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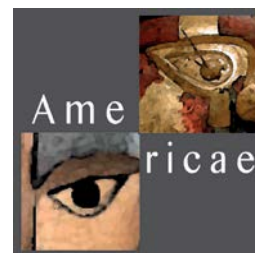
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Bone tools and ornaments in the Classic period Valley of Oaxaca, Mexico

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In prehispanic Mesoamerica, bone was a broadly recovered raw material for the fabrication of implements and ornaments, used in both ritual and domestic production activities. To date, researchers have employed broad, general descriptions for these tools such as awls, needles, and perforators, but little consistency exists in the terminologies and categories that describe the range of osseous tools. Through excavations at four Classic period sites in the Valley of Oaxaca, we have amassed over 1100 bone tools, ornaments, and other worked pieces. Here we illustrate and define the principal classes of bone implements and the animal species (including human) that were utilized, while offering preliminary thoughts regarding the tasks for which they were used. Specific animal species seemingly were preferred for making certain tools, but local availability also was a factor. Across our Valley of Oaxaca contexts, the variability in tool assemblages points to diversity in household economic activities with implications for how we understand the Classic period economy. In line with previous Mesoamerican research, we surmise that a key use of bone tools was associated with fiber working and weaving.

Keywords: Valley of Oaxaca, Mesoamerica, Classic period, bone tools, ornaments, fiber working.

Herramientas y ornamentos de hueso del periodo Clásico en el Valle de Oaxaca, México

En la Mesoamérica prehispánica, el hueso fue una materia prima ampliamente usada para la fabricación de herramientas y ornamentos, ambos utilizados tanto en actividades rituales como domésticas. Hasta la fecha, investigadores han utilizado descripciones generales para estas herramientas, como punzones, agujas y perforadores, pero existe poca consistencia en la terminología y las categorías que describen el rango de las herramientas óseas. Gracias a las excavaciones en cuatro sitios del Clásico en el Valle de Oaxaca, hemos recogido más de 1100 herramientas, ornamentos y otros fragmentos trabajados de hueso. En este artículo definimos e ilustramos las clases principales de este tipo de herramientas y las especies animales (incluido el ser humano) que fueron utilizadas para su fabricación; al mismo tiempo proporcionamos algunas ideas preliminares en cuanto a las tareas para las cuales se usaron. Parece que especies específicas fueron preferidas para hacer ciertas herramientas aun cuando la disponibilidad local fue también un factor determinante. A través de los contextos del Valle de Oaxaca, la variabilidad en los conjuntos de herramientas evidencia la diversidad de las actividades económicas en la unidad doméstica, la cual tiene implicaciones en cómo entendemos la economía del periodo Clásico. Acorde con previas investigaciones mesoamericanas, consideramos que hubo un uso clave de las herramientas de hueso asociado al trabajo de fibras y al telar.

Palabras clave: Valle de Oaxaca, Mesoamérica, periodo clásico, herramientas de hueso, ornamentos, el trabajo de fibra.

Outils et ornements en os au cours de la période classique dans la vallée d'Oaxaca, Mexique

Dans la Mésoamérique préhispanique, l'os était une matière première largement employé pour la fabrication d'instruments et d'ornements utilisés à la fois pour les activités rituelles et domestiques. À ce jour, les chercheurs ont utilisé des descriptions générales pour ces outils, comme les poinçons, les aiguilles et les perçoirs, mais il existe peu de cohérence dans les terminologies et les catégories qui décrivent la gamme d'outils en os. Grâce à des fouilles menées dans quatre sites de la période classique dans la vallée d'Oaxaca, nous avons recueilli plus de 1 100 outils, ornements et autres pièces travaillées en os. Ici, nous illustrons et définissons les classes principales d'instruments osseux et les espèces animales (y compris humaine) qui étaient utilisées pour leur fabrication, tout en offrant des idées préliminaires concernant les tâches pour lesquelles elles étaient utilisées. Des espèces animales spécifiques étaient apparemment préférées pour fabriquer certains outils, mais la disponibilité locale était également un facteur déterminant. Dans l'ensemble des contextes de la vallée d'Oaxaca, la variabilité des assemblages osseux révèle la diversité des activités économiques au sein de l'unité domestique, ce qui a des implications sur notre compréhension de l'économie de la période classique. En accord avec des travaux antérieurs en Mésoamérique, nous proposons que l'un des usages clé des outils en os a été lié au travail de la fibre et au tissage.

Mots-clés: vallée d'Oaxaca, Mésoamérique, période classique, outils en os, ornements, travail de la fibre.

IN PREHISPANIC MESOAMERICA, animal and human bones were worked into a range of tools and ornamental objects that have been recovered from both ritual and domestic contexts. Exquisitely carved and incised bone implements have received the most attention (e.g., Caso 1969; Dacus 2005). Yet much more abundant are a range of utilitarian tools that have been described as awls, needles, perforators, and a diversity of other names (e.g., Middleton et al. 2002; Moholy-Nagy 1994; Teeter 2013; Tolstoy 1971). To date, the characterizations of these and other bone tools are not always consistent between sites or across larger regions, and few authors provide significant analysis or illustration of entire worked bone assemblages. Without consistency in nomenclature and knowledge of the range of variation for specific classes of artifacts in any assemblage or complex, meaningful comparisons are difficult to make.

We do not exempt our own research from this assessment. In prior publications (Feinman and Nicholas 2004a, 2006, 2007a and b, 2012; Haines et al. 2004; Middleton et al. 2002), in which our focus was on the Classic period economy of the Valley of Oaxaca, we did reference bone tools as components of broader artifact complexes. But previously we have not presented a systematic, holistic discussion of the bone tools from each context we have researched. To date, there is no systematic analysis of archaeological bone tools from the Valley of Oaxaca. Although less abundant than stone and ceramic artifacts

in most contexts, bone objects are more durable and commonly preserved far better than tools made of wood or other perishable materials.

Here, we present a systematic analysis of bone tools and ornaments from four Classic period (AD 250-900) sites that we excavated in the Valley of Oaxaca. We also draw on a broader Mesoamerican archaeological literature to interpret the contexts in which these artifacts were used. Through this broader review, we recognize certain parallels in overall tool forms and the animal species that were exploited. Our goal is twofold: to compare Classic period bone tool assemblages in the Valley of Oaxaca to learn how they vary between and across sites and how such variability informs our views of the prehispanic economy and to provide a more systematic set of bone tool classes (and illustrations) that other archaeologists can build on to facilitate cross-site and cross-region comparisons.

We begin with a short discussion of bone tools in Mesoamerica before briefly introducing the four Valley of Oaxaca sites—Ejutla, Lambityeco, El Palmillo, and the Mitla Fortress (Figure 1). We then present detailed descriptions and illustrations of the principal tool and ornament classes, their variability, the animal species and skeletal elements preferred for each, and some thoughts concerning how the implements likely were used. We follow with a comparison of the bone tool assemblages at the four valley sites including considerations of their

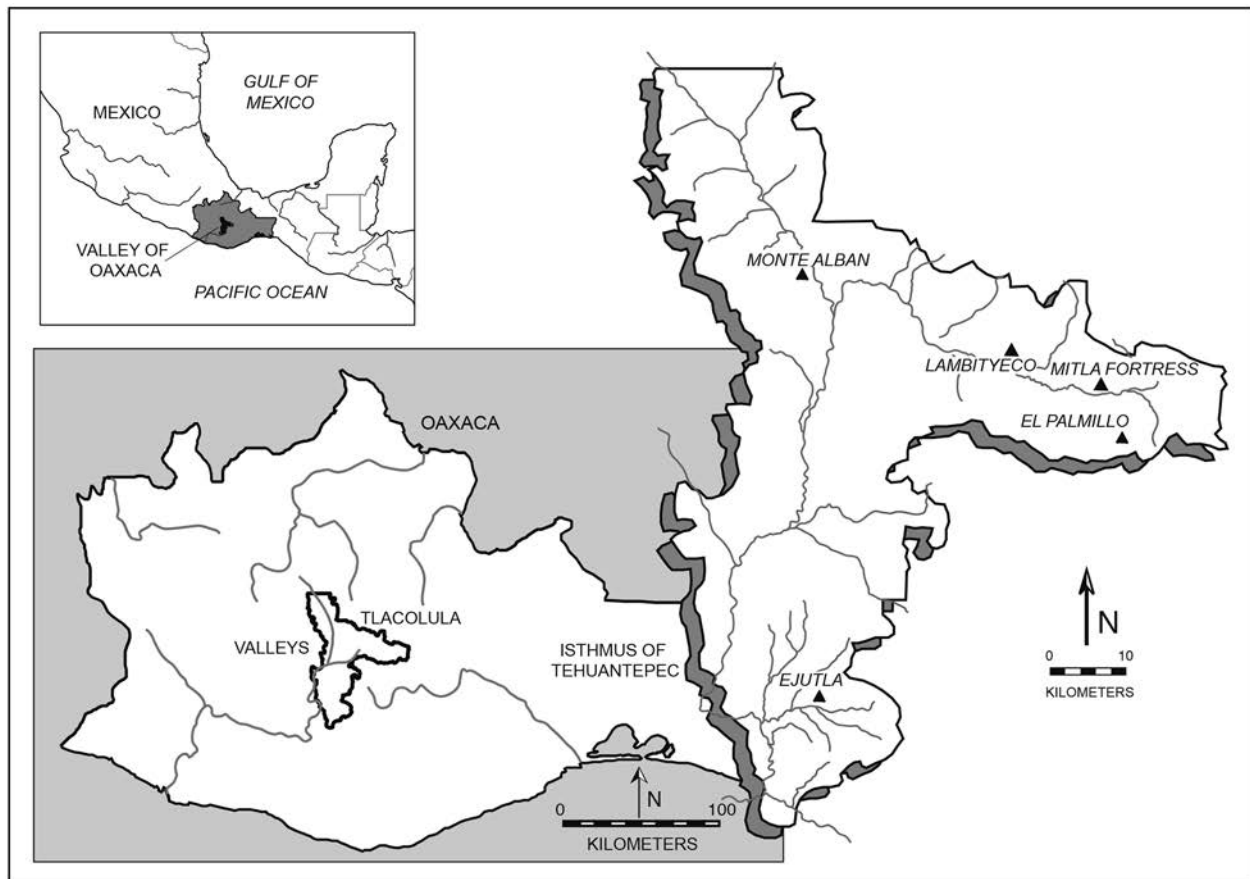


Figure 1. Map of the Valley of Oaxaca showing sites mentioned in the text (© L. Nicholas and G. Feinman).

contexts and associated artifacts. These synthetic analyses help refine and sharpen our perspectives on Classic period economic activities in the region and for prehispanic Mesoamerica more generally.

BACKGROUND TO ANALYSIS OF BONE TOOLS IN PREHISPANIC MESOAMERICA

Bone implements have been recovered from prehispanic sites across Mesoamerica but have historically received much less attention than highly decorated ceramics or carved jade ornaments. The sheer volume of ceramics at most Mesoamerican sites overwhelms bone assemblages of which the worked bone is only a small part. In many reports, bone tools and ornaments are considered only briefly, often as part of compendia of utilitarian or miscellaneous artifacts (e.g., Ekholm 1944; Kidder 1947; MacNeish et al. 1971; Meighan 1976; Moholy-Nagy 2003; Willey 1972, 1978; Willey et al. 1994). Some researchers employ categories that lump tool forms into a few broad groups while others split the objects into dozens of specific forms. Inconsistencies in nomenclature abound, limiting the potential for comparison. Generally, little contextual analysis linking bone tools to other components of a site's artifact assemblage is undertaken.

Fortunately, in contrast, elaborate worked bone objects from ritual contexts have been described in detail, such as the 24 carved bone "weaving pins" that were cached with an elite Maya woman in a tomb at Naranjo in northeastern Guatemala (Dacus 2005), the 34 exquisitely carved implements made from jaguar and eagle bones from Tomb 7 at Monte Albán in Oaxaca (Caso 1969: 177-218), and the dozens of engraved bone implements from Temple 1 at Tikal (Triak 1963). Across Mesoamerica other bone implements such as stingray spines and shark teeth have long been tied to ritual bloodletting (Borhegyi 1961; Flannery 1976: 341-344; Flannery and Marcus 2005: 95-96; Hamblin 1984: 31; Kidder et al. 1946: 156; Marcus and Flannery 1994: 60; Moholy-Nagy 1994: 107-109; Peres et al. 2013: 123; Schele and Miller 1986: 186; Willey 1972: 239). Jade and even mammal bone splinters were used to make imitation stingray spines (Flannery 1976: 341; Moholy-Nagy 1994: 110).

Tolstoy's (1971) study of bone implements from a dozen sites in central Mexico was one of the first attempts to look at broader assemblages and provide a list of diagnostic bone tools, although his study did not present a complete inventory. More comprehensive studies of worked bone and tools, and their contexts, have been carried out at select Maya sites (e.g., Crow 2017; Moholy-Nagy 1994), including recent efforts to document the production steps involved in making bone tools (Emery 1997, 2008, 2009; Emery and Aoyama 2007; see also Talavera et al. 2001). Many bone tools have been specifically, although not exclusively,

tied to weaving and the manufacture of textiles and other woven goods (Chase et al. 2008; Feinman and Nicholas 2004a; Halperin 2008; Hamman 1997: 154-157; Manzanilla 2006; McCafferty and McCafferty 2000, 2008; Middleton et al. 2002; Pohl 1994).

Across Mesoamerica deer was a preferred taxon for making tools (Emery 2008: 216, 2009: 465; Flannery and Marcus 2005: 74 *passim*; Hamblin 1984: 141-142; MacNeish et al. 1971; Meighan 1976; Newman 2013; Pérez Roldán et al. 2017: 101; Thornton 2011: 153-154; Tolstoy 1971: 292; Valentín Maldonado and Pérez Roldán 2010; Valentín Maldonado et al. 2017; Willey 1972: 229-237). Other taxa including dog, rabbit, peccary, jaguar and other cats, turkey and other birds, turtle, and human are mentioned less frequently and in lower quantities (e.g., Caso 1969: 179; Flannery and Marcus 2005: 254, 334; Hamblin 1984: 66, 96; MacNeish et al. 1971; Meighan 1976; Moholy-Nagy 1994: 107; Teeter 2013: 206; Valentín Maldonado et al. 2017; Willey 1972: 238). Yet at some sites human bone was a principal material worked into both tools and ornaments (e.g., Kidder 1947: 58-59; Pérez Roldán et al. 2017: 101), including Teotihuacan where more than 75% of worked bone and debris, including a wide range of tool forms and ornaments, was reported as human (Campos-Martínez and Pérez-Roldán 2016).

We draw on this broad background as well as reported household inventories from Formative period houses in the Valley of Oaxaca (Drennan 1976; Flannery and Marcus 2005). These sources provide a foundation for the following discussion of the most common bone tools and ornaments from four Classic period sites for which we have excavated collections.

FOUR CLASSIC PERIOD SITES IN THE VALLEY OF OAXACA

Although each of the four excavated sites has an extended occupational history, most contexts pertain to the Classic period, when all of the sites had significant populations. One of our aims in choosing these sites was to excavate a sample of houses at multiple locations to obtain household-level information on domestic activities that would enable exploration of questions about Oaxaca's ancient economy (e.g., Feinman 1999; Feinman and Nicholas 2000, 2004a, 2010). All of the house excavations include small exterior areas that are adjacent to the residential construction. At all four sites we found evidence of house-based production of a range of different goods seemingly in part for exchange. These activities varied from site to site and even house to house (Feinman and Nicholas 2004a, 2006, 2007b, 2012). Bone tools and other worked bone were present in the faunal assemblages at all four sites. The bone tools do not appear to have been crafted primarily for exchange themselves but were used in the fabrication of other goods and resources (Feinman and Nicholas 2004a, 2007b).

The Ejutla site is situated in a small alluvial valley at the southern end of the Valley of Oaxaca, near the base of the tallest mountain in the area (see Figure 1). We surveyed the site in the mid-1980s and recorded prehispanic occupation in a roughly 1 km² area in and around the modern town—Ejutla de Crespo (Feinman and Nicholas 2013). We opted to excavate at the site because of large quantities of marine shell debris observed in fields at the eastern edge of the town, which is more than 100 km from the Pacific Coast. From 1990 to 1993, we excavated a Classic period house and its immediate surroundings and documented a range of craft activities, including ceramic manufacture and the production of a range of shell ornaments (Feinman and Nicholas 2000, 2004a). Intermixed with the shell and ceramic debris were large quantities of heavily worn obsidian blades and chert microdrills that were used to work the shell. There also was lapidary debris created by the same cane drills used to make shell disks (Feinman and Nicholas 2000: 135-136). Bone was generally less well preserved in the alluvial deposits at Ejutla than at the other three sites, but we still recovered dozens of bone tools in addition to other worked bone fragments and ornaments.

The other three sites are located in the dry, eastern, Tlacolula arm of the valley. El Palmillo is a large hilltop terrace site on the top and steep slopes of a rocky ridge that descends from mountains at the eastern edge of the Valley of Oaxaca. At its greatest expanse during the Classic period, the site's inhabitants constructed more than 1400 terraces, most of which were residential (Feinman and Nicholas 2004b). Over a decade (1999-2008) we excavated eight residential terraces/houses spanning the bottom to the top of the hill (Feinman and Nicholas 2009, 2012; Feinman et al. 2002). The three houses near the bottom of the hill were smaller and had fewer rooms (Terraces 1162, 1163, 1147, while the three residences at the top were larger, more elaborate structures (Terrace 335 Structure 35, Platform 11) adjacent to the civic-ceremonial core of the site. We also excavated a small ballcourt next to the palatial structures. The houses on two mid-slope terraces (925, 507) were intermediate in size and elaboration. During the excavations we collected ample evidence of a range of economic activities, including stone working and processing of xerophytic plants in most houses, and ceramic production in the lowest set of residences (Haines et al. 2004). Worked bone and tools were recovered from all excavated contexts, but with considerable variation in quantity and form among the residences (Feinman and Nicholas 2012: 243).

The Mitla Fortress is located on a freestanding rocky butte just west of Mitla in eastern Tlacolula. The site is known mostly for a series of tall stone, defensive walls that ringed the top of the hill during the Postclassic period (AD 900-1520), but the site was more than just a military redoubt; during the Classic period it was a population center, with more than 500 terraces and other residential structures (Feinman and Nicholas 2004b). Between 2009

and 2011 we excavated three residential terraces, two just below the defensive walls (Terraces 56 and 57) and one farther down the slope (Terrace 276) (Feinman and Nicholas 2011, 2012; Feinman et al. 2010). In addition to working local stone and processing fiber from xerophytic plants, the inhabitants of the fortress made obsidian blades from imported cores and raised turkeys (Feinman and Nicholas 2012: 241, 244; Lapham et al. 2013, 2016). Although we recovered similar quantities of bone tools and other worked bone on all three terraces, the tool forms and the species preferred to make the tools varied by residence (Feinman and Nicholas 2011).

Lambityeco has long been in the regional archaeological literature following excavations of several palaces at the site by John Paddock in the 1960s (Paddock et al. 1968). This large site on the valley floor in the middle of the Tlacolula arm consists of two major architectural sectors that are largely chronologically distinct, the earlier sector (Yegüih) to the east (Formative through Early Classic, 700 BC-AD 500) and the later sector (Lambityeco) to the west (Late Classic, AD 500-900), where Paddock excavated two palatial residences (Lind 2017; Lind and Urcid 2010). During this early work at the site salt production and ceramic production were documented as important economic activities (Lind and Urcid 2010; Payne 1970; Peterson 1976). We worked at Lambityeco in 2013-2016, excavating a residence (Mound 165) and associated ballcourt, plaza, and temple (Mound 170) (Feinman and Nicholas 2016; Feinman et al. 2016) in the main civic-ceremonial core of the site just south of the two palaces excavated by Paddock. We recovered relatively few stone or ceramic artifacts or features associated with productive activities; the exception was a cluster of large jars in the earliest surface of the residence that likely were used in salt production (Feinman et al. 2016). Instead, most of the material remains were associated with ritual activities, including incredible quantities of figurines and whistles and large ollas and serving vessels. In addition, the residence had high numbers of bone tools and beads. Based on the modest size and layout of the residence, despite its proximity to prime civic-ceremonial space, we suspect that its

occupants were functionaries associated with ritual activities, perhaps low-level priests (Feinman and Nicholas 2016; Feinman et al. 2016).

BONE TOOLS

The faunal assemblages from excavated contexts at the four sites comprise more than 1100 tools, ornaments, and other worked bone debris (Table 1). There are 655 tools and tool fragments that are complete enough to determine their form and 142 ornaments. Most of the tool forms correspond to general descriptors employed at other Mesoamerican sites—awls, perforators, needles, battens,

Context	Awl	Batten	Perforator	Blood letter	Needle	Needle/perforator	Disk/spindle whorl	Pressure flaker	Shuttle	Straw	Chisel	Ornament	Other worked bone
El Palmillo													
T1162	18	11	–	1	7	3	5	3	–	–	2	2	19
T1163	7	5	3	–	3	–	2	2	–	–	–	4	3
T1147	6	5	–	–	3	3	1	3	–	–	1	–	6
T925	15	16	6	1	6	–	–	1	–	–	–	11	30
T507	24	2	3	1	8	4	3	1	–	–	–	9	9
T335	12	20	5	5	11	–	1	5	1	–	–	15	38
St35	19	21	9	2	10	–	1	3	1	1	–	7	26
Pl11	20	33	13	2	4	–	–	1	–	–	–	20	22
Ballcourt	1	1	1	–	1	–	–	–	–	–	–	–	1
Mitla Fortress													
T56	18	12	2	–	2	–	4	2	1	–	–	8	39
T57	24	9	4	2	10	1	1	–	–	–	–	14	31
T276	8	9	17	4	2	2	1	1	1	–	–	5	37
Ejutla	10	2	3	–	7	1	–	1	1	–	–	14	47
Lambityeco													
Ballcourt	2	–	–	–	1	–	–	–	–	–	–	2	–
M165	35	21	11	–	6	1	2	–	–	–	–	27	34
M170	3	3	2	1	–	–	–	–	1	–	–	2	4
Plaza	6	5	1	–	1	–	1	1	–	–	–	2	5
Total	228	175	80	19	82	15	22	24	6	1	3	142	351

Table 1. All worked bone at four Classic period sites in the Valley of Oaxaca (data compiled by L. Nicholas and G. Feinman).

pressure flakers, and disks. The remaining worked bone includes 133 tool fragments that were too small to categorize with confidence and another 218 pieces of bone debris with cut marks, polish, or other evidence of working. Although we recovered some worked bone on all terraces and other residential contexts, we found no production contexts with abundant debris and by-products such as Emery (2008, 2009) has documented for the Classic Maya and Janusek (1999) for the Andean region. We did record evidence for bead making from dog bones on Mound 165 at Lambityeco.

About 40% of the implements in our sample are complete enough to identify the taxa used to make the tools (Table 2). Zooarchaeological analysts on the project used comparative collections of modern fauna and a wide range of skeletal guides to aid identification. The two most preferred species for tools were white-tailed deer (*Odocoileus virginianus*) and human, followed by domestic dog (*Canis familiaris*), cottontail rabbit (*Sylvilagus* spp.), jackrabbit (*Lepus* spp.), and large birds, including turkey (*Meleagris gallopavo*). Except for human bones, the relative abundance of these taxa is similar to those in a small sample analyzed for Monte Albán (Valentín Maldonado and Pérez Roldán 2010). Another 10-15% were too heavily processed, partial, or poorly preserved to make a definitive identification, but based on size and the nature of the bone they were clearly from large mammals, either deer or human (coded as UID large mammal). The rest are from unidentified taxa (UID).

Long bones were by far the preferred skeletal element for making implements. Collectively, tibias, from a range of species, were the most commonly chosen skeletal element. By species and element, deer metapodial was the most frequent element employed to make tools; other preferred bones were deer antler and tibia, human and deer femur, turkey tibiotarsus, and human humerus. In many cases the bones were too heavily modified to identify the specific element beyond long bone of a particular species. Most of the bone ornaments recovered are beads or pendants; those that could be identified to taxa were dog, turkey, and other birds. The remaining worked bone includes pieces that have clear evidence of modification but are too small to determine the end product or precise use. Some pieces are debris from making tools. These worked pieces include human bone, which is especially abundant in contexts where human bone was most abundantly utilized to make tools.

In classifying the bone implements, we highlight the principal distinguishing characteristics of each form (Table 3). All classes of tools exhibit variability to some extent, with the more abundant forms divisible into subgroups that may have had distinct uses. Some tool categories grade into each other, for example, thinner awls with sharp tips can be difficult to distinguish from perforators. Although most implements were crafted for use in productive activities, some perforators and awls also could have been used ritually as bloodletters

(context can be one factor in making this determination). Most bone implements in the sample are not complete. If only the tip is present, it is a challenge to distinguish perforators from needles. When only a small piece of a tool midsection is present, it is not always possible to categorize the tool. Some broken tools may be reworked to serve a different purpose and then not fit within specified classes. Nevertheless, by focusing on the most complete tools in our collections, we do see formal consistencies, which apply beyond particular contexts and sites. These observations from the Oaxaca sample, in the context of the wider Mesoamerican literature on bone artifacts, provide an empirical foundation for the classes discussed in the sections to follow.

AWLS

Overall, awls ($n = 228$) are the most abundant tool class at each of the four sites, although they are not necessarily the most common implement in each context at specific sites. Awls typically are crafted from long bones and have thick upper ends that taper to either a well-defined point or a more rounded, blunt tip. Of the 70% of awls that are sufficiently complete to identify to taxonomic class (i.e., large mammal [deer or human], bird), genera, or species, the majority (85%) were crafted from deer or human long bones (see Table 2). Most of the rest were made on dog and large bird long bones. The longest, straightest, and sturdiest skeletal elements were selected, such as femur, tibia, and metapodial (see also Emery 2009: 465). The working end of the implement was cut and abraded to form a point; the nonworking end may be unmodified or smoothed for easier handling. Although it can be difficult to determine if burning was accidental or deliberate (Flannery 1986), approximately 25% of the awls at the four sites were burned to some degree and may have been intentionally exposed to fire (Figure 2, next pages). Hardening implements by purposeful burning turns them into sturdier tools (Emery 1997: 465). The higher proportion of awls that are burnt compared to other tool categories (only pressure flakers have a higher percentage) reflects the preference for a more durable implement.

Because awls are general-purpose tools that could have been used for a wide variety of tasks, they are variable in form and size. In previous analyses, they often are divided into short and long awls (Teeter 2013: 293; Tolstoy 1971: 292-294; see also MacNeish et al. 1971: fig. 118). Short awls vary between about 6 and 10 cm while long awls range from 12 cm to more than 20 cm in length. Approximately 40% of the awls in our collections are complete enough to make this size distinction, and of those, there are far fewer long awls than short ones, which can be further divided into subgroups based, in part, on species and skeletal element.

Deer metapodials (metatarsals and metacarpals) were used to make short awls at all four sites (Figure 3a-f).

	Ejutla	El Palmillo								Mitla Fortress			Lambityeco		
Tool	House	T1162	T1163	T1147	T925	T507	T335	St35	Pl11	T56	T57	T276	M165	M170	Plaza
Awl															
Deer	3	3	—	1	3	3	4	7	8	5	4	2	4	1	4
Human	1	—	—	—	1	—	—	4	2	3	11	6	20	—	1
Dog	—	—	—	—	—	8	—	1	—	1	1	—	—	—	—
Rabbit/jackrabbit	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—
Bird	—	—	—	—	—	—	—	—	2	—	1	—	—	1	—
Turkey	1	—	—	—	—	—	—	—	—	—	2	—	1	—	1
Bobcat	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
UID large mammal	2	1	—	2	1	1	2	3	6	4	5	—	7	1	—
UID	3	13	7	3	9	12	6	4	1	5	—	—	3	—	—
Batten															
Deer	—	4	—	—	—	1	3	4	7	5	1	3	—	—	—
Human	—	—	—	—	2	—	3	—	1	1	3	5	3	1	1
Dog	—	—	—	—	—	—	—	—	1	—	—	1	—	1	1
Rabbit/jackrabbit	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
Bird	—	—	—	—	—	—	1	—	1	1	—	—	3	—	—
Turkey	—	—	—	—	—	—	—	—	—	—	—	—	2	—	1
UID large mammal	1	2	—	2	1	1	4	3	19	5	5	—	3	—	—
UID	1	5	5	3	13	—	8	13	4	—	—	—	10	1	2
Perforator															
Deer	—	—	—	—	—	—	—	1	1	—	2	2	—	—	—
Human	—	—	—	—	—	—	—	—	—	—	—	5	1	1	—
Dog	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Rabbit/jackrabbit	—	—	—	—	—	2	—	1	1	1	—	3	2	—	—
Bird	—	—	—	—	—	—	—	—	2	1	1	3	1	—	—
Turkey	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—
UID large mammal	1	—	—	—	—	—	—	1	6	—	1	—	—	—	1
UID	2	—	3	—	6	1	5	6	2	—	—	4	5	1	—
Bloodletter															
Deer	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Human	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—
Dog	—	—	—	—	—	—	—	—	—	—	1	3	—	—	—
Rabbit/jackrabbit	—	—	—	—	—	—	1	2	1	—	—	—	—	—	—
Gopher	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Turkey	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Shark	—	—	—	—	1	1	2	—	—	—	—	—	—	—	—
UID	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—
Needle															
Deer	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Human	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rabbit/jackrabbit	—	—	2	—	1	—	5	—	—	—	1	—	—	—	—
Bird	—	—	—	—	—	—	—	—	—	1	3	—	—	—	—
Turkey	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
UID	7	7	1	3	5	8	6	9	4	1	6	1	6	—	1

Table 2. Principal tools by animal taxa and context at each site (does not include ballcourts; UID = unidentified; data compiled by L. Nicholas and G. Feinman).

Category	Description
Awl	Long, sturdy tool with one broad end that tapers to a well-defined point or more rounded, blunt tip. Typically crafted on a large mammal long bone, often a deer metapodial. Often fire-hardened to increase durability. Divided into two groups based on size.
Perforator	Long, slender tool with sharply pointed tip. Tool may be smoothly finished with circular cross section or crafted from flat section of bone with less finished edges.
Bloodletter	Long, slender tool that is similar in form to a perforator but is more finely made, more fragile, or comes to sharper point than most perforators. May be highly polished or decorated, often found in special contexts. Includes shark teeth and sharpened animal teeth.
Needle	Long, slender, straight tool with a pointed tip and eye for stringing on the opposite end. All edges smoothed. Has circular or slightly flattened cross section.
Batten	Long wide and relatively flat tool with smoothed edges and blunt tapered ends. Typically made on a mammal long bone, often a tibia.
Disk/spindle whorl	Slightly curved circular implement with a central perforation. Typically crafted from cranial bone, mostly often human.
Shuttle	Slightly curved tool with smoothed edges and a perforation near one end. Typically crafted from shafts of long bone or rib.
Pressure flaker	Sturdy, solid tool with tapered tip that often has edge damage. Typically an antler tine. Frequently fire-hardened to increase durability.
Chisel	Triangular or wedge-shaped tool with one beveled end.

Table 3. Principal bone tool categories (© L. Nicholas and G. Feinman).



Figure 2. Burnt tools (objects with the same letter are from the same context). Perforators: a. El Palmillo, T925; b. Ejutla. Antler tines from El Palmillo: c. P111, d. St35. Awls: e. El Palmillo, P111; f. Lambityeco, M165; g. Mitla Fortress, T57; h. Ejutla (© L. Nicholas).

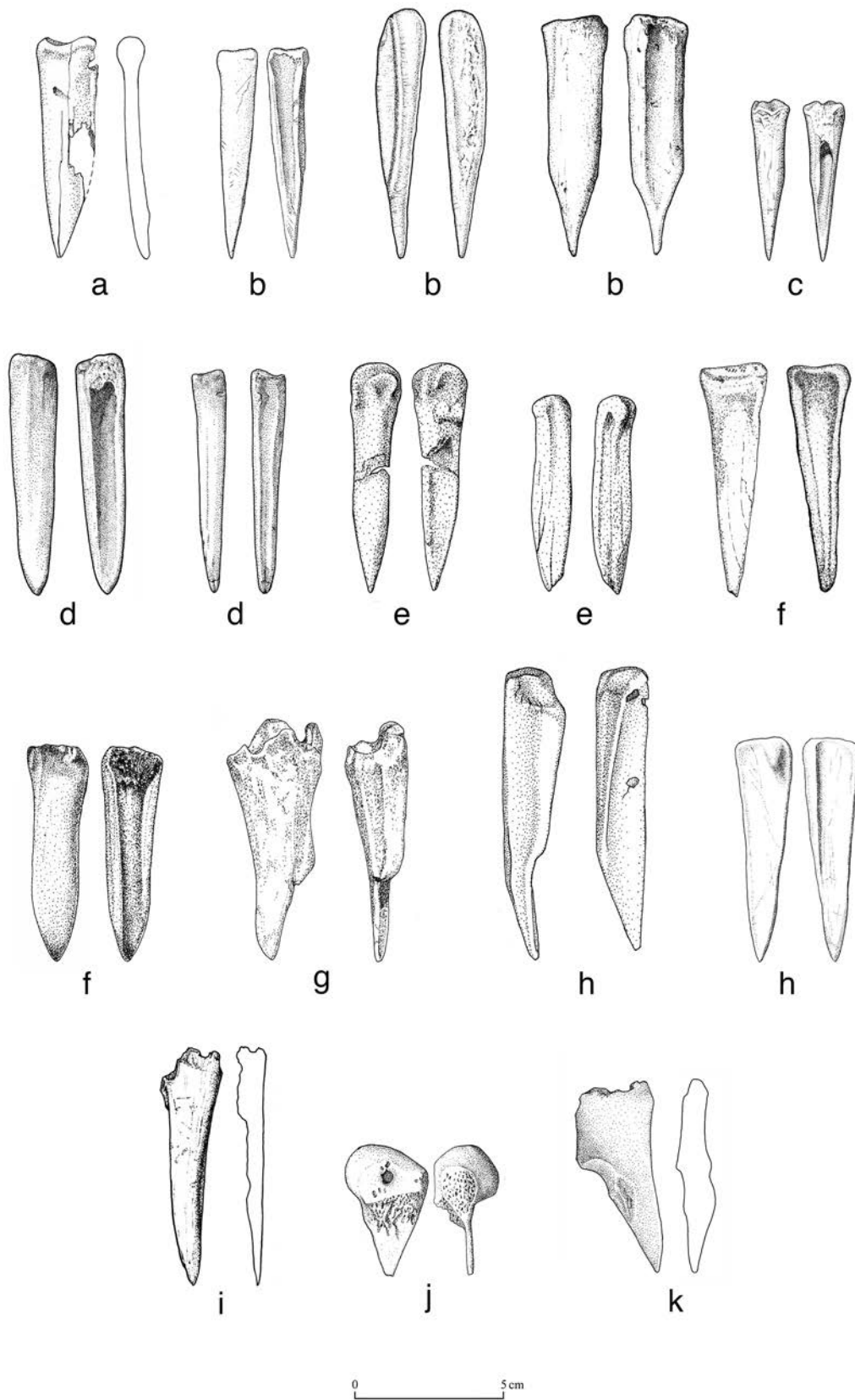


Figure 3. Short bone awls made on deer bones (objects with the same letter are from the same context; tools shown with exterior view on left and either interior or side view on right). Metapodial: El Palmillo, a. T507, b. St35, c. Pl11; Mitla Fortress, d. T56, e. T57; Lambityeco, f. M165. Tibia: El Palmillo, g. T507, h. T335; Mitla Fortress, i. T276. Humerus: El Palmillo, j. T335. Ulna: El Palmillo, k. T925 (© L. Nicholas and G. Feinman).

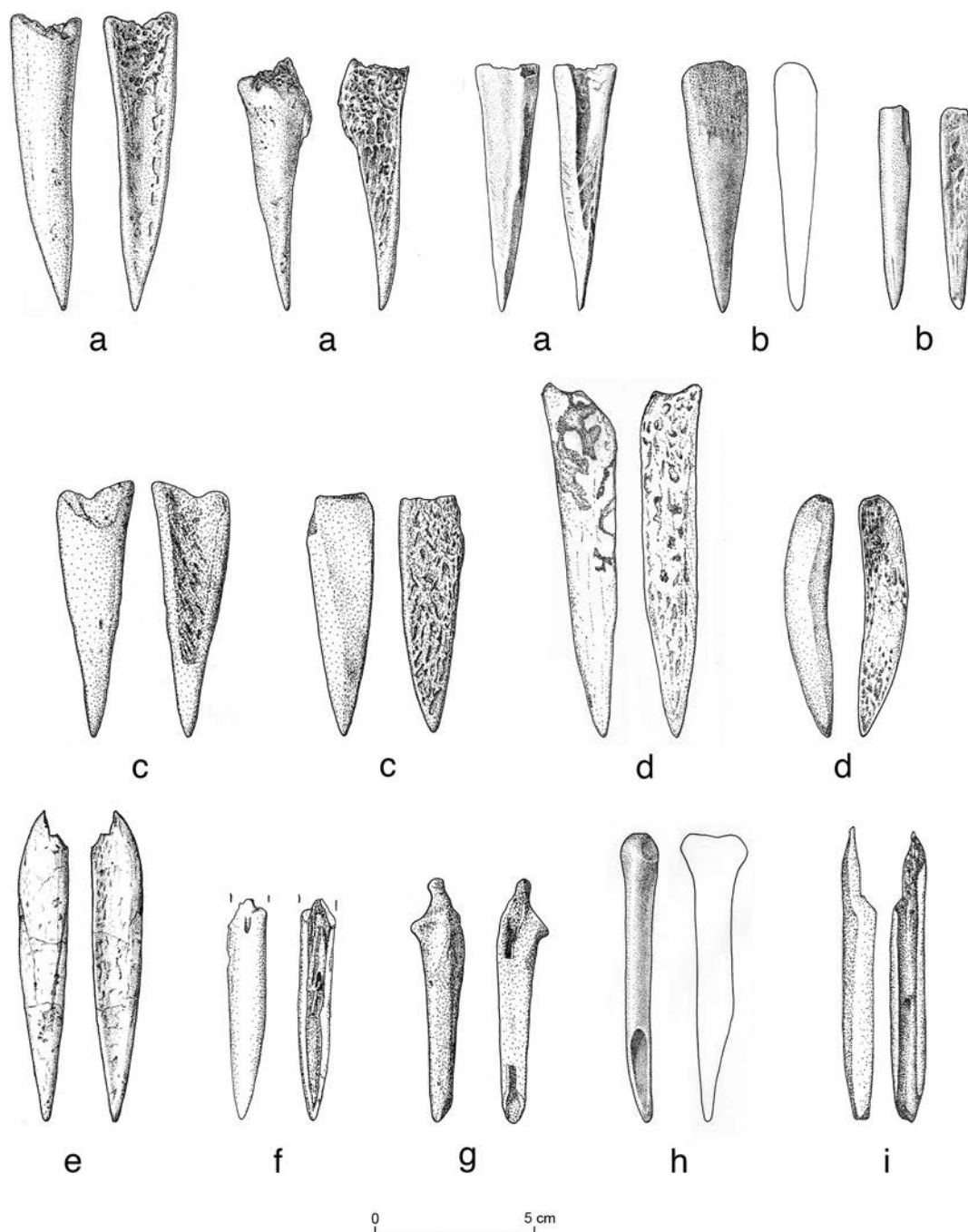


Figure 4. Short bone awls (objects with the same letter are from the same context; tools shown with exterior view on left and either interior or side view on right). Human long bones: El Palmillo, a. St35; Mitla Fortress, b. T56, c. T57; Lambityeco, d. M165. Unidentified long bone: El Palmillo, e. St35. Dog long bones: El Palmillo, f. T507; Mitla Fortress, g. T57, h. T56. Turkey long bone: Lambityeco, i. M165 (© L. Nicholas and G. Feinman).

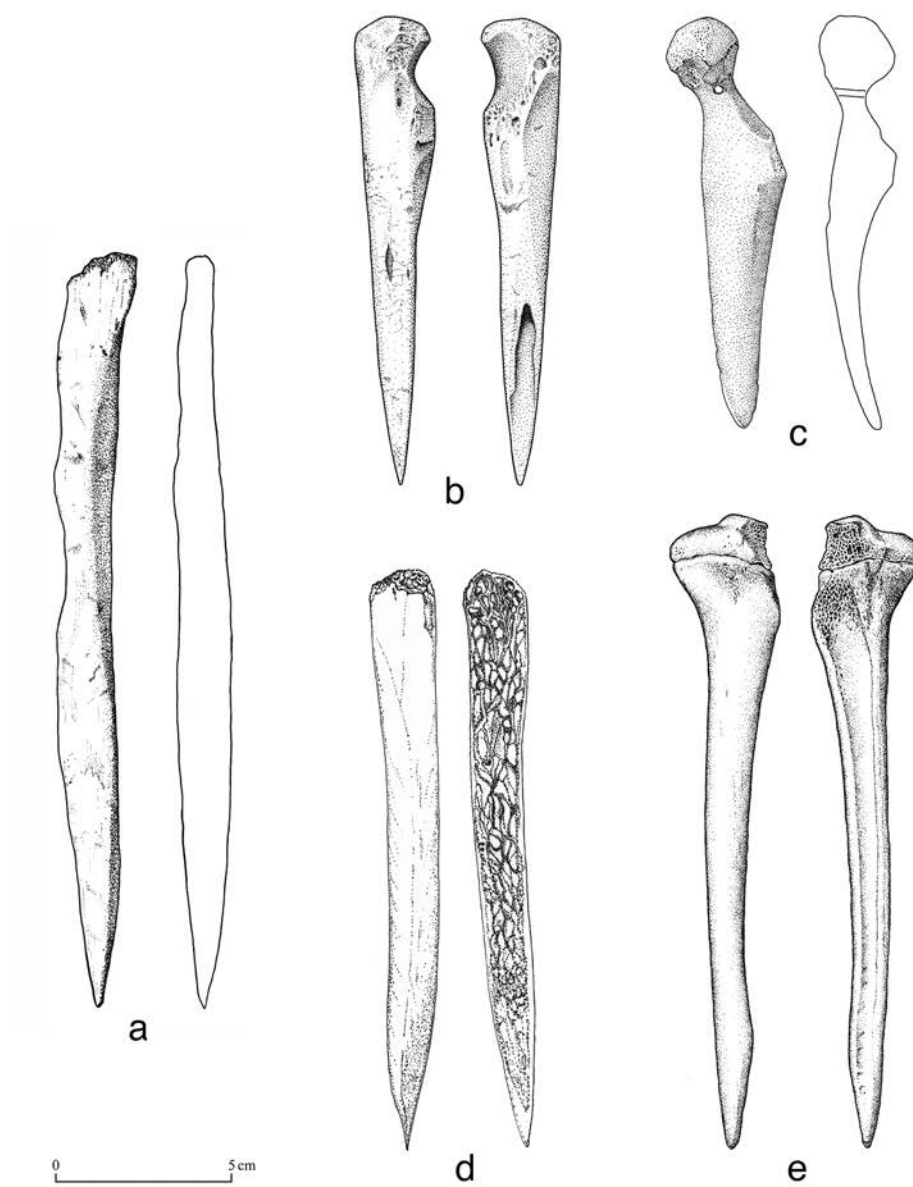


Figure 5. Long awls (tools shown with exterior view on left and either interior or side view on right). Human long bone: Mitla Fortress, a. T276; El Palmillo, b. P111, c. T925; Lambityeco, d. M165. Dog tibia: El Palmillo, e. St35 (© L. Nicholas and G. Feinman).

They were a preferred element for awls, not only in our collections but also across Mesoamerica (Flannery and Marcus 2005: 74; Hamblin 1984: 142; Kidder 1947: 54; MacNeish et al. 1971: 141; Teeter 2001: 290; Tolstoy 1971: 292) and into the American Southwest (e.g., Cosgrove and Cosgrove 1932: 57-58; Kidder 1932: 203; Tuthill 1947: 65). These stout awls were made from a metapodial bone that was split vertically, so that one epiphyseal end remained (Teeter 2001: 293, 2013: 209). This end then was modified or smoothed to varying degrees to facilitate handling. In the Oaxaca sample, this nonworking end of the tool more often was the proximal rather than the distal end. The cut edges of the long bone shaft were abraded smooth and the working end was cut and abraded to form the point. The medullary cavity is generally visible for much of the length of the tool. Most metapodial awls are 6-8 cm long. Other stout awls that generally retain at least part of either the distal or proximal end of the bone for the nonworking end were made on deer tibia (Figure 3g-i), deer humerus (Figure 3j), deer ulna (Figure 3k), and a bobcat (*Lynx* spp.) tibia. Although not common, awls made on deer ulna have been reported elsewhere (Willey 1972: 229-231).

Another set of short awls consists of somewhat flatter implements with a characteristic V-shape that are made on split long bones (Figure 4a-e). Usually, the bone was split lengthwise and both ends were completely cut away. The nonworking end and the edges of the long bone shaft were abraded smooth and the working end was cut and abraded to a point. These tools are variable in length and generally, but not always, less robust than metapodial awls. They are most commonly made on human long bones, with femur and tibia the preferred elements (see also Kidder 1947: 54; Valentín Maldonado et al. 2017). Similar awls also were crafted from long bone splinters.

Short, narrow awls were made from long bones of dogs and large birds, most often turkey (Figure 4f-i). For some of them, much of the bone shaft was left intact with the working end beveled to create a point. The nonworking end may retain some of the original end of the bone or it may be heavily modified. In others the medullary cavity was exposed. In our sample, few of these awls were recovered intact.

There are only nine awls at the four sites that we could determine were long awls. These awls tend to be highly finished implements, often with a dagger-like appearance and very little evidence of use wear. Six were made on human long bone, with no clear preference for any one skeletal element (Figure 5a-d, Figure 6), three were fashioned on deer long bone, and one was made from a dog tibia (Figure 5e). Several of the complete long awls were crafted on bone shafts that had both ends removed and smoothed or cut and abraded to a point, although two awls retained the proximal end of the bone. Most of the long awls were recovered as part of offerings or burial contexts, so we suspect that they were not utilitarian tools and instead were ceremonial

objects with ritual significance (see also Caso 1969: 190, fig. 182; Ekholm 1942: 113; Tuthill 1947: 65; Valentín Maldonado and Pérez Roldán 2012). A similar, long awl-like implement is depicted as a bloodletter in the Florentine Codex (Sahagún 1950-1982, book 3: fig. 10).



Figure 6. Long awls made on human bone. Tibia (left): Mitla Fortress, T276. Ulna (right): El Palmillo, PI11 (© L. Nicholas).

Although roughly as many awls were made from human as from deer long bones, the patterns in our sample vary by site. At Lambityeco and the Mitla Fortress, twice as many awls were made from human bone, while at El Palmillo almost five times as many were made of deer. On only one terrace (507) at El Palmillo were a significant number of awls made with dog bone. These patterns in part reflect environmental settings—as El Palmillo is closer than the other three sites to preferred habitats for deer—a point we return to below.

The Classic period awls likely were used for a range of tasks. Based on prior analyses, they are thought to have been part of textile/fiber toolkits, used as weaving picks (Chase et al. 2008: 131; Halperin 2008: 114; Hamman 1997: 157) and to punch holes for sewing (McCafferty and McCafferty 2000: 50). They also could have been used as punches for hide and leatherwork and in basketry (Drennan 1976: 213; Flannery and Marcus 2005: 74; Halperin 2008: 114; Teeter 2013: 209; Tolstoy 1971). Tools similar to deer metapodial awls from Formative period sites in Oaxaca have been employed in the region into the 20th century to slit open

cornhusks and to remove kernels from cobs (Flannery and Marcus 2005: 74; Flannery and Winter 1976: 37; Winter 1972: 152-153; see also Crow 2017: 22; Halperin 2008: 114; Reh 1939). We do not know if the Classic period awls were used for all of these tasks, but other artifacts found in association with the awls can help refine our assessment (Teeter 2013: 209).

PERFORATORS AND BLOODLETTERS

Perforators are more sharply pointed and slender than awls. They have a straighter, more linear appearance (Figure 7). As with awls, most perforators are shaped from long bone shafts. The edges of the tool are usually, but not always, finely finished, and the tips are cut and abraded to a sharp point. The nonworking end of the complete perforators in our sample usually were cut and smoothed, although a few retain an end that has been minimally modified. Approximately 15% of the perforators were burnt to some degree. The proportion of awls that were fire-hardened was almost twice as great.

The bone shafts used for perforators generally were heavily processed, but more than half could be classed to at least large mammal, bird, or more specific taxa. Perforators were made from the same animals as awls, including deer, human, dog, jackrabbit, cottontail rabbit, turkey, and unidentified bird. But the proportions of each taxon are markedly different than for awls. Overall, there were almost equal numbers of perforators made from small animals (rabbits and birds, including turkey) as

from large mammals (deer and human) (Table 2). In addition, while the preferred skeletal elements for awls were metapodial, femur, and tibia, perforators were made from a wider range of elements, including smaller long bones like fibula, radius, and ulna. Like awls, perforators may have been used for multiple tasks, such as to pierce animal hides and to create holes for sewing textile garments. They also may have served as weaving picks (Halperin 2008: 114; McCafferty and McCafferty 2008: 150). The “weaving pins” from Naranjo are inscribed with glyphs and motifs that relate to weaving and cloth production (Dacus 2005: 23-34).

A small number of perforating tools in our sample were distinctive (Figure 8, next page). Some are formally like the majority of perforators but were especially well made, highly polished, painted, or fragile. This small subset of 19 perforating implements all lacked evidence of use wear. Many of them were found in special contexts and do not appear to have been employed for the array of utilitarian tasks noted for perforators above. We suspect this smaller subset of perforating tools was used principally in autosacrificial rituals such as blood-letting (e.g., Feinman 1991: 467-469; Graulich 2005; Joralemon 1974; Joyce et al. 1991). From ethnohistoric accounts, scholars have long known that Aztec elite considered the ritual offering of blood as essential to keeping the cosmos in order (Anawalt 1982). The historical basis for the importance of blood and blood offerings through self-immolation goes back at least two millennia in prehispanic Mesoamerica and is widely

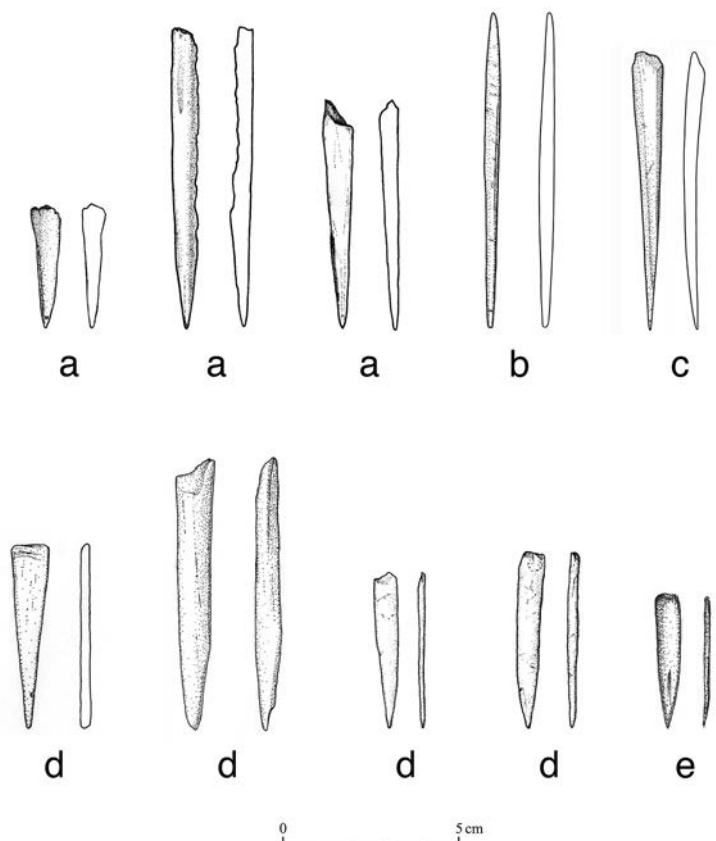


Figure 7. Bone perforators (objects with the same letter are from the same context; tools shown with exterior view on left and either interior or side view on right): Mitla Fortress, a. T276; El Palmillo, b. ballcourt, c. Pl11, d. St35; Lambityeco, e. M165 (© L. Nicholas and G. Feinman).

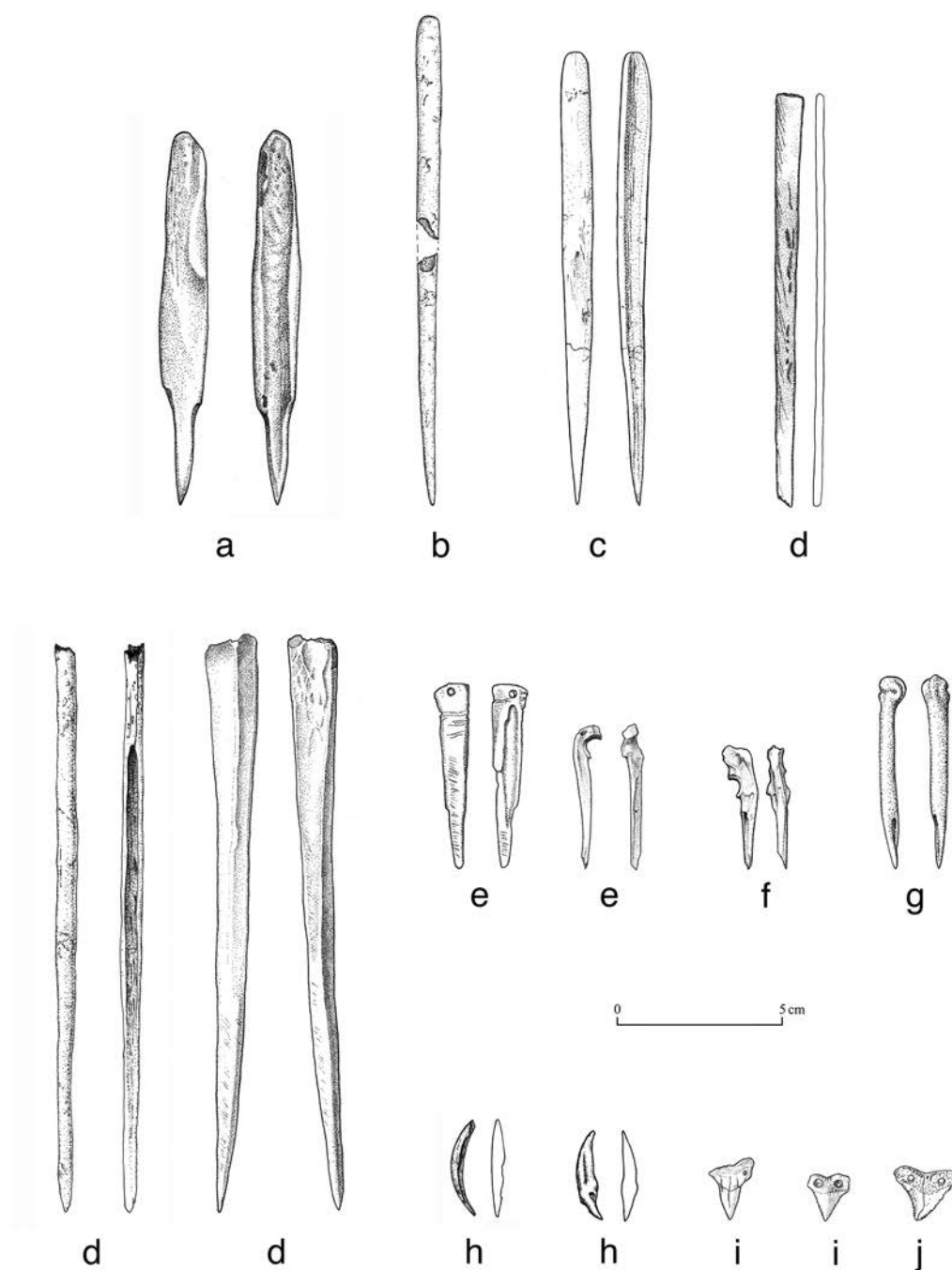


Figure 8. Bone bloodletters (objects with the same letter are from the same context; tools shown with exterior view on left and either interior or side view on right): Lambityeco, a. M170; El Palmillo, b. T1162, c. P111, d. T335, e. St35, f. P111; Mitla Fortress, g. T57, h. T276. Shark teeth: El Palmillo, i. T335, j. T507
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evidenced (e.g., Flannery and Marcus 1976; Grove 1987; MacNeish 1981). Scenes of autosacrifice are represented in cave paintings, on Maya polychrome pots and carved stelae, and in codices (e.g., Brady and Stone 1986: 23; Joralemon 1974). The Maya glyph for “displaying one’s blood” (Stuart 1984: 17) occurs as part of hieroglyphic inscriptions on some bone implements (e.g., Trik 1963: 11). Ethnohistoric accounts also list bone objects (among many implements) that served as bloodletters, including sharpened bones and stingray spines (Marcus 1983; Nicholson 1971; Tozzer 1966).

Five of the bloodletters from El Palmillo were long (approximately 15 cm or longer), well finished and highly polished, and much narrower than the long awls that also appear to have been used ceremonially (Figure 8b-d). A complete bloodletter from Platform 11 was crafted from a human long bone (Figure 8c) and is similar to an implement included in Tomb 6, Mound 195 at Lambityeco, excavated by John Paddock (Lind 2003: fig. 20). A second tool from Burial 64 on Terrace 335 at El Palmillo was crafted from a cut and smoothed jackrabbit humerus that was painted red on one end (Figure 8d top, missing tip). Elsewhere, similar implements, including ones that were carved or highly polished, have been classed as pins (e.g., Dacus 2005; Meighan 1976: plate 112; Willey 1972: 235, fig. 200, 1978: fig. 169 m).

On Mound 170 at Lambityeco, a human radius was cut and abraded into a uniquely shaped bloodletter that was highly polished and exhibited no use wear (Figure 8a). The extra effort expended in shaping this set

of perforators seemingly was not necessary for utilitarian tasks. Three smaller tools from El Palmillo were made on rabbit and jackrabbit long bones, each with one end worked to a point (Figure 8e-f). At the Mitla Fortress, a dog metapodial was crafted into a sharply pointed tool (Figure 8g), and a tool made on a turkey radius was part of Offering 28 on Terrace 57 that also included a human foot. Animal teeth also were likely bloodletters, including four imported shark teeth (*Carcharodon carcharias*) at El Palmillo (Figure 8i-j) and three dog canines cut to have sharp tips at the Mitla Fortress (Figure 8h).

NEEDLES

Needles are slender, straight tools with a pointed tip and an eye for stringing thread at the top end (Figure 9). The eyes of needles were drilled biconically in our collections and elsewhere (Moholy-Nagy 1994: 112). The entire tool is generally well formed, abraded smooth, and most often cylindrical or oval in shape, although some needles have a flatter profile. In our sample, most of the needles were already broken when recovered, but the dozen or so complete or mostly complete (broken across the eye) needles in our collections are 6–8 cm long. When the eye is missing, it is not always possible to distinguish between needles and perforators; but perforators tend to widen more away from the tip while most needles retain a smaller diameter throughout.

Needles are almost exclusively crafted from long bones, including splinters. Because needles are so highly

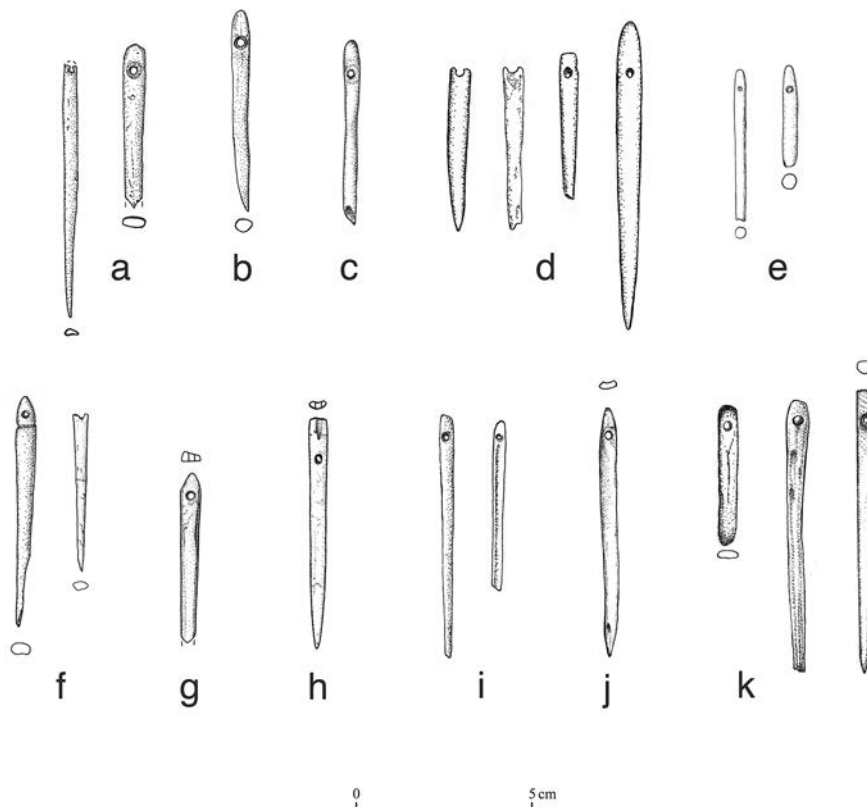


Figure 9. Bone needles (objects grouped by letter are from the same context): El Palmillo, a. T1162, b. T1147, c. T1163, d. T507, e. T335, f. St35, g. ballcourt, h. Pl11; Mitla Fortress, i. T56, j. T276; Lambityeco, k. M165 (© L. Nicholas and G. Feinman).

processed, for only 20% could we determine the taxa or specific skeletal element. Most of the needles in that subset were made on bird and rabbit long bones, especially radii (Table 2). Few needles or needle fragments were burnt.

Flannery and Marcus (2005: 74) make a distinction between small needles (c. 5 cm long) with circular cross-sections used for sewing and larger needles with oval cross-sections made from deer long bone splinters (c. 10-13 cm long) for drawing strips through the coils of baskets. Most of the needles in our collections are smaller needles for sewing. We have no complete examples of larger needles, although the larger size and flatter cross-section of some needle fragments leave open the possibility that they were used for tasks other than sewing. Long, wide needles also could have been used in the processing of coarse fibers, for example in making mats (Gates St-Pierre et al. 2016: 64-67).

BATTENS

Battens are made on flat sections of long bones modified to have straight, smoothed edges along the length of the tool (Figure 10). The ends can be blunt or taper to a rounded tip or point. The ends of most battens are not sharp enough to have been used as awls, nor are they sufficiently sturdy, and they typically taper to one edge instead of a central point. Larger, wider battens often retain some curvature of the long bone shaft, and a few retain either the proximal or distal end as a handle (see also Lind 2003: fig. 21). Most of the battens that we recovered were not complete, often missing at least one end. Based on the size of the more complete examples, battens ranged from approximately 10 cm to over 22 cm in length, with a few smaller ones between 6 and 8.5 cm, matching the size range for 15 battens previously published from Tomb 2 at Lambityeco (one was 7.3 cm, the rest were between 10.3 and 22.3 cm; Lind 2017: 83). Most battens in our sample (as well as those from Tomb 2) are only 1 to 2 cm wide.

One-third of the battens in our collections were too fragmentary to make any taxon determination; of the rest, 85% were made on large mammal long bones, with tibia the preferred skeletal element. Overall more battens were made of deer than human bone, but, like awls, the patterns vary greatly by site (Table 2). The predominance of deer over human long bone was greatest at El Palmillo, while there were equal proportions of human and deer battens at the Mitla Fortress. There were no deer bone battens at either Lambityeco or Ejutla. Two small battens at El Palmillo were made of rabbit bone, and at Lambityeco, four were made of bird, including turkey, long bones. The two battens at Ejutla could not be identified to taxa.

We strongly suspect that the battens in our collections were utilized in weaving to separate the warp threads and compress the newly added weft threads (e.g., Sayer 1988:

27-28), with batten size related to the width of the woven product. At both El Palmillo (Terrace 335) and Lambityeco (Mound 165), there were thin, narrow battens that may have been used to weave finer threads, such as cotton or a fine maguey fiber. Although Caso did not identify the carved bone implements in Monte Albán's Tomb 7 as battens, one of them has a scene with a patron of weaving holding a batten (Caso 1969: 192). These flat implements display the classic form with angled tips recorded in the Florentine Codex as part of a set of weaving tools (Sahagún 1950-1982, book 8: fig. 75). Formally similar tools have been identified as battens by other investigators (Lind 2003: 60-61, 2017: 82-83; McCafferty and McCafferty 1994: 146; Pohl 1994: 8-9). Bone tools with a similar shape also have been called spatulas or spatulates (Crow 2017: 23; Ekholm 1944: 484-485; McNeish et al. 1971: 145; Moholy-Nagy 1994: 110; 2003: 60-61, 2008: fig. 212; Newman 2013: 589; Tolstoy 1971: 293; Valentín Maldonado et al. 2017; Willey 1972: 236-237, fig. 202). Nevertheless, we suspect that the main use of these implements was associated with fiber working given their repeated illustration in codices, often in conjunction with backstrap looms (e.g., Berdan and Anawalt 1997: fol. 60r; McCafferty and McCafferty 1991; Sahagún 1950-1982, book 10: fig. 58).

DISKS/SPINDLE WHORLS

There are approximately two-dozen bone disks. These were recovered from all sites except Ejutla (Figure 11a-e, next pages). Most of the disks were made on cranial bone, and one, at the Mitla Fortress, is made on a turtle carapace. The cranial disks are mostly human; only two, at El Palmillo, are deer. The cranial fragments were abraded into circular forms and typically have a central biconical perforation with a diameter of 6 to 10 mm. The disk from turtle shell was too fragmentary to determine if it also had been perforated. The diameters of the disks range between 4 and 8 cm, and the weights between 6 g and 30 g. Centrally perforated bone disks have been found at other sites in Oaxaca and elsewhere in Mesoamerica (Drennan 1976: 215; Moholy-Nagy 1994: 110, 2003: 60), often made from human crania (Kidder 1947: 56-57; Kidder et al. 1946: 153-154; MacNeish et al. 1971: 146; Paddock et al. 1968: 14). There are various interpretations of how the disks were used, for example, to fasten clothing (Moholy-Nagy 2003: 60) or as spindle whorls (Kidder 1947: 55-57).

Ceramic spindle whorls are a common tool in textile production (e.g., Carpenter et al. 2012; Chase et al. 2008; Halperin 2008; McCafferty and McCafferty 2008; Parsons 1972). They are added to the base of a spindle to provide greater control as the revolving spindle twists fibers into thread (Parsons and Parsons 1990: 180). The weight of spindle whorls generally correlates with the thickness of the thread that is produced (Carpenter

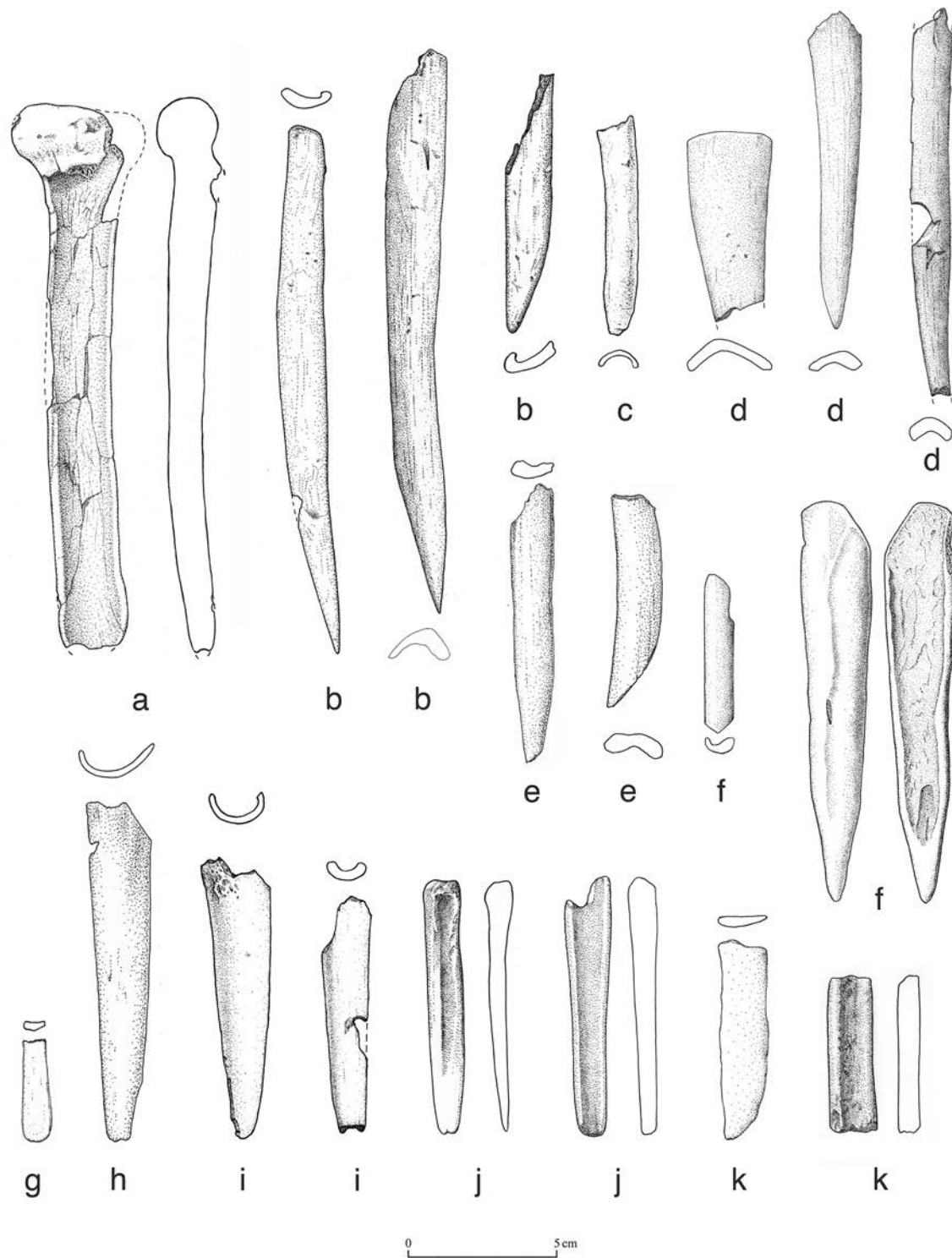


Figure 10. Bone battens (objects with the same letter are from the same context; tools shown with cross section or with exterior view on left and either interior or side view on right): El Palmillo, a. P111, b. T1162, c. St35, d. T925, e. T335, f. T335; Lambityeco, g. M165, h. M170; Mitla Fortress, i. T276, j. T56, k. T57
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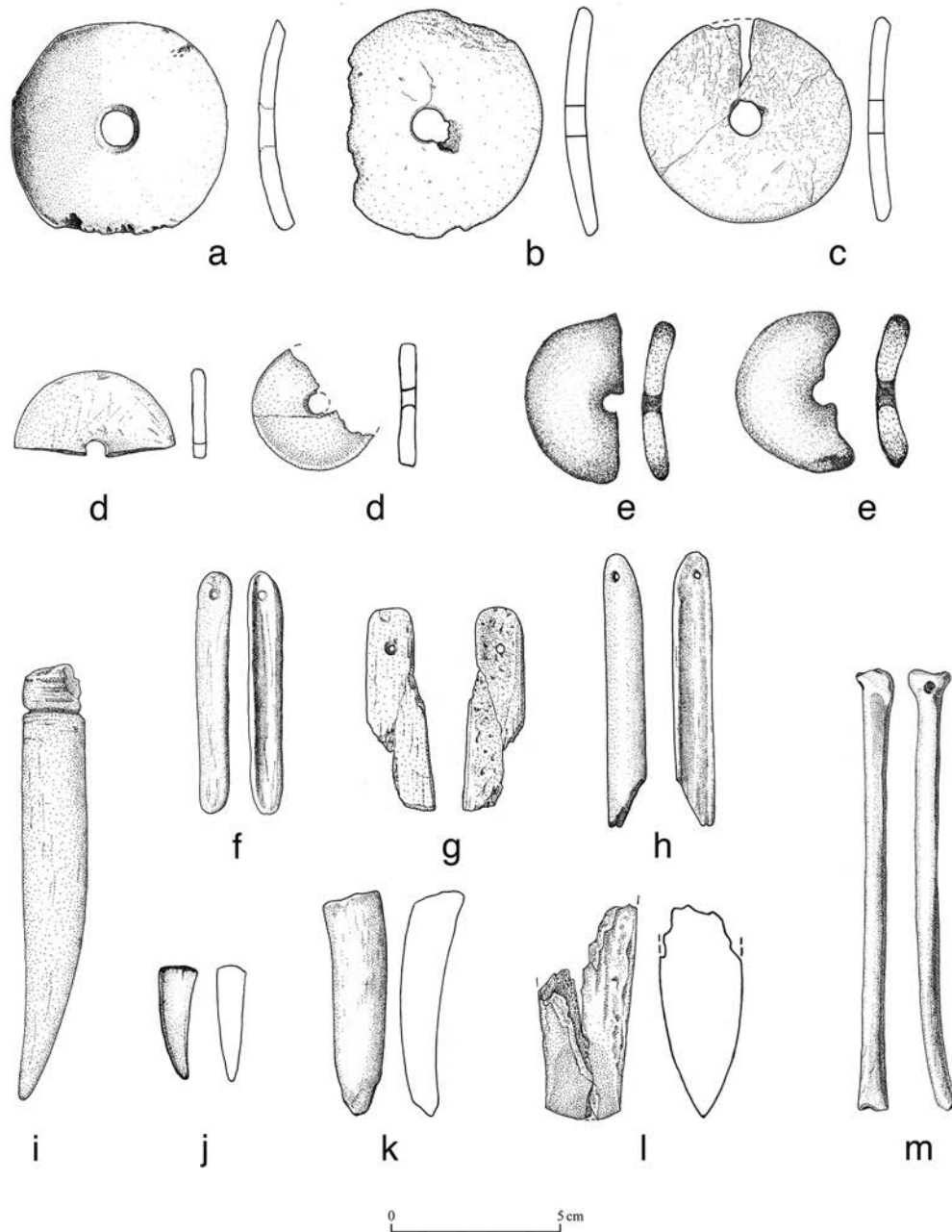


Figure 11. Other bone tools (objects with the same letter are from the same context; tools shown with exterior view on left and either interior or side view on right). Disks/spindle whorls: Mitla Fortress, a. T276; El Palmillo, b. T507, c. T1163, d. T1162; Lambityeco, e. M165. Shuttles: El Palmillo, f. ST35, g. T335; Mitla Fortress, h. T56. Antler tine pressure flakers: El Palmillo, i. T1447; Mitla Fortress, j. T276, k. T56. Chisel: El Palmillo, l. T1162. Straw/hollow tube: El Palmillo, m. St35 (© L. Nicholas and G. Feinman).

et al. 2012; Parsons and Parsons 1990: 315-316), patterning into three main groups: cotton, fine maguey, and coarse maguey. The weights and center perforations of all the bone disks fall within the size ranges of the ceramic spindle whorls (see Carpenter et al. 2012: 391) from all four sites. They correspond most closely with the middle group of ceramic whorls and so also could be used to spin thread from a variety of fibers.

SHUTTLES

In our collections, a small number of implements are slightly curved, cut from long bone shafts or ribs that are abraded smooth on all edges and drilled near one end (Figure 11f-h). They appear to be shuttles used in weaving to move weft threads through the warp (Sayer 1988: 27). We identified only six possible shuttles in our sample; there could be more but when the end with the hole is broken, identification is insecure. Generally, use wear is more evident on the exterior surface of these implements than on the edges. Two were made of jackrabbit bone (1 rib, 1 long bone), two of large bird long bone, one of human long bone, and one of unknown long bone. There was at least one of these tools at each of the four sites.

PRESSURE FLAKERS

Although not numerous, there are deer antler tines in our collections with evidence of crushing or other use wear on the tip (Figure 11i-k). More than 40% are burnt to some degree (see Figure 2c, d), likely to fire-harden them to increase their strength (e.g., Flannery 1986; Hamblin 1984: 141-142; MacNeish et al. 1971: 142). These tools are more common at El Palmillo, where there likely was greater access to deer and more stone working (Haines et al. 2004) than at the other three sites. Worked deer antler tines often have been interpreted as pressure flakers to work other materials (e.g., Crow 2017: 23; Cummings 1940: 65; Flannery 1986; Flannery and Marcus 2005: 121 *passim*; Teeter 2013: 210; Tolstoy 1971: 295; Willey 1978: 171), especially stone (Hamblin 1984: 141-142; Moholy-Nagy 2003: 61), both in making tools and resharpening chipped stone tools when they become dull. The bases of deer antlers were used as hammers in Formative period Oaxaca (Drennan 1976: 215; Flannery and Marcus 2005: 163; see also MacNeish et al. 1971: 141-142; Tolstoy 1971: 295); the only two antler bases with evidence of use wear in our Classic period collections do not appear to have been used as hammers; one was worked into a chisel (see below).

CHISELS

There are only a few tools in our collections that could be classified as chisels (Figure 11l). Chisels are triangular or wedge-shaped tools that have been cut and abraded

to form a flat working edge. All three chisels in the sample are from lower terraces at El Palmillo. The best example was made from deer antler, with a working edge approximately 2 cm wide. Chisels or tools with chisel-like ends are listed in only a few Mesoamerican bone tool assemblages (Campos-Martínez and Pérez-Roldán 2016: 101; Teeter 2013: 210; Willey 1972: 230, 238). Drennan (1976: 213) noted that tools he called gouges with flat chisel-like points have use wear indicative of a straight longitudinal motion.

HOLLOW TUBE

One bone tool was highly distinctive. It is a hollow tube 13 cm long that was made from a jackrabbit tibia (Figures 11m, 12). Both ends of the bone were cut off and abraded smooth, and a small hole was drilled through one side of the bone near the proximal end. Although the use of this object is unclear, we think it could have been used as a straw for imbibing pulque. The consumption of pulque through a straw during a ceremony is depicted in several Aztec documents, including the Magliabechiano Codex (Boone 1983: fol. 85r) and the Florentine Codex (Sahagún 1950-1982, book 4: fol. 14; see also Anawalt 1993). In the latter, a rabbit vessel holds the pulque. The hollowed out jackrabbit bone was recovered from an offering that was part of the ritual termination of a sweatbath associated with a palace in the upper precinct of El Palmillo; the skeletal remains of three rabbits and several other bone tools were part of this offering (offering 73, Feinman and Nicholas 2009: appendix IV), which raises the possibility that the Aztec association between rabbits and pulque (e.g., Anawalt 1993) may have been more widely held.



Figure 12. Hollow tube with perforation made from jackrabbit tibia, El Palmillo, St35 (© L. Nicholas).

ORNAMENTAL OBJECTS

Most of the bone ornaments at the four Valley of Oaxaca sites are tubular beads and pendants (Figure 13, next page; Table 4, next pages). Several polished tubes appear to be blanks for making tubular beads. Bird (including turkey) and dog long bones were the preferred taxa and skeletal elements for making tubular beads, which generally had highly polished surfaces and smoothly abraded ends. About 40% could not be identified to taxa. Tubular beads made from bird bone range

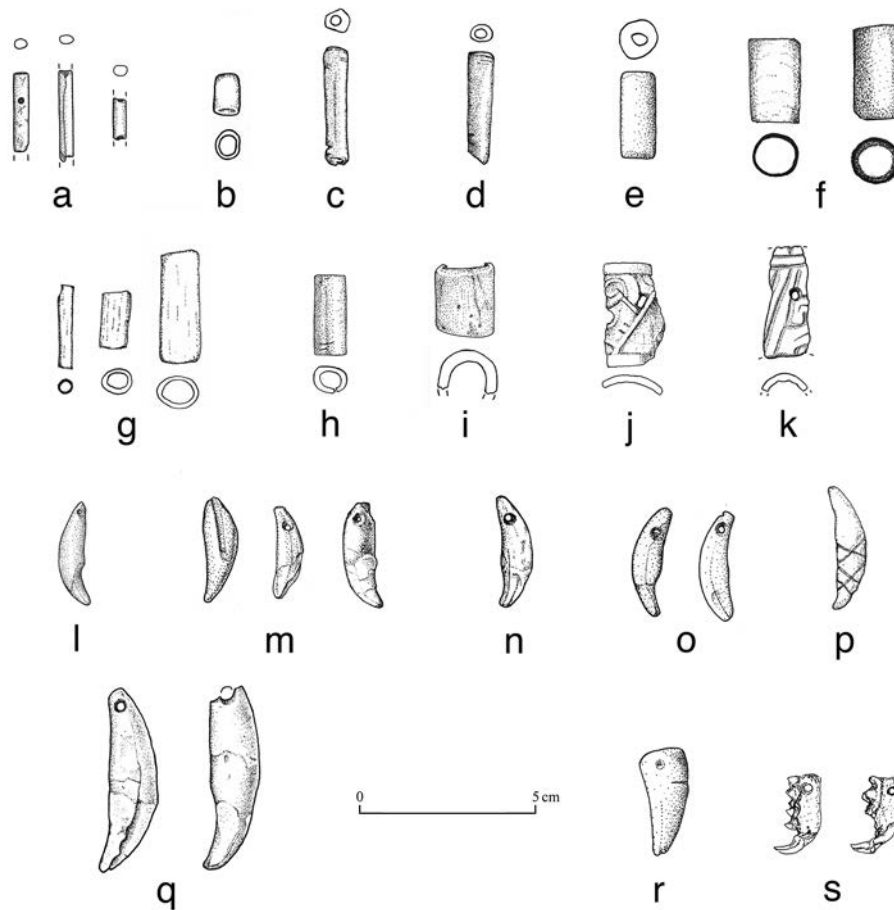


Figure 13. Ornaments (objects grouped by letter are from the same context; beads shown with cross section; other ornaments shown one view). Bird bone beads: El Palmillo, a. P111; Mitla Fortress, b. T56, c. T276. Jackrabbit bead: Lambityeco, d. ballcourt. Dog bone beads: Mitla Fortress, e. T57; Lambityeco, f. M165. Other bone beads: Lambityeco, g. M165; El Palmillo, h. T1162, i. T1163. Carved beads: El Palmillo, j. T335, k. P111. Dog canine pendants: El Palmillo, l. T925, m. St35; Mitla Fortress, n. T276, o. T57; Lambityeco, p. M165. Jaguar canine pendants: El Palmillo, q. St35; Mitla Fortress, r. T57. Weasel mandible pendants: El Palmillo, s. T507 (© L. Nicholas and G. Feinman).

between 1 and 3 cm long and 4-7 mm in diameter. Four beads made from rabbit long bones are similar in size to the bird bone beads. Turkey and dog beads are larger, from 2 to 4 cm long and between 9 to 15 mm in diameter. Half of the dog beads were recovered from the Mound 165 residence at Lambityeco, where we also found bone debris from making the beads (Figure 14; Feinman and Nicholas 2016). Overall, this context had twice as many bone beads as the most elaborate palace (Platform 11) at El Palmillo and more than three times as many as any other context at the four sites. These beads may have been made and used as ritual paraphernalia by the ceremonial attendants (low-level priests) that we suspect resided in the Mound 165 residence at Lambityeco. Only two bone beads were carved (Figure 15, next pages); one each was found in the masonry tombs on Terrace 335 and Platform 11 at El Palmillo.

Most of the pendants were made from animal teeth, especially dog canines (Figure 13l-p). They were polished and biconically perforated through the root for suspension. Perforated dog canines were found at three of the four sites and have been reported at other sites in Oaxaca



Figure 14. Dog bone debris (above) and tubular beads (below) from Lambityeco, M165 (© L. Nicholas).

(Drennan 1976: fig. 73; Flannery and Marcus 2005: 219, 383; Joyce 1991: 759) and elsewhere in Mesoamerica (Ekholm 1944: 484; Hamblin 1984: 114; Kidder 1947: 57; Kidder et al. 1946: 155; Moholy-Nagy 1994: 111,

	Ejutla	El Palmillo								Mitla Fortress				Lambityeco		
	House	T1162	T1163	T1147	T925	T507	T335	St35	Pl11	T56	T57	T276	M165	M170	Plaza	
Tool/ornament																
Armadillo plate	-	-	-	-	-	-	-	-	8	-	2	-	-	-	-	
Bird bone bead/ bead blank	-	-	-	-	-	-	-	-	5	5	-	1	1	-	1	
Deer antler bead	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	
Dog tubular bead	2	1	-	-	-	2	-	-	-	-	1	-	7	-	-	
Dog tooth pendant	1	-	-	-	1	1	4	4	-	-	2	3	4	-	1	
Dog unknown ornament	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	
Gopher tooth bead	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	
Human bead, pendant	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	
Human other, unknown	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	
Jaguar tooth pendant	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	
Rabbit/jackrabbit bead	-	-	-	-	-	-	3	-	1	-	-	-	-	-	-	
Turkey tubular bead	-	-	-	-	-	-	-	-	1	-	1	-	5	-	-	
Turtle shell ornament	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Turtle shell drum	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	
Weasel pendant	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	
UID bead/bead blank	4	1	2	-	7	2	4	-	5	-	3	-	7	-	-	
UID pendant	-	-	1	-	2	-	1	1	-	1	-	-	-	-	-	
UID placa	4	-	-	-	-	-	2	-	-	1	-	-	-	1	-	
UID ring	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UID ornament	-	-	-	-	1	1	1	-	-	-	2	-	-	-	-	

Table 4. Bone ornaments at each site (does not include ballcourts; UID = unidentified; data compiled by L. Nicholas and G. Feinman).



Figure 15. Carved bone beads from T335 (left) and P111 (center) at El Palmillo; carved dog canine (right) from M165 at Lambityeco (© L. Nicholas).

2008: 73, fig. 213; Willey 1972: 239, 1978: 171; Willey et al. 1994). At Ejutla, the perforated dog tooth was an incisor. One unperforated canine at Lambityeco was incised with crisscross lines (Figure 15), and other canines at all four sites were highly polished. These latter pieces may be unfinished ornaments or special objects like amulets (e.g., Flannery and Marcus 2005: 330, 335; Willey et al. 1994).

Much less common were perforated jaguar (*Panthera onca*) teeth (Figure 13q-r). Two jaguar canines at El Palmillo were highly polished and perforated through the root and placed in an offering in Structure 35, one of three palaces at the top of the site. The jaguar canine on Terrace 57 at the Mitla Fortress was more modified, with part of the root end cut off and abraded smooth; there was an incomplete perforation on the root below the enamel. Although we did not recover any jaguar canine pendants in our excavations at Lambityeco, two are reported from Tomb 6 in the Mound 195 palace (Lind 2003: 59). Small numbers of perforated feline canines, most likely jaguar or puma, have been reported elsewhere in highland Mexico (MacNeish et al. 1971) and at Maya sites (Kidder 1947: 57; Moholy-Nagy 2008: 73, fig. 213; Willey 1972: 239). Also at El Palmillo,

two small weasel (*Mustela frenata*) mandibles had been perforated for stringing; both were part of the grave offerings of Burial 53 on Terrace 507 (Figure 13s; for a dog mandible that is perforated for stringing, see Valentin Maldonado et al. 2017: fig. 3).

At all four sites, loose dog canines were recovered in quantities three to four times higher than they naturally occur as a proportion of a dog's dental apparatus, a pattern previously noted by Hamblin (1984: 114). Because of their durability, it is not unusual for animal teeth to be overrepresented in faunal assemblages, but the high quantities of canines implies cultural importance (Hamblin 1984: 114; Pohl and Feldman 1982). Dog teeth, especially canines, were a larger proportion of all dog remains at Ejutla than at the other sites. We suspect that they were curated as unfinished ornaments to be strung with shell ornaments that also were made at the site (Middleton et al. 2002). Animal (and human) teeth were strung into necklaces, often interlaced with shell and bone beads, throughout prehispanic Mesoamerica (Hepp and Rieger 2014: 119; Joyce 1991: 759; Kidder et al. 1946: 155; Merwin and Vaillant 1932; Thompson 1939; Thornton 2011: 104; Willey 1972: 239).

In a few contexts we recovered small bone plaques, including 10 small armadillo (*Dasypus novemcinctus*) plates, most of which were found in association with the masonry tomb on Platform 11 at El Palmillo (Figure 16 left; Feinman and Nicholas 2009). Armadillo plates may have been used as inlay or sewn onto clothing (Flannery and Marcus 2005: 96). Worked and unworked turtle shell fragments at Ejutla and the Mitla Fortress may have been intended for a similar use (Figure 16 center and right). At Ejutla a fragment of turtle shell with a partial perforation on one edge may be a broken, unfinished ornament.

Only at the Mitla Fortress did we find a possible musical instrument, the partial remains of the shell of a Mexican mud turtle (*Kinosternon integrum*) that had been placed as an offering in an adobe wall during a rebuilding episode on Terrace 56 (Figure 17). The



Figure 16. Small armadillo plates (left), El Palmillo, P111; carved and drilled turtle shell (center), Ejutla; cut turtle shell (right), Mitla Fortress, T276 (© L. Nicholas).

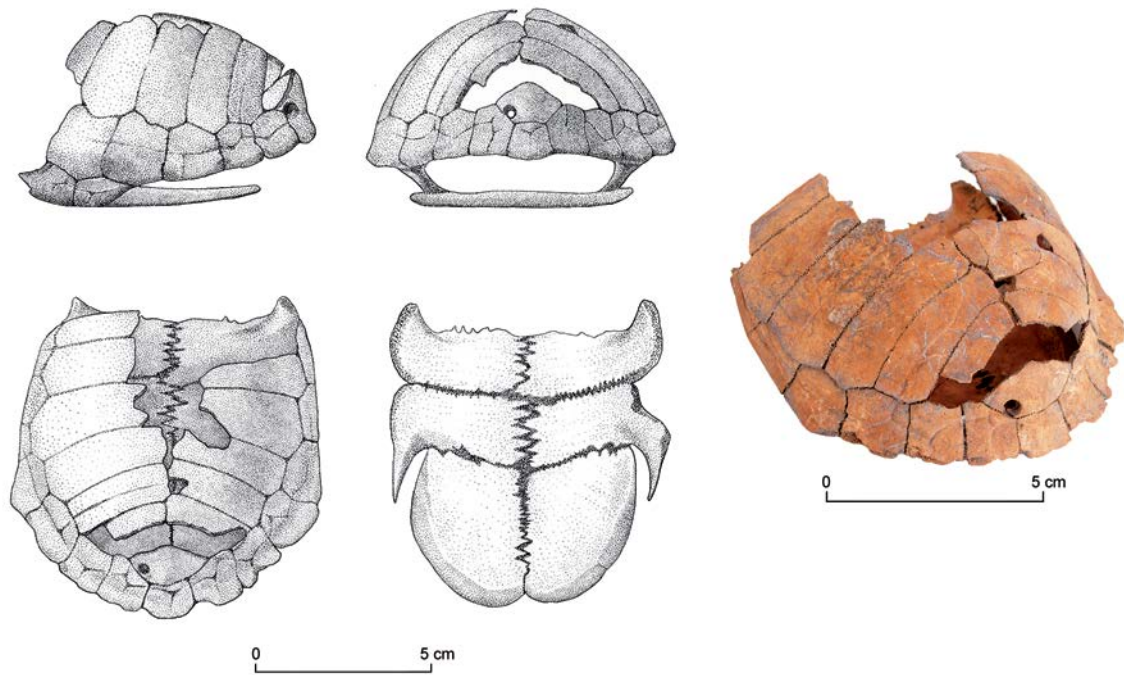


Figure 17. Turtle shell drum: Mitla Fortress, T56 (© L. Nicholas and G. Feinman).

turtle shell appears to have been crafted into a drum (e.g., Amadio 2006: 46-47; Crow 2017; Flannery and Marcus 2005: 96-97). There was one small perforation on the back end of the carapace, possibly for suspension.

BONE ARTIFACTS: TAXA SELECTION

Bone was an important resource or raw material, used to make a range of tools and ornaments at all four valley sites. Bone tool forms at the four sites show a great deal of standardization in size, method of processing the bone, and the specific skeletal elements that were preferred, as Emery (1997: 556-564, 2008: 217, 2009: 466) and Moholy-Nagy (1994: 111) observed in the Maya collections they analyzed. Similar bone tool forms have been reported across a much larger geographic expanse that includes the American Southwest (e.g., Cosgrove and Cosgrove 1932; Di Peso 1956; Kidder 1932).

In our sample, the preferred taxa reflect the species that were most abundant at each site or context, with greater use of human bone at settlements where large mammals such as deer were less abundant. Different taxa were preferred for tools versus ornaments, with three-quarters or more of human, deer, and rabbit bones used to make tools. In this sample, human, and especially deer, bones were not commonly worked into ornaments. In contrast, almost half of dog remains, including perforated/decorated teeth (but not counting curated, unperforated canines), were used to make beads and pendants, and less than a third of worked dog bones were crafted into tools. Although more bird bones were worked into tools, they were the second preferred taxa for ornaments after dog.

TOOL ASSEMBLAGES AND ECONOMIC ACTIVITIES AT CLASSIC PERIOD SITES IN OAXACA

We reexamined the bone tool assemblages from all four sites to ensure consistency in how we classed and interpreted bone objects. For that reason, in some cases, the numbers presented here are slightly revised from those published previously for specific contexts at Ejutla and El Palmillo. Nevertheless, the overall patterns correspond to what we previously observed.

Some tools were likely multipurpose implements, yet most of the bone tool forms at the four sites previously have been linked to elements of fiber working and textile production (e.g., Chase et al. 2008; Halperin 2008). To evaluate and amplify this seeming association, we briefly examine the bone implement complex in conjunction with ceramic and stone tools—spindle whorls and chipped stone raspadors (large, dome-shaped scrapers)—that have been explicitly tied to spinning and processing fiber (e.g., Carpenter et al. 2012; Chase et al. 2008; Halperin 2008; Hester and Heizer 1972; Robles García 1994). A full discussion of all productive activities for the four Classic period sites is beyond the scope of this paper. Rather, our aim here is to assess in a broader context the use of bone implements during the Valley of Oaxaca Classic period.

Previously (e.g., Feinman and Nicholas 2007b, 2012, 2017), we have noted indications of fiber working in each household at all four sites. But the number and proportion of specific tool forms in each domestic assemblage varies by site and household (Table 5, next page; Figure 18, next pages). This variation yields important perspectives on distinct sets of activities that were enacted in different

	Ejutla	El Palmillo								Mitla Fortress			Lambityeco		
Tool	House	T1162	T1163	T1147	T925	T507	T335	St35	Pl11	T56	T57	T276	M165	M170	Plaza
Bone awl	10	18	7	6	15	24	12	19	20	18	24	8	35	3	6
Bone batten	2	11	5	5	16	2	20	21	33	12	9	9	21	3	5
Bone needle	7	7	3	3	6	8	11	10	4	2	10	2	6	–	1
Bone perforator	3	–	3	–	6	3	5	9	13	2	4	17	11	2	1
Bone perforator/needle	1	3	–	3	–	4	–	–	–	–	1	2	1	–	–
Bone shuttle	1	–	–	–	–	–	1	1	–	1	–	1	–	1	–
Spindle whorl (all materials)	106	19	17	16	7	25	40	49	25	15	16	11	42	4	7
Small spindle whorl	81	5	2	3	4	9	12	21	13	6	5	2	12	1	2
Medium spindle whorl	17	11	11	11	2	11	24	25	11	6	8	8	27	3	5
Large spindle whorl	1	3	4	–	1	4	4	3	1	3	3	1	2	–	–
Stone/ceramic spinning bowl	–	3	1	4	1	8	5	6	2	3	1	–	1	1	1
Stone spinning tool	–	–	–	–	–	–	–	1	1	2	1	–	–	–	–
Stone raspador	10	40	27	22	43	47	27	83	52	44	52	23	34	8	4

Table 5. Bone, ceramic, and stone tools associated with each site (most of the perforated bone disks fall into the middle group of spindle whorls; all other spindle whorls are ceramic; data compiled by L. Nicholas and G. Feinman).

contexts. The small number of raspadores and the large number of small (in relation to larger) spindle whorls at Ejutla, for example, reflects a much greater focus on cotton than maguey fibers. Ejutla is closer to lowland areas where cotton was grown (Feinman and Nicholas 2013: 118) and is better watered than eastern Tlacolula where the other three sites are situated (see Figure 1). Based on the presence of so many small spindle whorls and many needles, the fiber-working activities at Ejutla were seemingly focused on the spinning of cotton thread and sewing. In contrast, the broader range of spindle whorl sizes and the large number of raspadores at El Palmillo and the Mitla Fortress likely reflects a greater focus on maguey fibers, which corresponds with the more arid

location of these sites (Feinman and Nicholas 2005). Although bone awls seemingly are multipurpose tools that were present in all contexts, they were relatively more abundant at the three Tlacolula sites where they may have been used with coarser fibers.

The residents of each house appear to have worked differential proportions of the available fibers and participated in different activities associated with processing fiber and turning it into woven goods. Some houses have more raspadores for processing maguey leaves to extract fibers, others have more spindle whorls for spinning thread, several have proportionally more needles for sewing, while a number have more battens for weaving with backstrap looms.

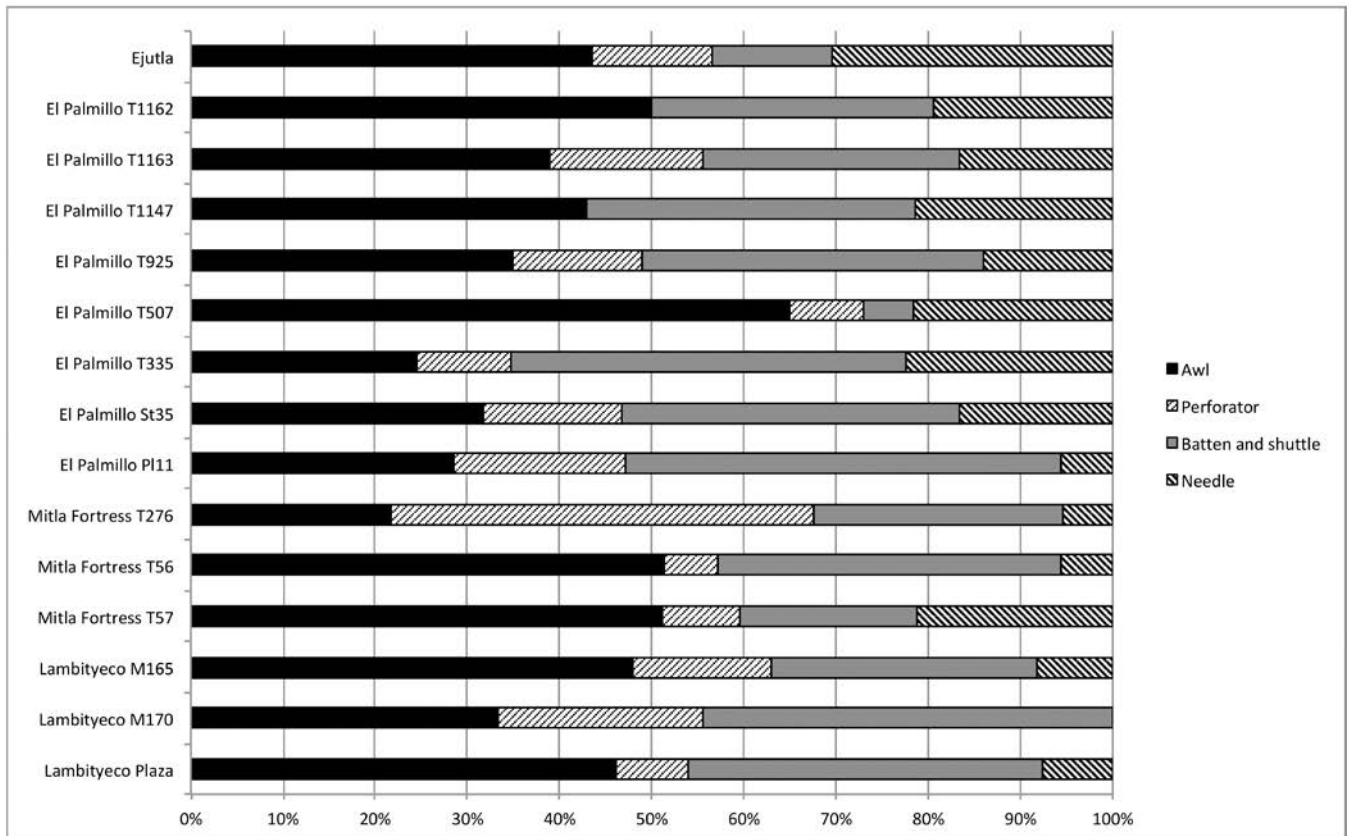


Figure 18. Principal bone tools associated with weaving and fiber working and their proportion in each excavated context (© L. Nicholas and G. Feinman).

To a degree, this household variation is related to status. Cloth, especially cotton, was a valuable commodity associated with elite status that also served as a medium of exchange (Baron 2018; Berdan 1987; Stark et al. 1998). In our sample, weaving battens are generally more abundant in high-status contexts. In Late Classic and Postclassic Oaxaca, elaborately carved ceremonial bone battens were included in tomb assemblages (Caso 1969; Lind 2017: 83-84). There are more battens and spindle whorls, especially lighter weight ones to spin finer fibers, in the three palatial residences (T335, St35, Pl11) at El Palmillo and the priests' residence (M165) at Lambityeco than in other, lower-status contexts. Weaving was an especially prominent activity in Platform 11, the most elaborate residence in this sample. The high number of bone ornaments at the Lambityeco residence and Platform 11 at El Palmillo provide additional confirmation of the high status of those domestic contexts.

There were differences as well among the commoner residential contexts at El Palmillo and the Mitla Fortress. Most of the spindle whorls on the lower terraces at El Palmillo (T1162, T1163, T1147) and the lowest terrace (T276) at the Mitla Fortress are too large for cotton and likely were used to spin maguey fiber. Only Terrace 1162 (El Palmillo) also has numerous battens and awls; some of the awls may have been used as weaving picks. In contrast, perforators are much more abundant on Terrace 276 (Mitla Fortress) than in any

other excavated context. The two intermediate terraces at El Palmillo have very different tool assemblages. Terrace 925 has few spindle whorls, but many battens and awls. Terrace 507 has many spindle whorls, including more small ones, than on the lower terraces, but almost no weaving battens. Although the residents of all three terraces at the Mitla Fortress engaged in some weaving, sewing was a more prominent activity on Terrace 57. In contrast to the variable distribution of tools related to fiber working, antler tine pressure flakers that are used to make or resharpen stone tools were present in low numbers in most residences.

Analyzing the bone tool assemblage of each context separately gives us a different perspective on the pre-hispanic economy. Not only did individual sites in the same region specialize in different goods (Feinman and Nicholas 2004a, 2006, 2007a; Lapham et al. 2013) but contemporaneous residents of different houses at the same site often engaged in distinctive suites of economic activities (Carpenter et al. 2012; Feinman and Nicholas 2007b; Lapham et al. 2016). The occupants of each house engaged in a range of economic pursuits (Feinman and Nicholas 2000, 2007a, 2007b), which we have referred to as multicrafting. Yet each house that was excavated included specific goods that the occupants did not produce or make themselves. In our view, this high degree of economic interdependence between households augurs an important role for market exchange (Feinman 2017;

Feinman and Nicholas 2010, 2012, 2017), given the significance of markets today in Oaxaca (Beals 1975; Cook and Diskin 1976) and more broadly in Mesoamerica toward the end of the prehispanic era (Berdan 1985; Feinman and Garraty 2010; Pohl et al. 1997).

CONCLUDING THOUGHTS

We highlight the importance of bone as a resource for tools and ornaments in the prehispanic Valley of Oaxaca. By systematizing the analysis of bone implements from four Classic period sites and by comparing bone tool assemblages across specific contexts, we see both similarities in the tool kits and activities associated with most, if not all, domestic units, but also variation in the specific set of tasks associated with each residence. Bone was such an important resource for making tools that even when large fauna was not readily accessible, human bone became the viable substitute.

Specifically, our contextual observations are in accord with prior research that ties a range of bone tools to fiber working and weaving (e.g., Halperin 2008; McCafferty and McCafferty 2008). The presence of these tools in conjunction with ceramic and stone implements, especially spindle whorls and raspadors, underscores the importance of fiber working in these Classic period Oaxaca contexts. Some bone tools, especially awls but also perforators, clearly had a range of uses, while needles, spindle whorls, and battens can be linked more closely to specific spinning and weaving tasks. Through this systematic, contextual consideration of bone tools, we see that individual households participated in a similar suite of activities, yet engaged to different degrees in the distinct steps of fiber working. These patterns of fiber working mirror the diversity of economic pursuits associated with prehispanic Oaxaca households more generally (e.g., Feinman and Nicholas 2012).

Overall, our aim has been to offer a basic analytical path for the examination of bone objects. Through the systematic consideration of bone tools as part of larger archaeological complexes, we see that basic classes of bone implements were broadly shared across prehispanic Mesoamerica, but even within one region, their distributional frequencies vary not only from site to site, but also among domestic units at the same settlement. Here, these findings provide portals into the variable economic practices, task specializations, and likely interdependencies between Classic period residential units in the Valley of Oaxaca, thereby providing a perspective and means to assess the conceptualization of the prehispanic economy in this region and for prehispanic Mesoamerica more broadly.

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