Safi/Gath Archaeological Project is directed by AMM; LKH and JLT serve as project archaeozoologists; HJG conducted the SEM and spectrographic analyses of the bones. Note that the locus of the bone workshop itself is 95404; the general surface around it was defined as locus 95405. For a preliminary study of the workshop, see Horwitz et al. 2006.

small portions of preserved distal shaft. All remains represent waste or *debitage* and no finished items were recovered. Many of the bones were burnt to varying degrees: this does not relate to working of the bone, but rather reflects their context in the destruction layer associated with this stratum.

Two aspects of bone working technology may be elucidated at the Tell es-Safi/Gath workshop.

1) The first focuses on the process of production from the whole bone to the finished product by reconstructing the *chaîne opératoire* (i.e. “operational sequence” or “core reduction sequence”). This idea of an operational sequence was defined by Bar-Yosef et al. (1992: 511) as «the different stages of tool production from the acquisition of raw material to the final abandonment of the desired and/or used objects. By reconstructing the operational sequence we reveal the choices made by... humans.” The *chaîne opératoire* perspective has most commonly been utilized in relation to prehistoric stone tool production (e.g., Bar-Yosef and Van Peer 2009; Karlin et al. 1991), but it can also be applied to document and describe the process of manufacture of other items (e.g., Schlanger 1994; Bleed 2001). This approach relates to the technology and skill applied to the process of transforming raw material into artefact.

2) The second aspect is the identification of the types of tools used in the manufacturing process, and specifically whether they were made of stone or metal. Using methods first developed by Olsen (1988) and later expanded upon by Greenfield (1999; 2000; 2002a; b; 2004; 2005; 2006) through extensive experimental research, a sample of 7 bones from the workshop were examined by one of the authors (HG). This approach focuses on the analysis of marks and modifications visible on the bones’ surfaces through the application of binocular and scanning electron microscopy.

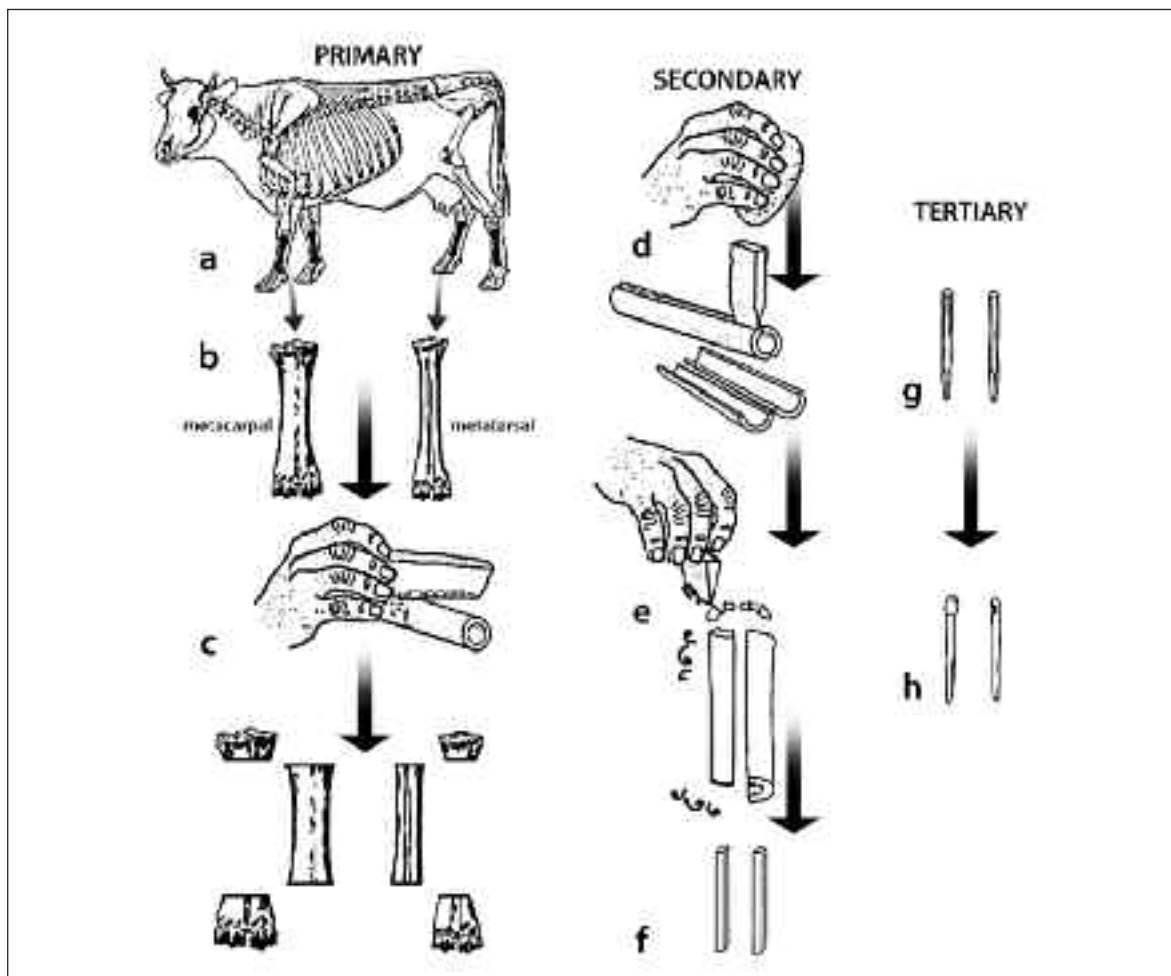


Fig. 3: Drawing showing suggested bone reduction sequence (*chaîne opératoire*) to produce artifacts.

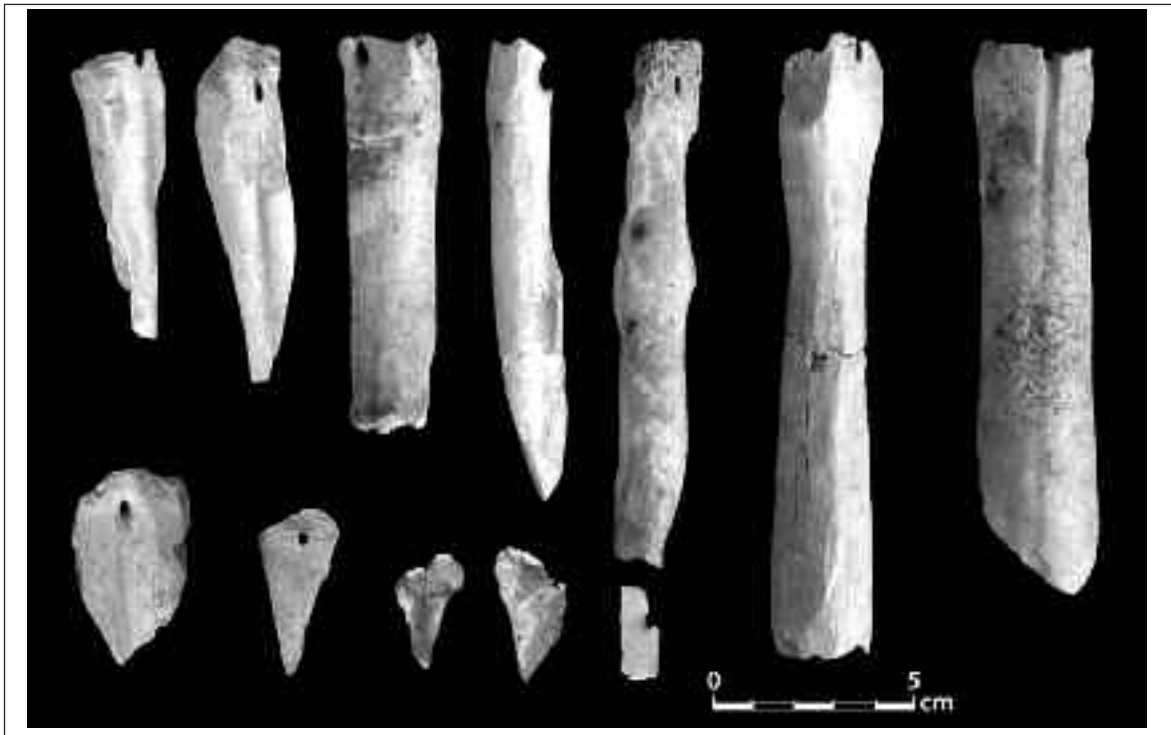


Fig 4: Photograph showing twelve of the fourteen distal metapodial ends represented in the workshop assemblage. Note absence of distal and proximal epiphyses and the incomplete shafts.

The Operational Sequence (*chaîne opératoire*)

Following researchers such as Ashby (2005), we have identified three main stages in the production of the Tell es-Safi/Gath bone artefacts.

1) *Primary Stage*: the initial processing of unworked material that involved and included raw material selection and the chopping/sawing up of complete bones into smaller, workable pieces.

The work at Tell es-Safi/Gath commenced with the selection of complete metapodia (metacarpals and metatarsals) of domestic cattle, *Bos taurus* (Fig 3a-b). These bones are all derived from adult animals, i.e. of large size, with fused ends and a thick and dense bone structure with a relatively large area of perpendicular long bone shaft. These are features which made them ideally suited for manufacture of artifacts since they can be reduced in all dimensions.

As attested to by the surviving bone debris (i.e. the presence of few epiphyseal ends in the assemblage, bone shafts without ends and smoothed shaft ends), both epiphyseal ends of the bones were cut off and the resulting shaft ends smoothed (Fig. 3c; Fig. 5a). The presence of multiple-stepped cut marks at the ends of the shafts suggests that a groove and snap technique may have been used to remove the epiphyses (Fig. 5b).

2) *Secondary Stage*: involved the conversion of these pieces into blanks and roughouts for the production of the final object.

The external surface of the metapodial shaft was then modified through chiseling resulting in the removal of bone flakes making the shaft less angular (Fig. 3e). As will be discussed below, this was achieved using metal chisels that left characteristic marks on the surface of the bones (Fig. 6).

The resulting metapodial shaft (minus ends) was then split into two equal halves down the shaft (Fig. 3d). This was probably achieved by percussion of a sharp tool against the midshaft of the bone which rested on a hard surface, such as the large doughnut-shaped stone found in the room which could have served as an anvil. Since metapodials are composed of two separate bones which fuse along their longitudinal axes before birth, but which retain a distinctive indentation or midshaft sulcus on the dorsal aspect marking where they fused, this morphological feature enabled the bone



Fig. 5: (a) Evidence of the primary production stage: a metacarpal bone with proximal and distal ends removed (Stage c). (b) Close up of metapodial ends showing stepped cut marks and deep groove at the shaft ends indicating possible use of a groove and snap technique for removal of bone ends.

to be easily split in a longitudinal direction. This action would have resulted in straight long bone ‘blanks’ ready for further working. We can reconstruct these actions due to the large number of elongated bone blanks made from halved metapodial shafts, which have extremely flat and straight edges as well as the presence of percussion fracture scars on numerous fragments (Fig. 7). Such longitudinal shaft fragments edges could only have been obtained by percussion action made on fresh bone with a sharp tool, since old bone would have fractured horizontally.

3) *Tertiary Stage*: This is the final phases of construction of the object when it was trimmed, smoothed and finished.

The resulting bone blanks (Fig. 3f) are then further reduced in size and shape, by chiseling extraneous bone and smoothing the surface, to form rough-outs (Fig. 3g-h).

4) *Final Product*

The central question remains, “what was being produced in this workshop”? Cattle metapodials, due partly to their availability as butchering waste and partly due to the physical properties of the bones – straight-sided, thick and easy to split longitudinally – seem to have been widely employed across time and space as a raw material for a variety of tools. Bone tool workshops are much more common in later sites, especially post-Roman sites in Europe (but see Ayalon 2005b). These workshops appear to have concentrated on the use of cattle metapodials for their products, which ranged from prayer beads and dice (Spitzers 2006) to combs (Mührenberg 2006) and, no doubt, other items as well. In prehistoric periods in the Levant, awls, needles and other pointed objects were frequently manufactured from long bones in general and especially from metapodials (Campana 1989; Le Dosseur 2006).

Unfortunately, no finished bone objects were recovered from the Tell es-Safi/Gath workshop. However, based on the size and shape of the bone blanks, we can suggest that the final products were elongated objects such as arrowheads, points, rods, etc. Several specific examples are noted here based on parallels to contemporaneous assemblages:

a) Arrowheads (Fig. 8a): Bone arrowheads are known from several Iron Age II sites in the Southern Levant, including Lachish (Tufnell 1953: 398, Plate 63; Gottlieb 2004: 1908, Colour Plate IX, Figure 27.1), Megiddo (Loud 1948: Plate 174), Gerar (Petrie 1928: 16, Plate XXIII) and Gezer (Macalister 1912: Plate CCXV). They vary in form, from simple rough points to elegant leaf shapes complete with tangs.



Fig. 6: Secondary stage of bone tool production: chisel marks on bones surface (Stage e).

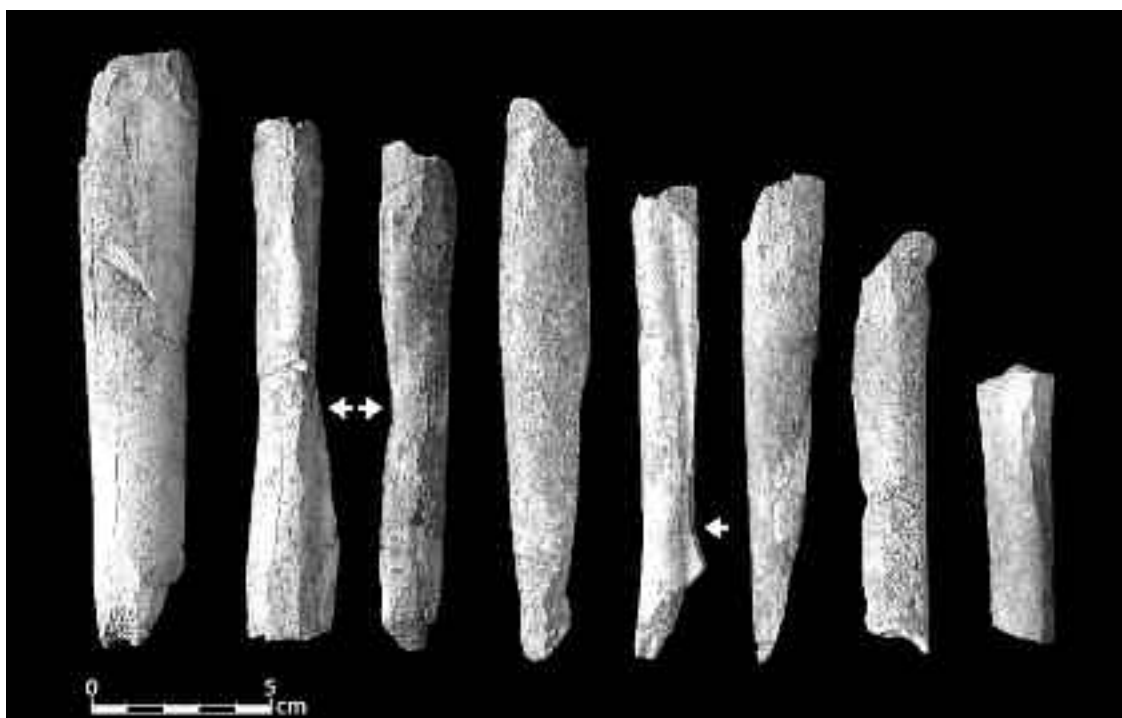


Fig. 7: Secondary stage of bone tool production: Long splinters of bone with straight edges and evidence for percussion marks –white arrows.

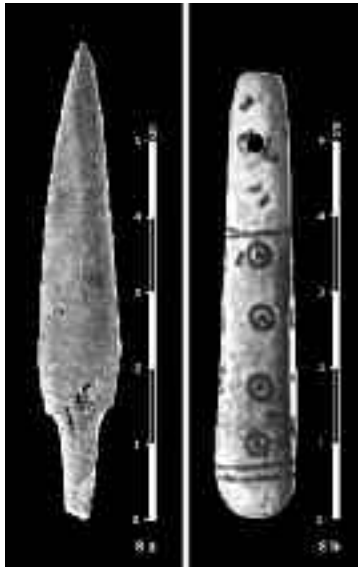


Fig. 8: (a) A bone arrowhead from Lachish, Stratum III (late 8th century BCE, registration number 39-798; photo courtesy of Israel Antiquities Authority); (b) A bone “pendant” from Tel Batash, Stratum V (Iron Age IB), L. 4.6. cm (photo courtesy of A. Mazar [after Panitz-Cohen and Mazar 2006: 262-263, photo 129:b]).

The evidence from the Tell es-Safi/Gath assemblage which supports this idea includes the presence of one piece that resembles a rough-out for a leaf-shaped arrowhead, the similarity of tool working marks on a bone arrowhead from Lachish which was discovered in the Assyrian destruction level at that site (Fig. 8a; see Ayalon and Sorek 1999: 33 for a close-up photograph of such an arrowhead), and the probability that this piece too was manufactured from a cattle metapodial. In terms of the archaeological context of the Tell es-Safi/Gath workshop – it was situated in a house which was destroyed during the the Aramean seige, suggesting that bone arrowheads may have been produced on site as part of the defensive measures before or during the Aramean attack. A similar context and explanation has been suggested for the bone arrowheads from Lachish (Gottlieb 2004: 1908).

b) Teardrop-shaped bone objects (Fig. 8b): Another possible object that might have been produced in this workshop is a class of objects whose use has been debated over the years. In many Iron Age contexts, elongated, teardrop-shaped bone objects are found, often decorated with a series of drilled concentric circles on the various facets of these objects. The objects have been interpreted as either related to divination (Tufnell 1953: 194, 205, 381-83), as decorative pendants (e.g., Platt 1978; Ariel 1990: 136-37; Mazar and Panitz-Cohen 2001: 262-63), or as a netting bobbin used in weaving nets (e.g., Ackerman and Braunstein 1982: 67).

c) Rods: Various types of rods, some decorated, some not, are well-known from Iron Age sites in Israel, and perhaps, might have been produced in the workshop (e.g., Ariel 1990: 140-41).

One relatively common type of implement fashioned from bone, i.e. handles, can seemingly be ruled out as having been produced in this workshop. Based on finds of several finished bone handles from Israel, Jordan and Iraq, Fischer and Herrmann (1995) contend that there existed a distinctive, if Assyrian-inspired, school of bone carving in the southern Levant for some point between ca. 900 and 700 BCE, and posit that one or more such workshops existed in the region, producing such work. The handles reviewed in the latter article appear to have been made from the long bones of bovids or cervids. The thickness reported for one of the carved bones, between 0.4 and 0.9 cm, generally accords with long bones of animals smaller than cattle, most likely sheep, goats, gazelles or fallow deer. Moreover, the handles were most likely manufactured on femora rather than metapodials and utilized a very different technique of modification, i.e. carving rather than splitting and chiseling.

Identification of Tools Used in the Production Process

As noted above, a large doughnut-shaped stone was found in the workshop adjacent to the bones, and it is possible that it was used in part of the production process, such as an anvil in both the primary and secondary stage of production (above). In addition, seven metapodials from the workshop assemblage: two metacarpals (bones 111, 57), four metatarsals (bones 69, 113, 103, 107) and

Bone/Sample	Bone Element	Part of Element Represented	Aspect Represented	% Represented of Total Bone
111	Metacarpus	Distal shaft	Cranial half	10
57	Metacarpus	Proximal and distal shaft	Lateral half	20
113	Metatarsus	Proximal and distal shaft	Lateral half	40
103	Metatarsus	Proximal and distal shaft	Lateral half	40
107	Metatarsus	Distal shaft	Cranial	5
49	Metapodial	Shaft		5
69	Metatarsus	Proximal shaft	Lateral half	5

Table 1a: Description of bones examined in SEM study

one unidentified metapodial (bone 49) were examined in order to identify the tool/s used to modify them (Tables 1a-b). All bones have an unusually high number and type of tool modification marks.

METHOD

In order to identify butchering and other modification marks, the surface of each of the bones was initially examined using a hand-held magnifying glass with low magnification and light optical (LOM) microscope (up to 40x). Subsequently, silicone moulds were made of areas showing modifications in order to further study the marks using a Scanning Electron Microscope (SEM). The SEM technique of analysis is described in detail elsewhere (Christidou 2005; Greenfield 1999; 2000; 2002a; b; 2004; 2005; 2006). It focused on distinguishing stone from metal tools used in artefact manufacture and butchery, using a variety of artefact morpho-types – flakes, blades, chisels, and scrapers. Variations on the technique of analysis are described below.

For the most part, SEM observations were made at low magnifications (c. 15-20x – all powers are relative to the microscope involved) and higher magnifications (50-100x). The variation depended on the size of the area or groove being examined. Larger grooves required lower magnification in order to fit into the image. Powers of 15-20x were the lowest magnifications useable in the SEM. Because of the size of the grooves, the highest magnification was limited to c. 100x. In cases where stone tool marks have been examined, higher magnifications are often found to be useful (e.g. up to 300x) because the grooves are thinner and finer in size. SEM photographs were generally taken from an overhead position at a 45 degree angle.

The first task was to identify the nature of the actions creating the grooves visible on the bone. This was done with recourse to experimental work that has established criteria for identifying the source of marks on bones. These include both natural and cultural sources.

1) *Natural* – scratches, gnawing, weathering cracks, etc. These are all easily distinguishable based on extensive research conducted over the past 30 years by a variety of authors. Scratches are randomly placed, rarely linear in direction and not of even depths (e.g. Binford 1981; Fisher 1995; Gifford 1981; Greenfield 1988; Lyman 1994; Olsen and Shipman 1988; White and Toth 1989).

2) *Teeth marks* – These are distinguished by their deep pitting and U-shaped grooves leading to and from pitted areas (Shipman 1981). The presence of any of these is described under ‘taphonomy’.

Bone/ Sample #	#slices/ chops/ chisel marks	Damage type	Direction of damage (to axis of bone)	Location of damage on bone	Sub-location of damage on bone	Location - face (begin with where it is most)	Sub-face - nearest border	Description (narrow, wide, gouge)	Raw Material of tool (light microscope)	Type of tool	Sharpness of tool
111	4	Groover	Parallel	Distal shaft	Immediately above distal epiphyseal line	Cranial	Whole	Wide	Metal	Groover	Sharp
57a	22	Slice	Parallel	Distal shaft	Lateral half	Cranial	Whole	Medium	Metal	Knife	Medium
57b	8	Chisel mark	Parallel	Shaft – proximal and distal	Lateral half	Cranial	Whole	Wide	Metal	Chisel	Sharp
113a*	11	Chisel mark	Parallel	Shaft – proximal and distal	Lateral half	Cranial	Whole	Wide	Metal	Chisel	Sharp
113b**	7	Chisel mark	Parallel	Shaft – proximal and distal	Lateral half	Cranial	Whole	Wide	Metal	Chisel	Sharp
103	20	Chisel mark	Parallel	Shaft – proximal and distal	Lateral half	Cranial and lateral	Whole	Wide	Metal	Chisel	Sharp
107a	5	Groover	Parallel	Shaft – distal	Distal half	Cranial	Whole	Wide	Metal	Groover	Sharp
107b***	5*	Slice and chop	Perpendicular	Shaft – distal	Immediately above distal epiphyseal line	Cranial	Lateral half	Wide, Narrow	Metal	Knife	Sharp
49	7	Slice	Parallel	Shaft			Whole	Wide	Metal	Slice	Sharp
69	27	Chisel mark	Parallel	Shaft – proximal	Whole	Lateral	Whole	Wide	Metal	Chisel	Sharp

Table 1b: Description of damage found on bones. Note that for three bones (57, 113, 107) two different areas on each bone were examined. These are listed as 'a' and 'b' respectively.

* Polished marks; Chisel made a series of parallel steps; then breaks at end. Chisel begins proximally, ends distally.

** Unpolished marks.

*** Slices consist of 3 narrow chop/chisel marks in addition to 2 deep slices/grooves.

3) *Cultural* – Experiments by various researchers have established the criteria for a number of sources for marks on bones created by tool use or production (e.g., Christidou 2005; Greenfield 1999; 2002a; 2006; Olsen 1988; Shipman 1981; von Lettow-Vorbeck 1998; Watts 1997).

The types of marks made by human activities can be divided into a few basic groups, as follows:

- 1) Slices are incisions that resemble relatively straight and thin lines.
- 2) Scrapes can be identified by the irregular removal of a layer from a base material by a shearing action, such that the base material is exposed over an extended area. A scrape tends to vary in width and depth over a very short distance. Scrapes will often have long straight fine parallel internal striations and present polish. They tend to lack a clear apex and may also show wave-like patterns in place of an apex.
- 3) A chisel mark is a more regular removal of layers. Marks left by chisels tend to be of uniform width and tend to be of similar depth, although they usually start very abruptly at one end and progressively rise toward the other end. Often fine parallel striations are visible to the eye because of irregularities in the chisel blade. Striations can also be made with a slight tooth pattern, as often found on modern chisels for working stone.
- 4) Channels made by a grooving instrument, such as a burin, to remove a thick strip of bone. Such marks will have relatively tall sides with a rounded apex.

THE RAW MATERIAL OF TOOLS

Even following the adoption of metal, stone tools continued to be used in the southern Levant (Rosen 1984; 1997). Consequently, the potential repertoire of tools used in the Tell es-Safi/Gath workshop includes those made of stone, copper, bronze and iron.

It is not easy to distinguish between metal and stone tool marks, but there are some general principles that one may follow based on experimental studies (Greenfield 1999; 2000; 2002a; 2006). The differences are visible under high light optical or low SEM magnifications. Metal knives produce either a sharp and balanced V- or a broad, angular, flat-bottomed, U-shaped profile, and lack any parallel ancillary striations (Fig. 9). In contrast, stone knives leave a more irregularly shaped profile, usually with a deep groove at the bottom of the groove, a steeply angled side and a gradual rising of the other side, and with one or more parallel ancillary striations. Lithic raw material differences can also be identified. Obsidian blades produce a narrower slicing mark than other stone types, but cannot be confused with a metal slicing mark. Slicing marks produced by different types of stone (flint and quartzite) are less easily distinguishable from each other. Variability in face (unifacial or bifacial) and retouch on stone blades make it difficult to distinguish between scrapers and flakes.

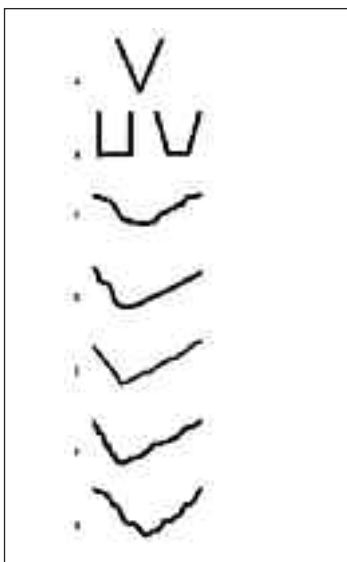


Fig. 9: Scheme showing that metal knives produce either a sharp and balanced V- or a broad |_|- shaped profile, and lack any parallel ancillary striations. Profile of characteristic metal and stone tool slicing marks:
 a. profile of metal blade – sharp flat-edged
 b. profile metal blade – dulled flat-edged
 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.

Until now, there has not been any systematic study designed to distinguish between copper, bronze, iron or steel tool types. This is largely because it was thought that there would not be any perceptible differences between the grooves created by the different raw materials (e.g. bronze and iron blades). However, as will be described below, there are some characteristics based on the ensuing analysis that suggest that there are differences. This is a matter which should be pursued in further study.

Generally, the cutting edge of a tool is composed of a substance that is as hard as, or harder, than the material it will cut and tougher. If not then the blade will either be ineffective in cutting (as it absorbs all the energy as it is damaged) or it wears away rapidly (if it is hard enough to transfer enough of the energy to damage the material). In the case of bone workshop from Tell es-Safi/Gath, either stone or metal tools would have been adequate to fashion the raw material in question.

Analysis of surface markings

The surface markings on seven cattle metapodials from the bone workshop were subjected to detailed SEM analysis. The results are listed here for each bone and specific features given in Tables 1a-b.

BONE 49

Physical observations – *Bos taurus* (domestic) metapodial shaft, 5% of original bone present, adult (fused and not porous), light weathering, modern damage present, and part of tool manufacture (debitage).

Manufacturing marks – There are seven marks (macroscopically visible) spread across the entire face of the shaft that accord with the use of a knife blade, parallel to the long axis of the bone. The marks are not wide, and were made with a sharp metal chisel aimed at artefact production.

SEM observations – At low levels of observation (c. 16x), marks left by a metal knife blade are visible (Fig. 10a). There appears to be at least two different sets of blade marks since they are oriented in more than one direction. A high powered image (100x) of one of the grooves (Figure 10b) shows that it is straight, with steep inclines on both sides and an apex that is dull and flat. There are no lateral striations visible. The width of the groove is narrow (250 microns).

BONE 57

Physical observations – *Bos taurus* (domestic), proximal and distal shaft of a metacarpus (lateral half), 20% of original bone present, adult (fused and not porous), light weathering, modern damage present, and part of a tool (debitage).

Manufacturing marks –

Face A – Twenty-two cuts (macroscopically) made by a metal knife blade. They lie parallel to the long axis of the bone, and are located on the lateral half of the distal shaft, across the entire cranial face. The marks are of medium sharpness and result from artefact production.

Face B – Eight wide scrape marks (macroscopically) made by a sharp metal chisel. They lie parallel to the long axis of the bone, and are located on the lateral half of the proximal and distal shafts, across the entire cranial face. The marks are of medium sharpness and result from artefact production.

SEM observations – This pattern is best viewed at low levels of observation (c. 16x) because the pattern of scrape marks is lost at high magnifications. There are several parallel marks from a single instrument visible in the photograph (Fig. 11a). A higher power image (50x) of the tooth mark of part of the chisel is visible in Figure 11b. The grooves are the same as in Bone 49 – straight, with steep inclines on both sides and an apex that is dull and flat. There are no lateral striations visible. The grooves for each chisel tooth are very narrow (250 microns), but the entire chisel width is very wide (c. 1200 microns).

BONE 69

Physical observations – *Bos taurus*, metatarsus proximal shaft (lateral half), 5% of original bone present, left side, adult (fused and not porous), medium muscle markings, light weathering, modern damage present, and part of artefact manufacture (debitage), and burned (brownish black).

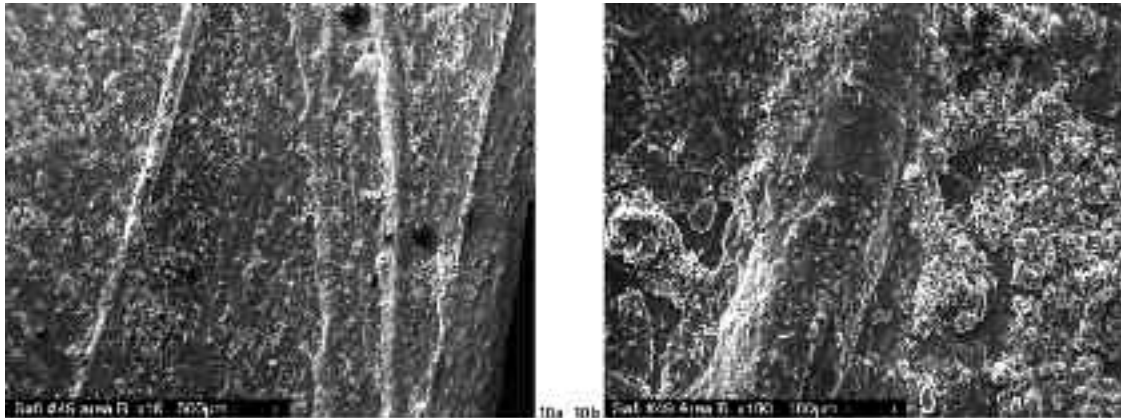


Fig. 10: SEM photograph of Bone 49:

(a) Areas A and B (magnification 16x).

(b) A zoom in of the tooth mark of part of the chisel is visible on the same bone in Figure 10a (Area B – magnification 100x). The grooves are straight, with steep inclines on both sides, and an apex that is dull and flat.

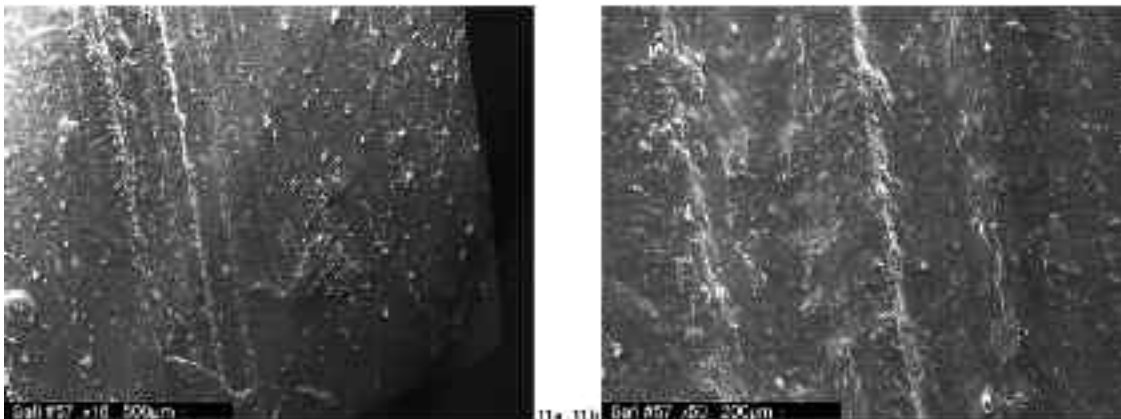


Fig. 11: SEM photograph of Bone 57:

(a), showing several parallel marks from a single scraping instrument visible in the photograph (magnification 16x).

(b) A higher power image of the tooth marks of part of the chisel is visible in Figure 11a (magnification 50x).

Manufacturing marks – Twenty-seven marks (macroscopically visible) accord with use of a sharp metal chisel. They lie parallel to the long axis of bone, on the proximal shaft, across the entire lateral face. The marks are very wide and were made with a sharp metal chisel during artefact production.

SEM observations – The SEM photographs indicate that a relatively flat or very small toothed chisel blade was used to make the visible striations (Fig. 12a). The striations are tightly packed and not very deep (Figure 12b). Each striation is c. 50 microns in width. The marks were made by a very different type of chiselling instrument than in Bones 49 and 57.

BONE 103

Physical observations – *Bos taurus* (domestic), metatarsus, proximal and distal shaft (lateral half), 40% of original bone present, left side, adult (fused and not porous), light weathering, modern damage present, and part of artefact manufacture (debitage).

Manufacturing marks – Twenty marks (macroscopically visible) accord with use of a sharp metal chisel. They lie parallel to the long axis of the bone and are located on the lateral half of the proximal and distal shafts, across the entire cranial and lateral faces. The marks are wide, and were made with a sharp metal chisel in the process of artefact production.

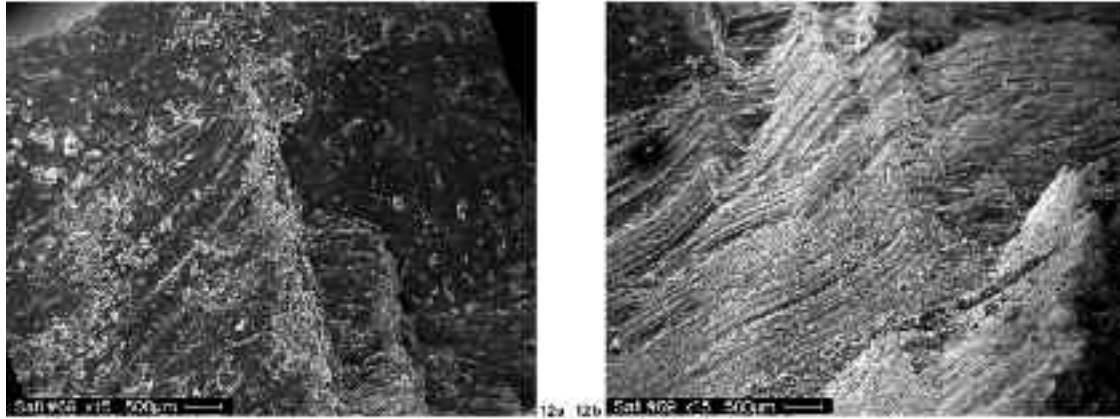


Fig. 12: SEM photograph of Bone 69:
 (a) showing edge of chiseling mark (magnification 1x);
 (b) showing the tight packed nature of the striations (magnification 15x). These indicate that a relatively flat or very small toothed chisel blade was used to make the visible striations.

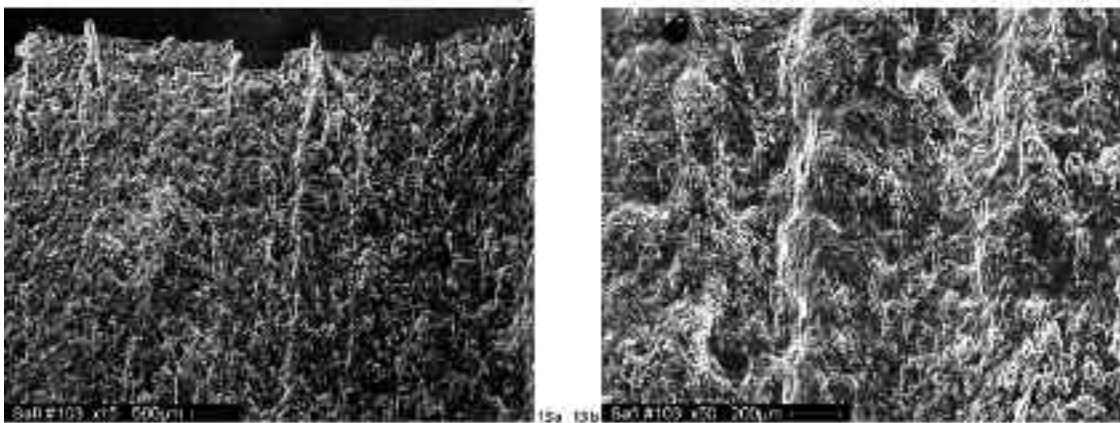


Fig. 13: SEM photograph of Bone 103:
 (a) showing many parallel small striations (magnification 15x);
 (b) At a higher power (50x), the ridges are very uneven and low.

SEM observations – The low magnification (16x) SEM photograph indicates that there are many parallel small striations (Figure 13a). At a higher power (50x), the ridges are very uneven and low (Figure 13b). They were made by a chisel with many small and low teeth.

BONE 107

Physical observations – *Bos taurus* (domestic), distal shaft of metatarsus (cranial face), 5% of original bone present, left side, adult (fused and not porous), light weathering, modern damage present, and part of tool manufacture (debitage).

Manufacturing marks –

Face A – Five wide scrape marks (macroscopically visible) made by a sharp metal chisel. They lie parallel to the long axis of the bone, and are located on the distal half of the distal shaft, across the entire cranial face. The marks are of medium sharpness and result from artefact production.

Face B – Three narrow and two wide slice marks (macroscopically) made by a sharp metal blade. They lie perpendicular to the long axis of the bone, and are located on the distal shaft, immediately above distal epiphyseal line, on the lateral half of the cranial face. The marks were made as the result of artefact production. As the bone was chiselled, the tool made a series of parallel steps, followed by a break at the end. The chisel marks begin proximally and end distally.

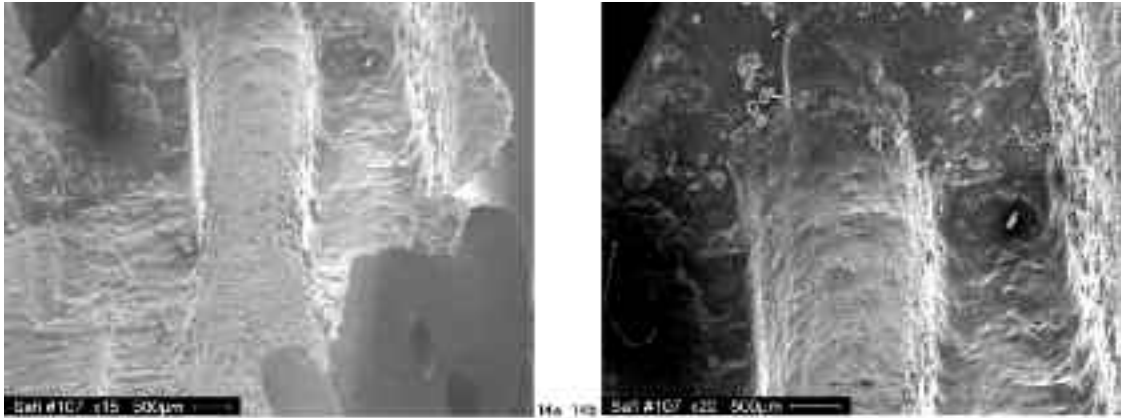


Fig. 14. SEM photograph of Bone 107:

(a) showing a single large groove made by a grooving instrument (burin?) on the edge of the bone (magnification 15x); (b) showing where the groove begins and the lack of parallel striations (magnification 20x). It is straight and steep on both sides with an apex that is rounded.

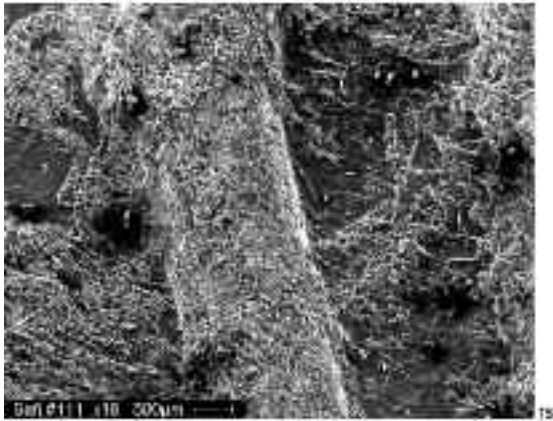


Fig. 15. SEM photograph of Bone 111 showing a single large groove made by a grooving instrument (burin?) on the edge of the bone (magnification 15x).

SEM observations – The SEM photograph is of a single large groove made by a large metal grooving instrument (a burin?) (Fig. 14a). The groove is straight and steep on both sides with an apex that is rounded. There are no parallel striations (Fig. 14b). The mark is extremely wide (c. 1200 microns). It may have been made by an iron instrument, since it is so much wider than any other type of instrument used on any of the other bones.

BONE 111

Physical observations – *Bos taurus* (domestic), metacarpus, distal shaft (cranial half), 10% of original bone present, left side, adult (fused and not porous), light weathering, no modern damage present, and part of tool manufacture (debitage).

Manufacturing marks – Four scrape marks (macroscopically visible) accord with the use of a sharp metal chisel. They lie parallel to the long axis of the bone, and are located immediately above distal epiphyseal line on the distal shaft, across the entire cranial face. The marks are wide and result from artefact production.

SEM observations – The SEM photograph is very similar to that of Bone 107. It is of a single large groove made by a large metal grooving instrument (burin). The groove is straight and steep on both sides with an apex that is rounded (Fig. 15). There are no parallel striations. The mark is very wide (c. 1200 microns) and comparable in width to that found on Bone 107.

BONE 113

Physical observations – *Bos taurus* (domestic), proximal and distal shaft of metatarsus (lateral half), 40% of original bone present, right side, adult (fused and not porous), light weathering, modern damage present, and part of tool manufacture (debitage). The bones represent stage 1 of artefact production sequence, whereby the bone was first chiselled and polished; and then new chisel marks were made without polish. There is a light sheen of surface polish on all exterior faces, except for where the new chisel marks are found on the proximal and distal ends.

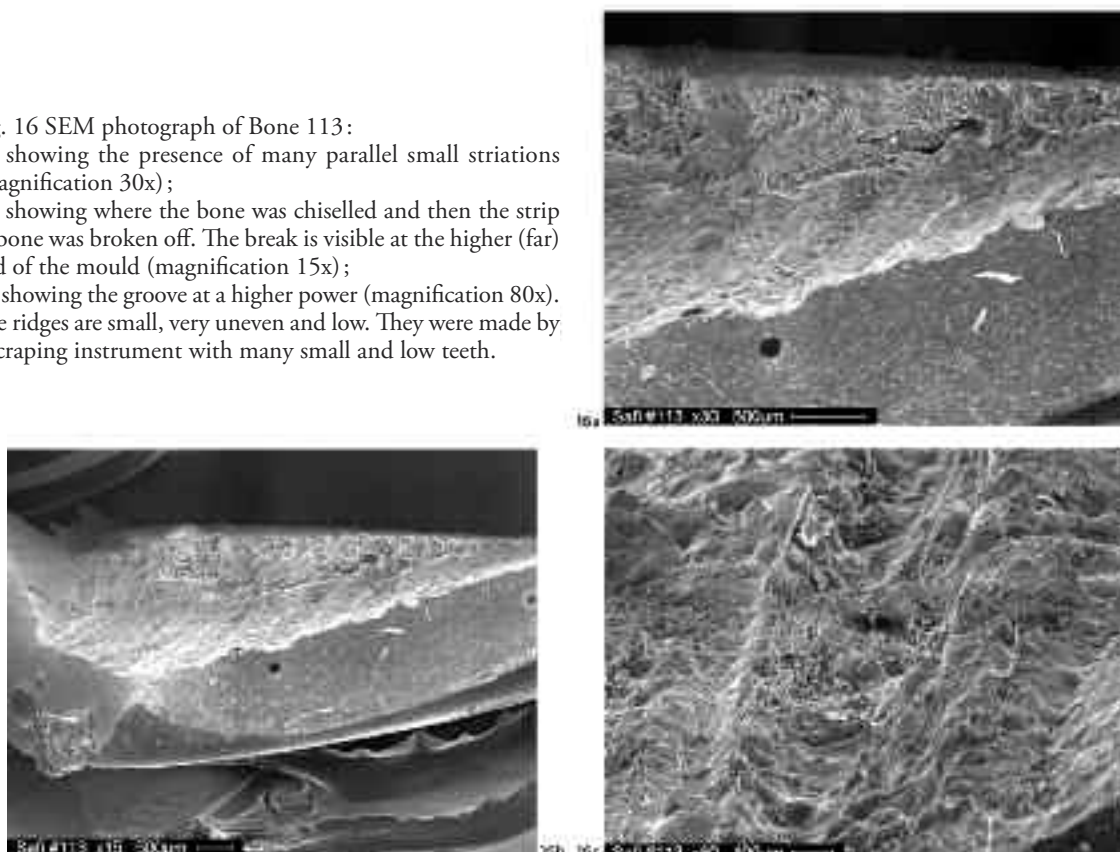
Manufacturing marks –

Face A – These marks represent Stage 1 of the production process. Eleven wide scrape marks (macroscopically) made by a sharp metal chisel, parallel to the long axis of the bone, located on the lateral half of the proximal and distal shafts, across the entire cranial face. The marks are from a sharp instrument and result from tool production. The marks are polished on this face.

Face B – These marks represent Stage 2 of the production process. The new chisel marks are without polish. There are seven wide marks (macroscopically visible) made by a sharp metal chisel, parallel to long axis of bone. They are located on the lateral half of the proximal and distal shafts, across the entire cranial face. The marks were made by a sharp instrument and result from artefact production.

SEM observations – The low power (15-30x) SEM photograph reveals the presence of many parallel small striations (Fig. 16a). The bone was scraped by a chisel and then the strip of bone was broken off. The break is visible at the far (higher) end of the mould (Fig. 16b). At a higher magnification (80x), the ridges are small, very uneven and low (Fig. 16c). They were made by a chiselling instrument with many small and low teeth.

Fig. 16 SEM photograph of Bone 113:
 (a) showing the presence of many parallel small striations (magnification 30x);
 (b) showing where the bone was chiselled and then the strip of bone was broken off. The break is visible at the higher (far) end of the mould (magnification 15x);
 (c) showing the groove at a higher power (magnification 80x). The ridges are small, very uneven and low. They were made by a scraping instrument with many small and low teeth.



DISCUSSION

The bone samples from Tell es-Safi/Gath that were subjected to SEM analysis have yielded some interesting results. Three mark types, cultural in origin, were identified on the workshop bones – slicing, grooving and chiselling activities. None of these appear to derive from scraping of blades across the bone (cf. Christou 2005). All the metapodia were modified by chisels, two were modified by groovers (Bones 107 and 111), and two (Bones 107 and 57) have chisel or groover and knife blade marks on them. All bones were modified in antiquity with the goal of artefact production.

The variety of groove shapes indicates that knives (possibly both narrow and broad blade types), engravers as well as chisels – smooth and small-toothed, were in use at the workshop.

The use of chisels can be identified by the characteristic wide and undulating profile of the marks they produce. In most instances, the chisel used was probably a tooth/claw chisel since it left very narrow internal grooves (grooves 250 microns in width) representing separate teeth of a multiple toothed scraping instrument. In contrast, some of the marks, such as those on Bones 107 and 111, were made by a wide metal engraving (grooving) instrument (grooves c.1200 microns in width), as the groove profiles have straight and steep sides and an apex that is rounded.

In some instances, the chisel marks follow a distinctive pattern. As the bone was chiselled, the chisel made a series of parallel steps; then broke off at the opposite end of the bone. The chiselling often began proximally and ended distally (for example Bone 111). Often each chiselled groove was made by multiple strokes in order to remove the layers of bone. The bone slivers resulting from slicing, chiselling and grooving would have been extremely thin and not of consistent length, making them unsuitable for use in tool manufacture. As such, the main aim of these activities was to reduce the mass of the larger bone blank and to shape it for artefact production. The fact that none of this 'fine' debitage has been recovered from the workshop may be attributed to natural diagenesis of these fragile splinters or that they were incinerated during the destruction of the house. A third option, that the workshop floor was cleaned, seems unlikely given the presence of larger bone debris.

In contrast to the chisel, the blades (knives) left a more V-shaped slicing profile, although two different sized blades may have been used since there are both narrow and broad slice marks. The very large size of some of the resulting grooves indicates a relatively coarse cutting instrument. It is hypothesized that iron was used since the size of the grooves far exceeds that seen on bones studied from earlier time periods (Greenfield 2004, 2005). The width and coarseness of the grooves may serve as a feature with which to trace the introduction of iron throughout the region.

It would appear that the two processes (grooving and chiselling) were more or less mutually exclusive in this small sample. There appears to have been little surface preparation of bones before the major chiselling took place. Bones were selected whole and then chiselled and further sub-divided.

One metatarsus (Bone 113) is the remnant of a production process where it was first chiselled and then underwent polishing, i.e. use-wear. This would be a remnant of stage one since there are chisel marks without polish. This is based on the presence of specimens, both with and without polish.

A total of 113 tool marks were identified on the sample of 7 bones – 73 chisel marks, 9 grooves, and 32 slice marks (Table 1a-b). The number of marks on any single specimen was highly variable; from a low of four (Bone 111) to a high of twenty-seven (Bone 69). There is clearly little uniformity in the distribution of cut marks by frequency.

Bone Tool Production and Craft Specialisation

The existence of this workshop, containing as it does not only blanks and debris, but also, seemingly, an anvil stone used in the production process, suggests that there existed full or part-time craft specialists who manufactured one or more types of bone implements. Therefore, the bone tool workshop is evidence of a specialised economy which we define, following Zeder (1988: 3), as “a set of economic relations in which there is external differentiation within related activities whose conduct is characterized by segregation in personnel, timing, and locale.” Thus, the importance of this workshop lies both in the specific, in terms of how the debris sheds light on the process of making bone

tools and debates related to the timing and spread of certain tool technologies, as well as the general, relating to the development of specialised economies.

Certainly, by the Iron Age II, craftspeople were common in the complex societies of the Near East, but as mentioned above, workshops documenting the work of such labourers in any craft are not common finds. What is more often used as documentation for the existence of craft workshops and specialists are stylistic traditions. In this way, Fischer and Herrmann (1995) posit the existence of a local Levantine centre for the crafting of elaborately carved bone handles, based on comparison of finds from sites in the Levant with contemporary ones from Iraq. Yet, style and its meaning is a matter of debate in archaeological literature (e.g., Sackett 1982; Wiessner 1983) and as such, without actual evidence for a workshop, it is difficult to prove that craft specialists existed in specific locales.

However, workshops, even without benefit of finished or near-finished products and evidence of distribution, certainly provide excellent evidence of craft specialization. The bone tool workshop presented here is particularly intriguing because it apparently represents the activity of a full or part-time craft specialist. In Rosen's (1997: 113) view, evidence for craft specialization consists best of workshops where only specialised goods are produced, as opposed to a wide variety of material culture. To judge by the restricted materials utilized, i.e. only cattle metapodials, and the standardized reduction sequence, a rather limited range of tools or even a solitary type would have been produced. Evans (1978: 115) listed a number of finds which should be present in order to establish that specialised craft production took place:

1. *Workshops*: specialised areas for craft activities.
2. *Tool kits*: specialised tools for craft activities.
3. *Storage facilities and/or hoards*: delimited locations for storing completed craft products.
4. *Resource exploitation*: regular exploitation of particular resources.
5. *Exchange and trade*: distribution of resources or craft products.
6. *Differential distributions*.

Of those six criteria, it is clear that this assemblage contains the characteristics necessary to fulfill several of Evans' criteria. The spatial distribution of the worked bones themselves, in addition to the doughnut-shaped stone, defines the workshop space and thus fulfills criterion 1. In terms of criterion 2, while we have not recovered, to our knowledge, tools related to working bones, the bones themselves display the impact scars of the tools used to shape them, perhaps most notably a toothed chisel (see below). The remaining criterion fulfilled by these finds is number 4, since only specific bones of one species were utilized in this workshop. The remaining criteria, 3, 5, and 6, rely on recovery of finished objects which we have so far not uncovered. Nonetheless, evidence for the existence of specialised production at a specific locale must depend not on finds of finished objects, which could have been traded over long distances, but rather manufacturing debris similar to that recovered at Tell es-Safi/Gath.

The Organization of Bone Tool Production

The workshop find, moreover, implies that a chain of specialization and close bureaucratic management existed in the Philistine city at this time. The exclusive use of cattle metapodials suggests not only craft specialization, but that the craft specialists working there were supplied with the metapodials from professional butchers. That is, in order to have been able to secure the necessary steady supply of a specific type of bone, there must have existed full-time butchers at least for cattle, rather than merely household-based butchery, as it presumably would otherwise have been difficult to collect the necessary bones. In fact, Zeder (1988: 9) argued that herding cattle in the Near East likely in and of itself required a degree of regulation, due to their water requirements and the decisions involved in managing herds for both labour and food. Texts from the Syrian city of Emar, dating several centuries earlier than the workshop at Tell es-Safi/Gath, already hint at centralized control over cattle: During a religious festival at the former city, participants brought the cult statue of the god Shaggar to the cattle barns and performed sacrifices there in his honour (Fleming 1997: 437). The location of the cattle, within a specific, seemingly central building, implies that the animals were owned or

controlled by a central authority, be it king or priesthood. Similarly, in I Kings 4, Solomon is described as receiving for his daily needs animals of various kinds, but specifically differentiated are stall- versus pasture-fed cattle, suggesting that some cattle were specially raised for tribute and meat production, promoting the emergence of specialised trades, namely herding and slaughtering, connected to that animal (see as well Nichols and Weber 2006).

We can surmise, therefore, that the bone workshop must have been supplied with the necessary raw materials from other specialists, and all of these interactions managed by officials representing the central authorities of the city. This is only a small window into the organization of production in antiquity, and yet it does shed new light on the degree of specialization and extent of bureaucratic organization within the general time period. Certainly, from the perspective of the wide variety of finished tools found in the Levantine archaeological record, it has long been recognized that various craft specialists, perhaps most notably potters, existed at least from the earliest sedentary or urban societies on (Evans 1978; Fischer and Herrmann 1995). Indeed, Ben-Shlomo, Shai and Maeir (2004: 26) posit that certain types of decorated pottery were made at Tell es-Safi/Gath during the Iron Age IIA. An interesting organizational difference, however, exists between bone tool manufacture and other crafts, such as potting. There is in principle a difference of specialization in the former case versus merely production in the latter case (cf. Costin 1991: 3). While ethnoarchaeological research demonstrates that potters themselves, or their immediate family members, are generally the ones to mine and prepare the clay necessary to make pottery (Tekkök-Biçken 2000: 97-98), archaeological evidence of bone-working debris implies greater specialization. Caches of bone-working debris from Roman period Caesarea and Medieval European sites are not found mixed with food bone debris. This suggests that butchering and bone-working were separate trades (Ayalon 2005b; Carelli 2006), no doubt because bones are a by-product of butchery rather than a raw material separately obtainable. The find of a bone tool workshop which clearly concentrated on the production of certain types of tools, implies not only specialization in the presence of one or more persons skilled in bone tool manufacture, but also specialised cattle butchers and, perhaps, cattle herders as well.

Types of Tools Used

Based on the microscopic examination, we are able to discern that all of the marks were made by metal tools and conform to marks made by experimental metal tools. The types of tools used to work the bones in the Tell es-Safi/Gath workshop comprised at least two sizes of metal knives, a burin and two types of chisels, one probably a tooth chisel. The majority of marks were made by an instrument with many small and low teeth, while the other may have been a burin resulting in broad furrows with straight and steep edges.

A chisel is a tool with one cutting edge which is used for carving and/or cutting material such as wood, bone, stone or metal. The blade is hafted into a handle. In order to cut, the cutting edge of the chisel is forced into the material. The driving force of the blade may be a mallet, hammer (for rough work) or hand (for lighter cutting chores). Serrations on the cutting edge, i.e. chisels with a set of “teeth” or notches on the blade, aid in cutting. The latter are called tooth or claw chisels and are generally used by stone carvers following the initial ‘roughing-out’ of a piece to remove more layers of stone and further define the form. The edge of the tooth chisel may have well-spaced teeth – for coarse work or, closely spaced teeth – for fine work. A serrated edge concentrates the force on a smaller area than a regular straight blade resulting in a high amount of pressure which allows it to penetrate harder materials than a straight edge. Therefore, a serrated edge is good for rough cutting, and can also cut through objects by only using a sliding motion with little pushing force, as with modern bread knives. Claw chisels typically leave ‘rake’ marks, having cut into the substance of the surface irregularly. One can identify the direction of the chisel edge based on the orientation of the rake marks. For working on concave curves and fine shaving of layers, the bevel of the chisel (the sloping area of the blade) faces downwards towards the item being worked. For deep cuts, convex curves and in places where the chisel can be nearly level to the item being worked, the bevel side of the chisel faces up.

According to various scholars (e.g., Muhly 1980: 51; McNutt 1990: 138-42), iron technology probably first developed in the Eastern Mediterranean, with the Aegean and Cyprus playing a critical role. The introduction of iron into the Southern Levant during the early Iron Age may have been strongly influenced by contacts with the Aegean world and possibly even through migrations of the 'Sea Peoples' (including the Philistines), albeit carburized iron objects appear earlier in Israelite sites (Davis et al. 1985; Stech-Wheeler et al. 1981). Although iron was a relatively common material in the Levant by the Iron Age IIA (for a list of late Iron Age I and early Iron Age IIA iron objects, see, e.g., McNutt 1990: 160-205), we do not have much evidence of the types of implements it was used to make presumably due to preservational factors. Numerous examples of knives are known (e.g., 12th century BCE Tell Qasile, 11th century BCE Tel Zeror, 10th century BCE Ashdod and Tell Jemmeh – Muhly 1982 –, 11th century BCE Tel Miqne-Ekron – for discussion and references, see, e.g., Dothan 1989, 2002; An additional, as yet unpublished iron knife has been discovered in a late Iron Age I/early Iron Age IIA context at Tell es-Safi/Gath), but few chisels have been reported. A few exceptions exist, including a 10th century BCE chisel from the site of Ta'anach (Stech-Wheeler et al. 1981: 252), which seems to have been made of wrought iron (i.e., iron with low carbon content forged after smelting, often with slag inclusions, resulting in a softer and less resistant metal) and not of stronger, carburized iron (i.e., iron to which carbon has been added) although the latter technology was already known in the region. Two chisels were found in excavations at Nimrud by Mallowan (1966) and most likely date to the 7th century BCE. Metallurgical analysis of these chisels demonstrated that one chisel was carburized, but the other only slightly; thus, one chisel is made of carburized iron and the other essentially wrought iron (Curtis et al. 1979: 379-80). However, even a wrought iron implement would have been suitable for bone working, as described for the Tell es-Safi/Gath workshop. The general lack of iron implements recovered from Levantine excavations, therefore, makes the present study of greater importance, documenting as it does the use of iron for relatively mundane activities.

The specific documentation of the use of the metal tooth or claw chisel in the Tell es-Safi/Gath bone workshop presents a useful chronological benchmark for the tool's appearance. There exists a debate within Classical archaeology as to the timing of the invention of the claw chisel, based on tool marks identified on statuary and masonry, as well as to whom the invention can be attributed – the Egyptians or the Greeks. Palagia and Bianchi (1994) convincingly demonstrate that the claw chisel was used in Egypt by the seventh century BCE, while the earliest evidence in Greece dates to the sixth century BCE. Not only is the bone tool debitage assemblage from Tell es-Safi/Gath two centuries older than the Egyptian evidence, but it also presents clear evidence that a small toothed iron chisel was used; Palagia and Bianchi (1994: 189-90) imply that later Egyptian chisels were made of bronze or copper, such as those documented by Petrie (1974). The question of the introduction of the claw chisel is relevant for the archaeology of the Iron Age Levant as well. Over the years, a lively debate has developed on the dating of the earliest appearance of masonry with claw (or "toothed") chisel marks, particularly in relationship to masonry discovered in the Iron Age citadel at Arad. While Aharoni (e.g., 1975: 38-40) dated masonry with toothed chiseling to the Iron Age, Yadin (1965) and subsequently others (for a recent summary, see Herzog 2002: 41-44) concluded that such chiseling does not appear in the ancient Near East during the Iron Age. Yadin (1965) rejected the Iron Age dating, and based on the masonry suggested an alternative, Hellenistic date for these elements in the Arad fortress. Thus, although the discovery of the use of the claw-chisel in the Iron Age IIA at Tell es-Safi/Gath does not imply that one must date masonry tooled with a claw-chisel to the Iron Age, it does indicate that the tools that could have been used to produce such masonry may have existed already during the Iron Age II.

Spectrographic analysis

Spectrographic analysis of the silicone molds from each of the metapodials studied for SEM analysis was conducted in order to determine if any foreign mineral elements were present. It was hoped that the silicone mold would pick up any residual foreign minerals on the bone surface in the grooves.

This analysis would help to determine if the metal butchering and tool marks on the various bones were made by bronze or iron tools. Similar analysis was successful at other sites (e.g. Greenfield 2006). However, none of the samples contained any evidence of foreign elements, probably the result of cleaning of the samples either in the field or laboratory prior to this phase of analysis. It is thus recommended that bone artifacts destined for detailed technological analyses should not be cleaned until moulds of their surfaces have been taken.

CONCLUSIONS

The uniqueness of the Tell es-Safi/Gath workshop offers an opportunity to study the production processes connected to one of most common types of materials used in ancient cultures, which up until now has barely been studied. Although further research is still needed, aspects of the production processes and indications as to the tools used have been found. A striking feature of the Tell es-Safi/Gath assemblage is the standardization evident in the skeletal elements chosen and the limited techniques and tools used in their modification. Most likely, this was intended to produce similarly-shaped artifacts.

Unfortunately, since there is little comparative material for these production methods, such that it is not possible to say whether or not there are any specific technological attributes that can be seen as unique to either the Levantine Iron Age in general, or the Philistine culture in particular. Perhaps, further study and additional parallels will provide hints in this direction. A few similarly worked cattle bones, probably metatarsals, were either waste products or partially completed tools. These have been retrieved from other sites in the region, such as in Middle and Late Bronze Age contexts at Ashkelon (Ayalon and Sorek 1999: 16, Fig. 4), and may represent earlier examples of the Tell es-Safi/Gath artifact production tradition.

In addition to specific information about the production process involved in the creation of the implements produced by this workshop, the Tell es-Safi/Gath workshop find has large implications for understanding the development of specialized trades in the evolution of Near Eastern urban societies. The way in which production must have been organized, relying on very specific bones presumably procured from full-time butchers who in turn may have been supplied by state-owned herds and state-managed herders, demonstrates a complex chain of professional organization. Finally, this study has shed light on metallurgy and iron tool use in the Iron Age II Levant, proposing an early date for the use of clawed iron chisels in this region.

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