SPINDLE WHORLS FROM EL PALMILLO: ECONOMIC IMPLICATIONS

Lacey B. Carpenter, Gary M. Feinman, and Linda M. Nicholas

We analyze household inventories from eight excavated residences at El Palmillo (Oaxaca, Mexico) with a focus on a large sample of spindle whorls. Measurement of the whorls provides a basis to suggest that a variety of fibers were spun in these Classic period households; however, the particular mix of fibers varied in each residence. The distribution of whorls by size and production technique was compared with the spatial patterning of other tool classes related to cloth production to illustrate that each household participated with differing intensity in the various steps of the cloth-making process while also being involved in other economic pursuits. The domestic multicrafting, along with the clear procurement of domestic goods through intra- and extracommunity transfers, is indicative of economic practices that incorporate both interdependence and flexibility to operate in a socioeconomic setting prone to fluctuations in both demand and climatic conditions such as those found in the Valley of Oaxaca, Mexico. The model generated from this bottom-up analysis illustrates the limitation of the command-oriented models of the prehispanic Mesoamerican economy and sheds new light on craft specialization and economic strategies that vary not only between elite and nonelite families but among commoner households as well.

Analizamos los complejos de artefactos de ocho residencias excavadas en El Palmillo (Oaxaca, México) enfocando sobre una colección grande de malacates. Las medidas variables de los malacates indican que los habitantes de estas casas del periodo Clásico hilaron una variedad de fibras; sin embargo, las fibras específicas utilizadas no eran exactamente las mismas en cada residencia. La distribución de los malacates por tamaño y técnica de producción fue comparada con la distribución de otras clases de herramientas relacionadas con la producción de tela para ilustrar que cada casa participaba con intensidad diferente en las varias etapas del proceso de hacer la tela al mismo tiempo que estaba involucrada en otras actividades económicas. La evidencia de que las casas se ocupaban en artesanías múltiples y claramente procuraban bienes domésticos por transferencias al interior y exterior de la comunidad indica que seguían una estrategia económica que incorporaba tanto interdependencia como flexibilidad para actuar en un ambiente socioeconómico propenso a fluctuaciones en la demanda y condiciones climáticas impredecibles, tales como las que se encuentran en el Valle de Oaxaca, México. El modelo generado por este análisis de casas revela las limitaciones de los modelos tradicionales que proponían que la economía mesoamericana prehispánica fue dirigida y centralizada. También proporciona nuevo conocimiento sobre la especialización artesanal y las estrategias económicas que variaban no solamente entre la elite y las otras familias, pero también entre las casas de la gente humilde.

Models for understanding and framing the prehispanic Mesoamerican economy are in the process of significant revision (Brumfiel 1996; Feinman 1999, 2006; Feinman and Nicholas 2004a, 2010; Hirth, ed. 2009; Inomata 2007a; King 2008; Offner 1981; Smith 2001), although many aspects of these economic systems remain to be fleshed out. Earlier theoretical models (Carrasco 1978, 1983; Sanders and Price 1968), which for decades relied on notions of politically directed or command economies (Polanyi 1957; Wittfogel 1957), are now being altered and revised. Earlier work had emphasized (1) elite economic control, (2) redistribution, (3) centralized storage, (4) household self-sufficiency, and (5) a reliance on maize farming supplemented by craft production. New archaeological research, focused largely on household excavations (Feinman et al. 2002;

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Flannery 1976; Flannery and Marcus 2005; Hirth, ed. 2009; Santley and Hirth 1993; Wilk and Rathje 1982), is leading to alternative interpretations. The house is now seen as the key unit for craft production and one of the hallmarks of the Mesoamerican economy (Feinman 1999; Feinman and Nicholas 2005; Feinman et al. 2007; Folan et al. 1979; Hirth 1998; Hirth, ed. 2009; Parsons 2009).

In this article, we focus on craft activities evidenced through horizontal excavations of eight Classic period (A.D. 200–850) houses at the site of El Palmillo, located in the Tlacolula arm of the Oaxaca Valley. We examine spindle whorl and bone tool distributions to look at cloth and fiber production and present evidence for household-scale production in the Mesoamerican economy. We aim to address questions regarding the nature of economic production and its location and relation to distribution and status. We argue that the diversified domestic production strategies at El Palmillo, when placed in a larger regional context, imply active networks of both intrasettlement and intersite exchange. Based on these findings, we propose an expanded view of the relationship between agricultural and craft production and question the presumption of domestic self-sufficiency.

Changing Models of Mesoamerican Economies

Over the years, scholars have endeavored to understand production, distribution, and consumption and the mechanisms that link these economic processes to broader social and political contexts (Brumfiel and Earle 1987; Costin 1991; Hirth 1996; Schortman and Urban 2004; Smith 2004). For prehispanic Mesoamerica, traditional models drew heavily on Marx, Polanyi, and Wittfogel and focused primarily on the Aztec, for whom descriptions (textual) of economic behaviors were more robust than for other Mesoamerican societies (Berdan 1983; Carrasco 1978, 1983; Sanders 1968; Sanders and Price 1968). These models have several central elements, including tribute; centralized management of land, water, or other means of production; and corvée labor (Carrasco 1978; Sanders 1968). Because the Tlatelolco market was such a prominent feature of the Aztec world, views of the Aztec economy included marketplace exchange. But such exchanges were often thought to have been controlled by political authorities (Smith 2004:76) and were not necessarily envisioned for other Mesoamerican economies (e.g., Kurtz 1974; Sanders et al. 1979:404–405).

One of the more explicit traditional models classified the ancient Mesoamerican economy as a redistributive system where a powerful ruling class was able to control production and regulate distribution by demanding large amounts of tribute (usually in the form of "wealth" goods) to be redistributed at the discretion of the state (Carrasco 1978:45). Additionally, this central authority regulated market prices, even buying unsold products (generally food, both fresh and cooked, and pottery) to ensure that participants maintained a certain standard of living (Carrasco 1983:77). These distributional interventions allowed the state to use the "directed" or "controlled" marketplace along with tribute as redistributive mechanisms. This model postulates that the governing body had exceptional power that was used both to control the kinds of goods sold in the market and to regulate their prices and distribution.

In spite of the top-down focus of these early works, households are mentioned as possible locales for production by both proponents and opponents of the redistributive or command model (Carrasco 1978, 1983; Offner 1981); however, it was not until the 1970s and 1980s that highland households became a major focus for concerted archaeological investigation (Flannery 1976; Flannery and Marcus 2005; Manzanilla 1986; Santley and Hirth 1993; Wilk and Ashmore 1988; Wilk and Rathje 1982). These excavations have highlighted the importance of households as basic economic and social units and often the locus of production and consumption (Hirth, ed. 2009). The current stream of domestic-scale research has reaffirmed notions of the importance of production/resource diversity in the Mesoamerican economy (e.g., Sanders 1968:93) having a human as well as an environmental basis (see Fisher et al. 2009).

Recent perspectives, drawn heavily from the empirical record of house excavations, emphasize the importance of domestic craft production and multicrafting in the ancient Mesoamerican economy (Balkansky and Croissier 2009; Feinman 1999; Feinman and Nicholas 2007; Hirth, ed. 2009). With a diverse suite of craft activities situated in dispersed household contexts, the ability of rulers to

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intervene or regulate such production seems nearly impossible, given the transport and communication technologies available, particularly where craft-working depends on widely available resources such as plants or clay. We do not expect that all commodities had identical production and distribution patterns; there may have been more restricted materials that had greater potential for control. We argue that production as a whole was not tightly controlled and there is little evidence that any one commodity, whether as a raw material or as a finished good, so greatly influenced the economy that control over it constituted economic domination.

Ongoing studies have found that individual households were involved simultaneously in several craft activities, producing a number of goods for immediate household consumption as well as wider exchange (Feinman and Nicholas 2007; Inomata 2007b). This perspective on multicrafting envisions households as "primarily concerned with their own success and thus striving to minimize risk and maximize productivity resulting in a diversified production strategy" (Hirth 2009:23; Shimada 2007).

Few scholars have drawn on ethnographic studies of the Oaxaca Valley from the early to mid–twentieth century that indicate that such diversified production strategies and mechanisms of distribution and integration were vital to the functioning of the economy (Beals 1970, 1975; Cook 1970; Cook and Diskin 1975; Parsons 1936). The nature of the Oaxaca Valley environment would seem to be compatible with flexible strategies of production (Beals 1975:20–21, 56–57) and a range of integrative mechanisms to meet the subsistence needs of its inhabitants in the face of highly variable and unpredictable conditions (e.g., Cohen and Browning 2007:233). This variation manifests itself spatially, seasonally, and annually (e.g., Kirkby 1973; Kowalewski 1982; Nicholas 1989). These ethnographic studies of Oaxaca and elsewhere in highland Mexico provide a resource for future considerations of the prehispanic economy, in that both the past and present economic strategies in these regions have featured production and exchange under variable and fluctuating conditions (e.g., Cook 1970; Kirkby 1973).

Our analysis of spindle whorls conceptualizes the implications of household activities at multiple scales, from local units to the region. We examine the ramifications of these data for ideas regarding economic distribution as well as to challenge the role traditionally ascribed to craft activities and the exploitation of xerophytic plants in prehispanic Mesoamerican economies.

The examination and division of whorls into fiber-specific categories serve to illustrate that a range of materials, both local and imported, were spun at El Palmillo. Variation in whorl frequencies and sizes across different household contexts provides a basis for examining the relationship of status to production, distribution, and consumption. In regard to access and economic status, the differences at El Palmillo are continuous rather than marked by a stark dichotomy between distinct economic classes. These findings challenge a central tenet of the redistributive model that postulates a sharply divided socioeconomic structure with a large producer group and a small administrative elite.

Eastern Tlacolula and the Importance of Xerophytic Plants

El Palmillo lies at the eastern edge of the Tlacolula arm of the Valley of Oaxaca, Mexico (Figure 1). Although Tlacolula is the driest arm in the valley, this area was one of the most densely inhabited during the Classic and Postclassic (Feinman and Nicholas 2004b; Kowalewski et al. 1989). The centrally situated city of Monte Albán retained degrees of political hegemony over this part of the valley during the first half of the Classic period. But coincident with (ca. A.D. 700–1000) and then following Monte Albán's decline, some of the region's most important prehispanic settlements were situated in the eastern arm.

Low and irregular rainfall in eastern Tlacolula makes conditions too dry to sustain consistently ample maize harvests today, and irrigation opportunities are spatially restricted and generally small in scale (Druijven and Kruithof 1992; Kirkby 1973; Nicholas 1989). Such conditions likely prevailed during most of the Classic and Postclassic, and one sixteenth-century account states that the people in the vicinity of Mitla did not consume much maize (Horcasitas and George 1955). In lieu of maize, the Classic and Postclassic populations of eastern Tlacolula depended on diverse drought-resistant plants (Feinman and Nicholas 2004b;

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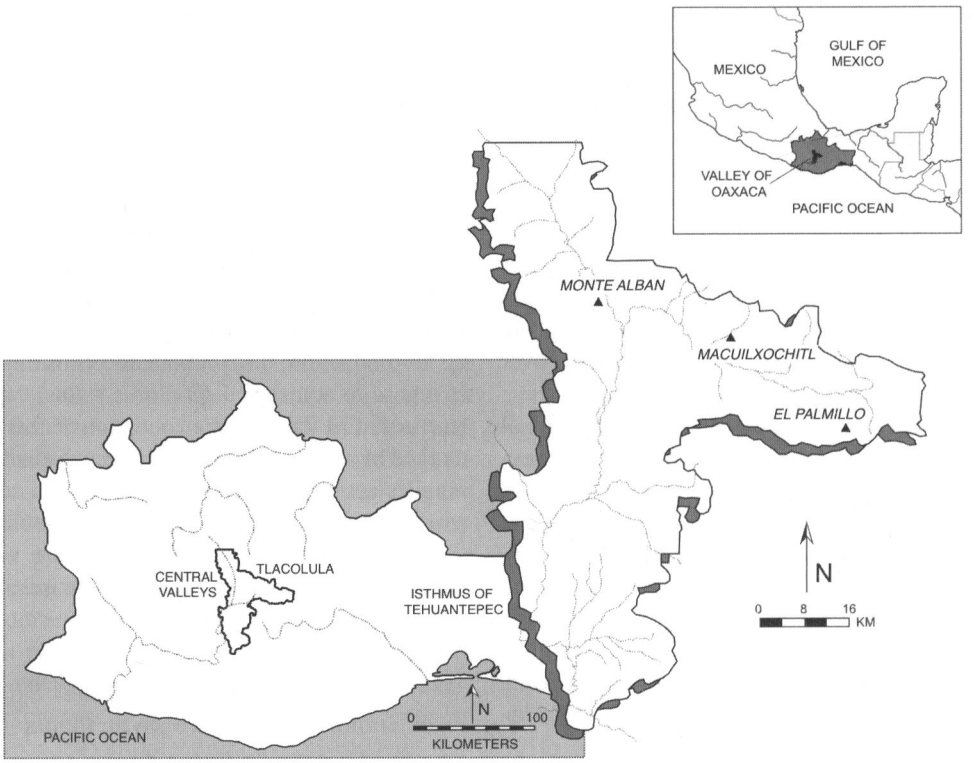


Figure 1. Map of Oaxaca, showing the Valley of Oaxaca and places mentioned in the text.

Feinman et al. 2007), still important in the region today. Prehispanic demographic expansion may have been fostered in this dry area only when valley-wide political integration and modes of adequate distribution were established under Monte Albán's hegemony during the Classic period. Eastern Tlacolula, which had been relatively sparsely settled before the Classic period, experienced more rapid demographic growth thereafter (Feinman and Nicholas 2005).

Archaeologists have viewed the triad of maize, squash, and beans as the foundation of Mesoamerican civilization. And while we do not dispute the critical importance of these crops, we join a growing number of researchers who recognize the significance of xerophytic (drought-resistant) plants, particularly maguey, as having been a key to the ancient Mesoamerican economy, serving as much more than a starvation food (Evans 1992; Feinman and Nicholas 2005; Feinman et al. 2007; Hernández 1959 [1577]). Xerophytic plants yield many important subsistence products, and maguey meets a variety of human needs, from calories to housing to fiber (Hough 1908; Parsons 2009). More specifically, the many species of maguey can be used as a source of liquid (*aguamiel*), caloric sustenance (pulque and roasted maguey hearts), fuel (dried leaves serve as firewood), shelter (dried leaves can provide roofing and windbreaks), cords and containers (fibers can be used for rope and netting), and clothing (from fibers extracted from the leaves).

Of the many maguey products, cloth was one of particular utilitarian, economic, and sociopolitical importance during the Classic period and later (Berdan 1987; Stark et al. 1998). For the Aztec, varieties of cloth, a good that was both labor intensive to craft and portable, served as a medium of exchange. Given this function, indicative of widely recognized value, producers potentially were connected to exchange networks extending beyond the community. Woven goods of maguey were traded for items with greater caloric value than the plant had itself (Evans 1992). In Mesoamerica, rope and cloth production most often took place in house-

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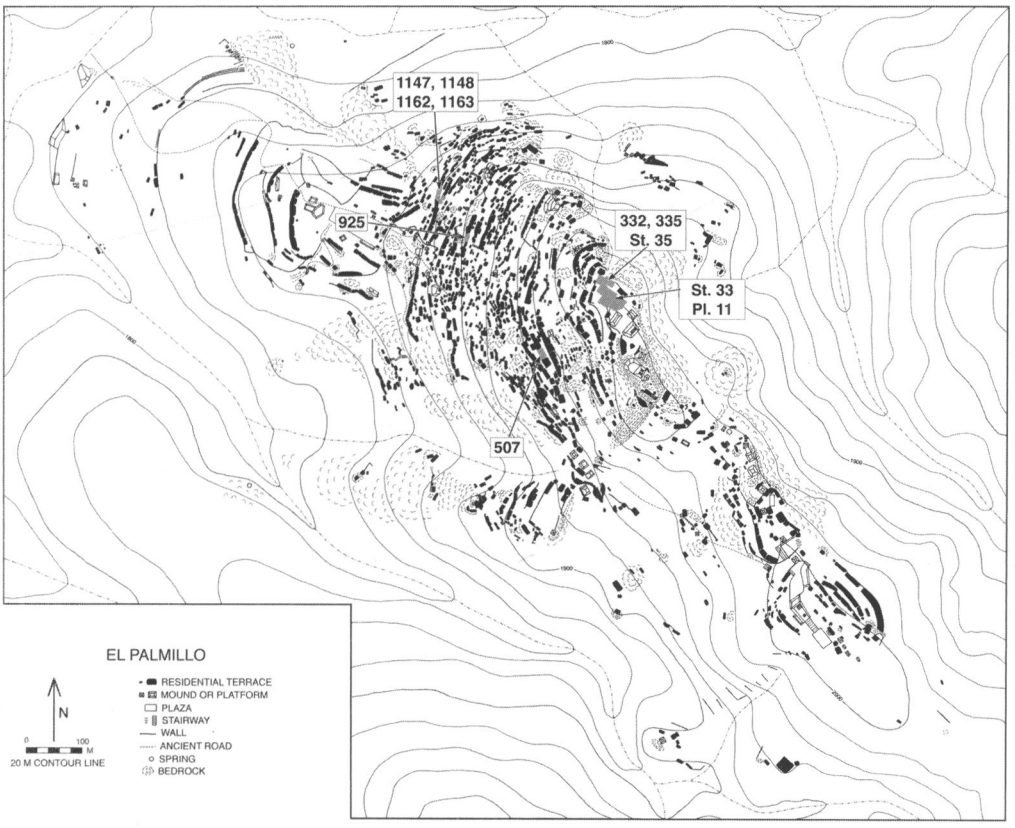


Figure 2. Map of El Palmillo, showing the location of excavated residential contexts.

holds (e.g., Hendon 2006; Nichols et al. 2000), thus affording domestic units access to wider socioeconomic networks.

El Palmillo

El Palmillo (Feinman and Nicholas 2004b; Feinman et al. 2002) is situated on a steep ridge (elevation 1,760–2,010 m) overlooking the modern town of Santiago Matatlán (Figure 2). The site was occupied for centuries but most densely settled during the Classic period, when it was one of the largest sites in the valley. The location is rocky and elevated above the valley floor. Xerophytic plants survive and thrive on the promontory today, growing particularly well on abandoned prehispanic walls. The diversity of economically useful plants on the site is much greater than found on neighboring ridges where prehispanic occupation was sparse or absent. During a botanical survey, eight species of maguey were identified at El Palmillo; in contrast, only two species were recorded for a neighboring hill (Middleton et al. 2001), indicating that some of the maguey species likely were brought to El Palmillo from elsewhere in the region and planted at the site during its occupation. The prehispanic occupants of El Palmillo appear to have actively tended xerophytic plants, cultivating a diverse array of useful species at the site. They could have been grown on terrace walls, on uninhabited slopes, and as living fences that provided privacy and a hedge against sediment erosion.

Although El Palmillo was mostly abandoned by the Postclassic period, its people and craft legacy did not move far. The name of the surrounding modern town, Matatlán, means "Place of the nets" in Nahuatl, indicating that fiber working persisted in the area. Furthermore, even today xerophytic plants play an important role in the local economy. Matatlán is currently known as the world capital of mezcal, an alcoholic beverage made from distilled juices extracted from the maguey plant.

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To explore household production, eight residential terraces were completely excavated over 10 seasons of fieldwork (1999–2008) at El Palmillo. The excavated terraces were selected from a cross section of the site ranging from near the base to the partially flattened top. Generally, status followed the gradient of the hill (Feinman and Nicholas 2009; Feinman et al. 2008), with three high-status residences near the top (Platform 11, Structure 35, Terrace 335) and five commoner residences below (Terraces 507 and 925 on the middle slope of the hill and Terraces 1162, 1163, and 1147/48 situated near the base). The three upper residences not only were larger and more elaborate (with larger patios, masonry tombs, and greater numbers of rooms) but had higher frequencies of obsidian, bone ornaments, greenstone, and shell. Access to these items as well as quantities of animal bone decreased in a clinal pattern from the houses at the top to those near the bottom (Feinman et al. 2008). All eight households were involved in craft activities, most notably cloth/fiber work and chipped-stone tool manufacture. The nature and intensity of such production varied from house to house (Feinman and Nicholas 2007:109), with one domestic unit also engaged in low-intensity pottery manufacture and others engaged in lapidary work.

Mesoamerican Spindle Whorls and the El Palmillo Collection

Prehispanic fibers and cloth from the Oaxaca Valley rarely preserve; however, ceramic spindle whorls and bone tools are more durable and serve as the most abundant evidence of ancient spinning and cloth production activities. A series of studies have examined the relationship between tools related to cloth production, illuminating aspects of the process and organization of production (Brewington 2000; Fauman-Fichman 1999; McCafferty and McCafferty 2000; Parsons 1972; Smith and Hirth 1988).

In a pioneering study, Mary Parsons (1972) isolated particular characteristics of spindle whorls (weight, diameter, hole diameter) as a means of determining the nature of whorl rotation and the kind of fiber spun. Additionally, she created a typology based on both stylistic attributes and physical characteristics and compared the relationship between such physical attributes and stylistic traits (form and decoration). She found that the whorls had a bimodal distribution, falling roughly into two categories. These categories corresponded to certain stylistic types. Parsons (1972) concluded that this statistical pattern represented two distinct groupings linked to use: one for cotton and another for maguey. She and others have noted the social distinction between these two fibers, with cotton tied to higher status and maguey tied to lower status (Berdan 1987; Stark et al. 1998). Parsons's work has provided the basis for many subsequent studies, and our current investigation builds on her general approach by comparing quantitative and qualitative whorl characteristics to assess possible whorl function. At El Palmillo, the physical characteristics of the whorls (weight vs. hole diameter) reveal a broad distribution of whorl sizes indicative of their use for spinning a variety of fibers (Figure 3).

Although all whorl attributes shed light on whorl function, weight is a key factor in limiting the type of fibers a spinner is able to use and the quality of thread produced. Parsons (1972) noted the potential for variation within the defined whorl groups, and subsequent studies have explored this variation as well as refined our understanding of how whorls work and what we can learn from them (Brewington 2000; Fauman-Fichman 1999; Halperin 2008; King 2008; McCafferty and McCafferty 2000; Parsons and Parsons 1990; Smith and Hirth 1988; Tiedemann and Jakes 2006). The fibers themselves hold some clues. Cotton is called a short-staple fiber, making it more fragile and thus slightly more difficult to spin (Smith and Hirth 1988). As a result, cotton is spun using a lighter whorl and a technique called support spinning. The lighter whorl prevents the fibers from breaking, and support spinning provides the spinner with more control over the whorl. Conversely, maguey is a long-staple fiber, and it requires a heavier whorl to maintain rotation in the spinning process. Maguey can be spun using two techniques: support spinning and drop spinning. Even fine maguey spun using support spinning requires a heavier whorl than cotton (McCafferty and McCafferty 2000; Parsons and Parsons 1990; Smith and Hirth 1988). Given the importance of whorl weight in spinning, we employ it as the dimension most indicative of the specific fiber that was spun with a particular whorl.

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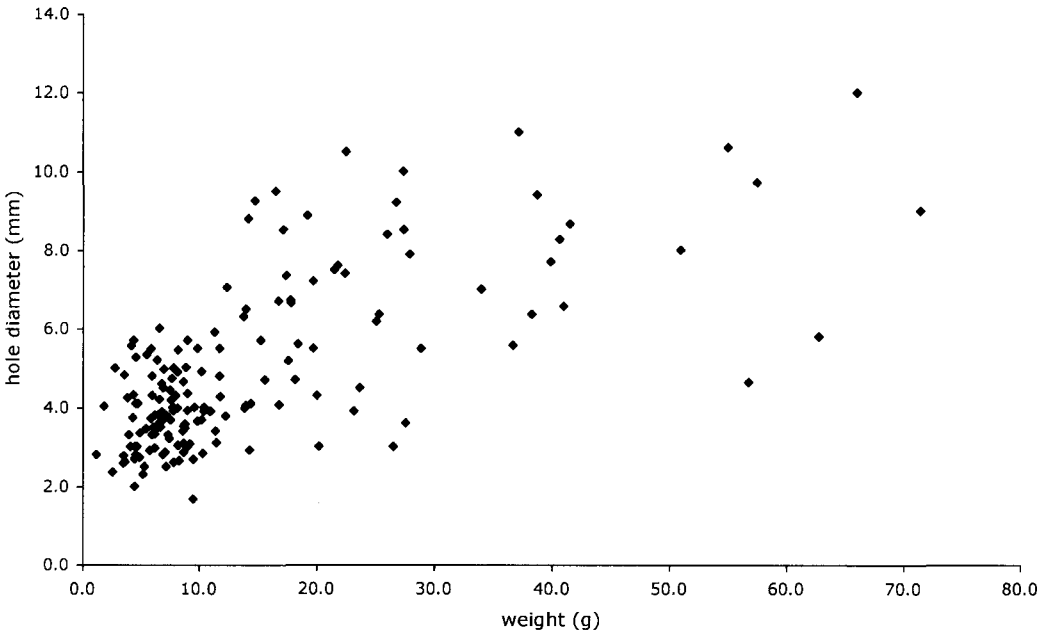


Figure 3. Spindle whorls at El Palmillo have a fairly continuous distribution (weight vs. hole diameter) and were used for a range of fibers including cotton and maguey.

In an ethnographic study of maguey spinners in central Mexico, Parsons and Parsons (1990) defined a clear relationship among whorl size, variation, and spinner preference. Informants were able to spin a range of maguey thread thicknesses on prehispanic whorls, but most expressed a preference for whorls of the same weight when asked to spin a particular thread weight. The whorls that most women refused to use were on the two extremes of the weight range. To refine our understanding of whorl use requires a balance between acknowledging whorl functional flexibility and drawing conclusions about how a whorl was likely used. Parsons and Parsons (1990) provide a starting point for defining groups that accommodate a wider variety of fibers and offer expectations for significant trends within a sample.

A total of 188 spindle whorls were collected during the excavations of the residential complexes at El Palmillo (180 are from the eight excavated houses, and eight are from surface or other contexts). Every excavated terrace contained multiple spindle whorls. Generally, the spindle whorls have a flat disk shape (Brewington 2000); however, despite this fairly ubiquitous shape, the whorls were produced using two different methods. Group 1 whorls were made by abrading a broken sherd and drilling a hole (usually biconical) in the center. This type of whorl is often referred to as a centrally perforated sherd disk (Halperin 2008:115; Figure 4). Group 2 whorls are modeled and perforated while the clay is still wet (Figure 5), identified by a lip of clay around the center hole. These physical and qualitative properties have implications for the nature of spinning and cloth production at El Palmillo and provide the basis for our analysis.

Spindle Whorl Analysis

In our analysis of the spindle whorl collection from El Palmillo, we explore whorl variability and note several spatial and temporal trends. We consider these data in the context of status, access to resources, the diversity of household activities, and exchange, factors that are central to current models of prehispanic economies. Beyond the general distribution of tools across all households, tool characteristics should simultaneously reflect the exploitation of a range of resources as well as the nature of status differentiation and its role in pro-

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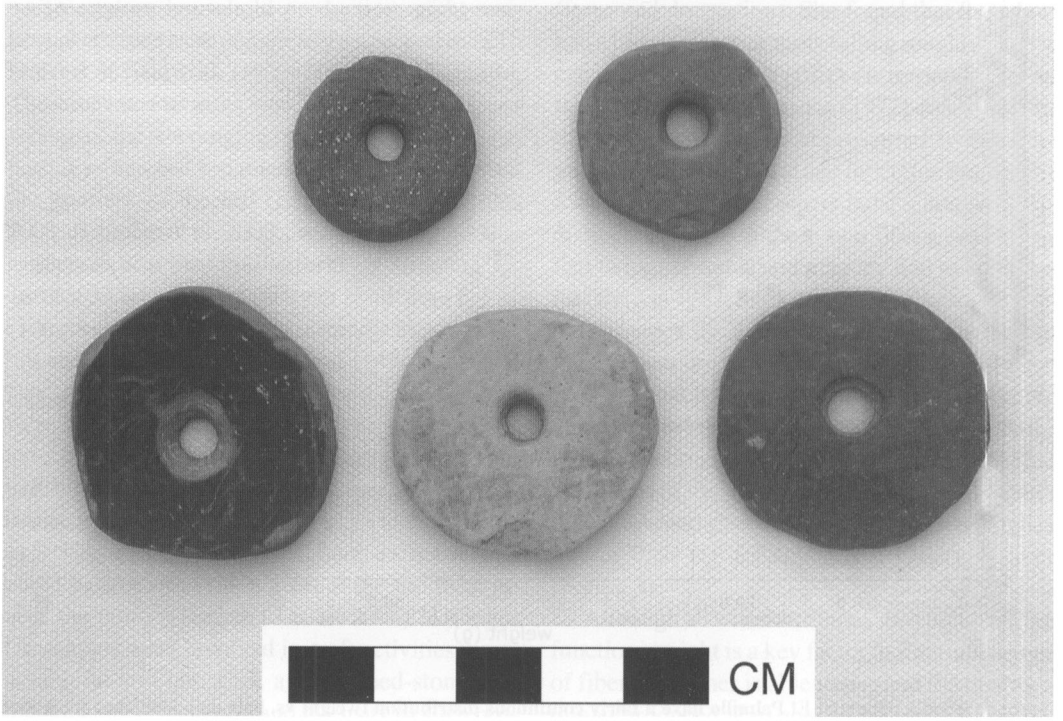


Figure 4. Group 1 (abraded) whorls from Terrace 507.



Figure 5. Group 2 (modeled) whorls from Platform 11.

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duction. To evaluate these expectations, we implemented a series of analyses including the spatial patterns that provide an empirical foundation from which to identify the organization of production at El Palmillo. We focus on three artifact types related to cloth production, but given the importance of textiles throughout Mesoamerica, we argue that these tools provide important insight into the functioning of the regional economy (for additional analyses of household artifacts from El Palmillo, see Feinman 2006; Feinman and Nicholas 2004a, 2007, 2009; Feinman et al. 2002).

To describe the whorls and compare the distribution of whorl variation across the site, we performed three statistical analyses (a principal components analysis, a student's *t*-test, and a comparison of whorl frequencies). We first define three groups of whorls based on size distributions in the assemblage. Next, we examine the distribution of whorls across the site as a general measure of the relationship between status and spinning. Finally, we examine whorls in concert with other cloth/fiber production tools (particularly bone and stone implements) at the household level to look at the resources exploited in different households, the activities of those households, and the relationship of resources and specific patterns of craftwork to status. Again, given the importance of textiles in prehispanic Mesoamerica, these tool assemblages provide an important perspective on variation in household strategies. Our ultimate goal is to identify patterns to understand the organization of cloth/fiber production at the site and explore regional implications for these economic strategies.

Physical Characteristics of El Palmillo Whorls

Much previous work has divided whorls into two groups, comparing whorls for cotton with those used for maguey (Fauman-Fichman 1999; Parsons 1972). As stated above, however, the whorls at El Palmillo were likely employed for spinning more than one or even two kinds of fiber. In order to better assess diversity in the El Palmillo whorl assemblage, we used principal components analysis. We chose this particular method because it most effectively displays the structure of our data. The whorls generally have the same flat disk shape, so size is most effectively measured by a combination of weight and diameter. We then used these two variables to extract the first principal component (Figure 6 and Table 1). Subsequently, we used a histogram of the first principal component to examine the nature of the distribution of size and determine the break points between size groups (see Figure 7 and Table 2). We defined three size groups in the El Palmillo assemblage—small, medium, and large (having break points at .03 and 1.96).

To interpret these results, we compared the groups with Parsons and Parsons's (1990) ethnographic study of highland spinners in central Mexico. In that study, informants seeking to spin fine maguey fiber would not use a 6.7-g whorl, stating that it was too light. They chose whorls weighing 12.5 g and 18.6 g as ideal for this task. Finally, they refused to use whorls over 30 g, arguing that they were for coarser items. These categories provide a good basis for interpreting the archaeological data. The "small" group we defined would be best suited for cotton, although the largest ones in this category also may have been suitable for other fibers such as fine maguey. The "medium" group would be well suited for fine and multipurpose maguey fiber, and the "large" group would be best suited for coarse maguey.

We also examined the whorls produced by different techniques (Group 1 [abraded, centrally perforated sherd disks] and Group 2 [modeled whorls]) to see if there is a relationship between whorl production technique and use. Whereas Group 1 whorls were recycled fragments of ceramic vessels, Group 2 whorls were made specifically to serve as spindle weights. Group 2 whorls are a new tool type (spindle whorls) created from the outset, rather than modified from an existing item (bowl or jar), and reflect a greater degree of planning. We grouped the whorls qualitatively based on how they were produced and then compared mean and modal weights from these groups. In this case, weight is used as an indicator of the type of fiber or range of fibers spun using those whorls. When we compared the mean weights of these two groups, we found that Group 2 (modeled) whorls are lighter than Group 1 (abraded) whorls, and the difference is statistically significant ($p = .002$; $t = 1.97$; $df = 150$); the mode and median replicate this trend (Table 3). Further, the weight range for Group 2 whorls (2.8–27.4 g) is smaller than that for Group 1 whorls (1.2–66.0 g).

These results have two implications. First, Group 2 whorls are lighter and better suited for

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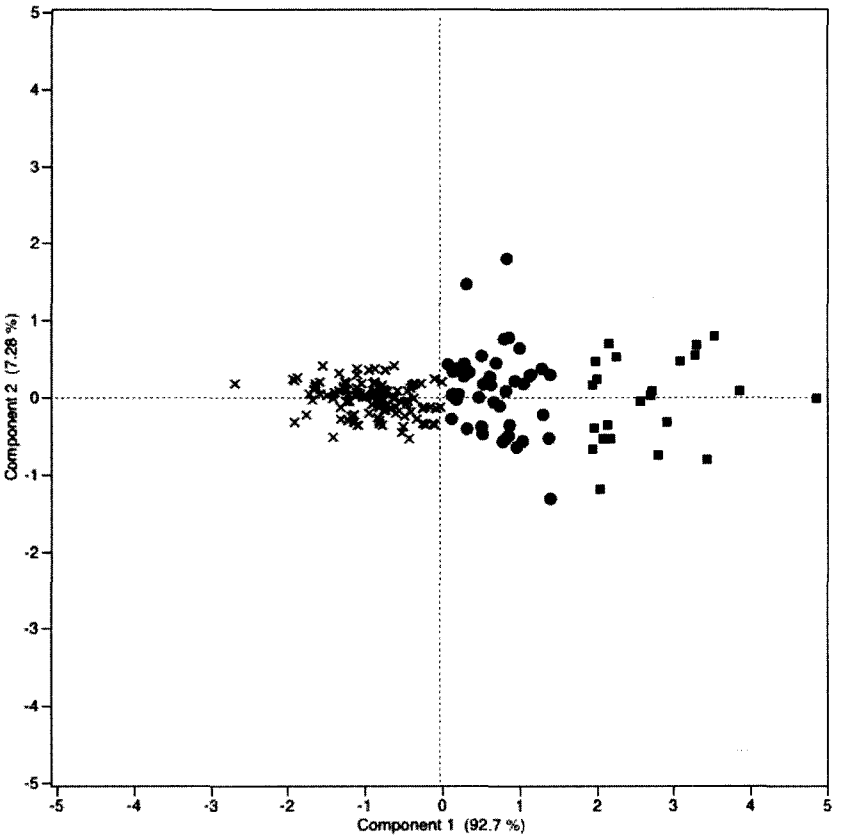


Figure 6. Principal components.

spinning finer fibers. Second, the narrower weight range means that they also have a more restricted purpose than Group 1 whorls. Below, we explore the spatial distributions of these trends in an attempt to establish a relationship between similarities as well as variability in characteristics such as weight, production method, and the social context of use.

Spatial Patterns and the Organization of Production

Although spindle whorls were found in all excavated residences at El Palmillo, the quantity ranges from as few as seven to as many as 48. Certain contexts had greater frequencies of whorls of particular sizes than others (Table 4). In addition, we examined the abundance of other tools in different residential contexts. Given the site-wide patterns of whorl diversity among mid-weight whorls as well as the presence of two whorl production methods with different use tendencies, we investigated the spatial distributions of these different whorls across the excavated residences in order to ascertain the variability in use and access to fibers.

Table 1. Principal Component Loadings.

Variable	Principal Component 1	Principal Component 2
Square root of weight	.96294	.26973
Diameter	.96294	−.26973

The distributions of the three function-related size groups defined through principal components analysis (cotton, fine maguey, and coarse maguey) across the site have implications for the nature of interterrace variation in production activities. The cotton group has the largest number of whorls (cotton: $n = 107$; fine maguey and others: $n = 45$; likely coarse maguey: $n = 23$). Cotton whorls have the most uneven distribution, forming 40 percent of the lower terrace whorl assemblage and 71 percent of the upper terrace whorl assemblage. The middle group is also unevenly distributed, making up 44 percent of lower terrace assemblages and only 17

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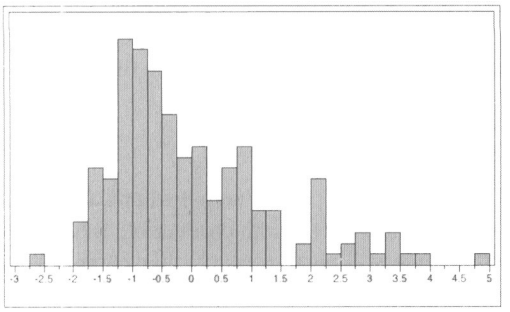


Figure 7. Histogram of the first principal component for whorl size.

Table 2. Summary Statistics for Three Spindle Whorl Size Groups.

	Weight (g)		
Variable	Small (n = 107)	Medium (n = 45)	Large (n = 23)
Mean	7.2	19.2	40.0
Median	7.2	17.8	38.3
Mode	7.8	17.8	32.0
SD	2.5	5.7	13.4

Note: Table includes 175 of the 188 whorls that were complete enough to obtain the necessary measurements (weight and diameter) for the analysis.

Table 3. Summary Statistics for Abraded (Group 1) and Modeled (Group 2) Spindle Whorls.

	Weight (g)	
Variable	Group 1 (n = 136)	Group 2 (n = 41)
Mean	16.2	9.5
Median	11.2	7.5
Mode	9.0	6.8
SD	13.5	5.6

Note: One hundred seventy-nine of 188 whorls were complete enough to be classified according to the production method; however, two Group 1 whorls were not complete enough to obtain weight measurements and are not included in the summary statistics.

Table 4. Distribution of Fiber-Based Spindle Whorl Groups.

Provenience	Small	Medium	Large	Unidentified
Terrace				
1162	4	7	2	–
1163	2	7	3	3
1147/48	3	7	–	4
925	4	2	1	–
507	12	4	4	2
335	20	10	6	–
Structure 35	35	6	5	2
Platform 11	21	2	2	–
Other	6	–	–	2
Total	107	45	23	13

percent of upper terrace assemblages. The likely coarse maguey group makes up 12 percent of the upper terrace assemblage and 16 percent of the lower terrace assemblage. Altogether, 60 percent of the lower terrace assemblages are suited for local materials (fine and coarse), while only 29 percent of the upper terrace assemblages are suited for local fibers. Nevertheless, within these groupings and general trends, individual terraces have highly variable assemblages indicative of house-to-house differences in cloth production activities. We discuss the issue of variation at the house level more completely in our consideration of household bone tool assemblages below.

In addition to these three groups, we also examined the distribution of whorls based on weight and production method to discern the social context of production. We used a student's t-test to compare whorl weights based on these attributes. As mentioned earlier, the terraces at El Palmillo fall generally into two groups—high status and lower status—but in reality, differential access to resources follows a continuum from the top to the bottom of the hill. Within terrace groupings, households share certain similar architectural styles and material culture (Feinman and Nicholas 2004b; Feinman et al. 2008). In a comparison of whorl weights from these two terrace groups, whorls from high-status households (Platform 11, Structure 35, Terrace 335) were lighter (had a smaller mean weight) than whorls from lower-status terraces, and the difference was statistically significant ($p < .001$; $t = 197$; $df = 150$). Mode and median weights show the same pattern; upper terraces have a mode and median of 9.0 g, while lower terraces have a mode of 22.4 g and a median of 16.8 g.

The results support the previously observed pattern in which the spinning of finer thread occurred in high-status residences. Although the whorls from these higher-status households span a wide weight range, the lower central tendency measures for weight indicate the preference for spinning finer fibers. These results fit with the broader Mesoamerican expectation that fine fiber is associated with high-status contexts (Nichols et al. 2000:267; Parsons 1972; Stark et al. 1998:8).

We also studied the spatial distribution of the two whorl types defined by production technique (Table 5). There are .4 Group 2 whorls per 10,000 sherds (nine total whorls) on the lower terraces and

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Table 5. Distribution of Production-Based Spindle Whorl Groups.

Provenience	Group 1	Group 2	Unidentified
Terrace			
1162	9	1	3
1163	12	1	2
1147/48	8	3	3
925	5	2	–
507	20	2	–
335	27	9	–
Structure 35	36	11	1
Platform 11	16	9	–
Other	5	3	–
Total	138	41	9

2.2 Group 2 whorls per 10,000 sherds (22 total whorls) on the upper terraces. Whorls of both types occur at 3.1 whorls per 10,000 sherds on the lower terraces and 8.1 whorls per 10,000 sherds on the upper terraces. As a result, Group 2 whorls occur 2.5 times more frequently on upper terraces than expected. This comparison reveals that residents of the upper terraces not only were spinning finer fibers but were spinning more intensively using whorls that were produced specifically to be spinning implements.

The presence of more Group 2 whorls on the upper terraces has additional significance in that the intensive site survey and subsequent excavation found evidence of small-scale ceramic production on lower terraces but not on upper terraces (Feinman and Nicholas 2007:112). If upper terrace residents were not producing ceramics for themselves, they would have had to engage in exchange with their neighbors downslope to obtain Group 2 (modeled) whorls. Such economic interdependence between contemporaneous households at El Palmillo is further evidenced by an examination of other artifact classes associated with fiber working.

Economic Specialization and Household Interdependence

Cloth itself rarely preserves, but whorls are not the only durable tools of cloth production. Bone tools, although less likely to preserve than ceramics, are evidence of weaving and sewing, among other activities, and thus serve as an important link between spinning and cloth making. Spinning is a rather common activity and is not in and of itself evidence for cloth production for exchange; however, the presence of a specific suite of bone and stone tools at El Palmillo is an important indicator that multiple steps in the sequence of cloth/fiber production occurred at the site in the past. Battens, awls, needles, and perforators are the most commonly found bone tools at El Palmillo (Table 6), and all have applications in the production of cloth and/or other fiber-based goods, although some bone tools such as awls are associated with other activities such as hide working. Awls, needles, and perforators are long, pointed tools likely used in sewing. Battens and shuttles (a relatively rare tool at El Palmillo) are wider, flatter tools used in weaving (Figure 8). Stone tools used in fiber extraction and processing include *raspadores* (specialized domed scrapers [Feinman et al. 2007; Haines et al. 2004; Hester and Heizer 1972; Robles García 1994]; Figure 9) and soft stone abraders. Although they could have been used for certain other tasks, their collective presence at El Palmillo is an indicator of this important initial step in cloth produc-

Table 6. Distribution of Tools Related to Cloth Production.

	Terrace							
Tool	1162	1163	1147/48	925	507	335	Structure 35	Platform 11
Bone needle	4	3	1	3	5	8	10	5
Bone batten	13	5	8	10	–	7	14	20
Bone shuttle	–	–	–	2	–	–	1	
Bone perforator	–	3	–	3	1	–	13	12
Bone perforator/needle	6	–	4	3	–	1	–	–
Bone awl	19	7	5	15	26	10	19	19
Bone awl/batten	–	–	–	3	–	5	1	4
Bone disk/whorl	5	2	1	–	3	–	1	–
Stone raspador	40	27	22	43	47	18	82	52
Stone abrader	15	21	12	16	45	56	24	30
Spinning bowl	3	1	4	1	8	5	6	2

Note: Differential distribution of various tool classes across all terraces shows differing participation in steps of the process.

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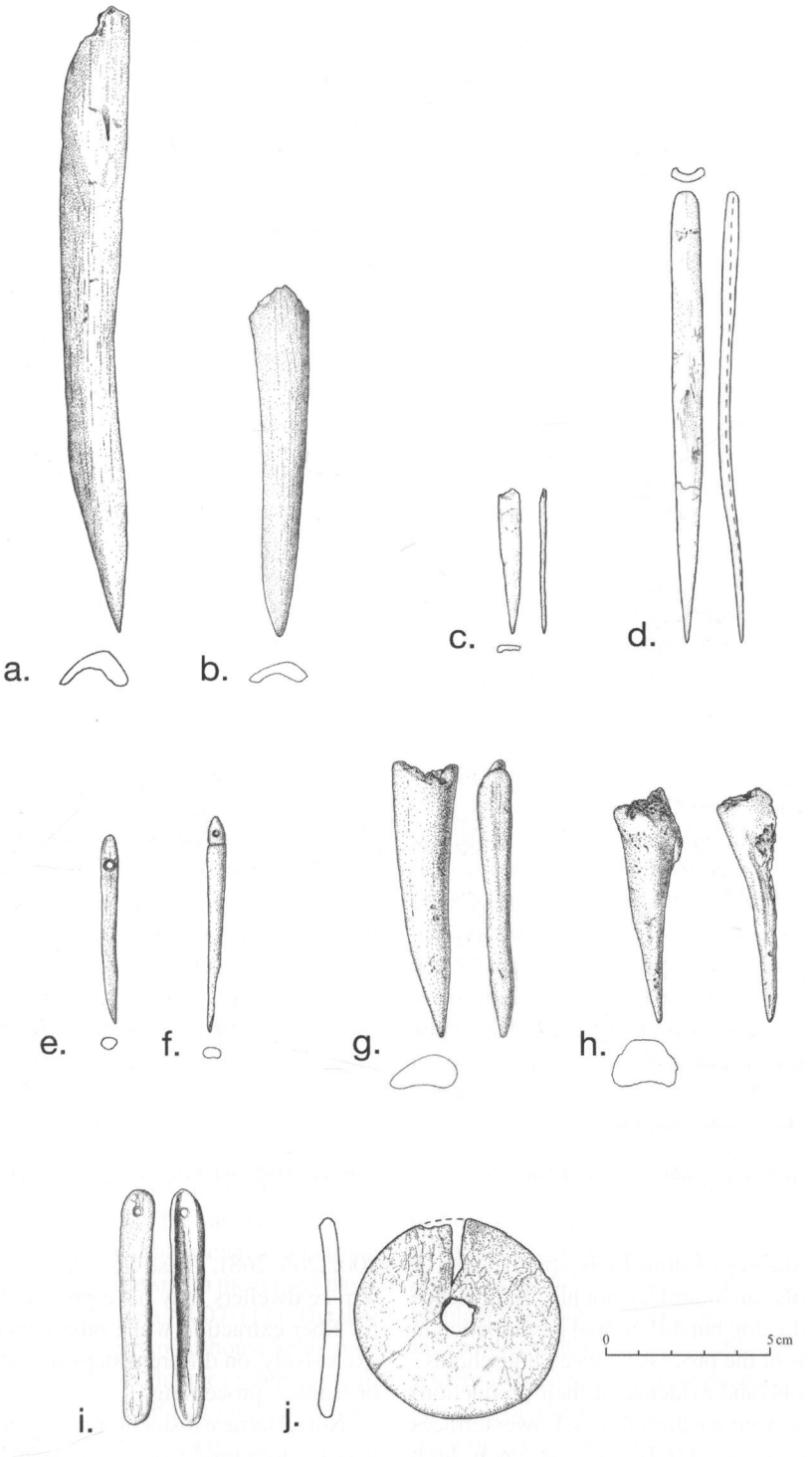


Figure 8. Drawings of tools related to cloth production found during excavations at El Palmillo: (a) batten, Terrace 1162; (b) batten, Terrace 925; (c) perforator, Structure 35; (d) perforator, Platform 11; (e) needle, Terrace 1147/48; (f) needle, Structure 35; (g–h) awls, Structure 35; (i) shuttle, Terrace 335; (j) perforated disk/spindle whorl, Terrace 1163.

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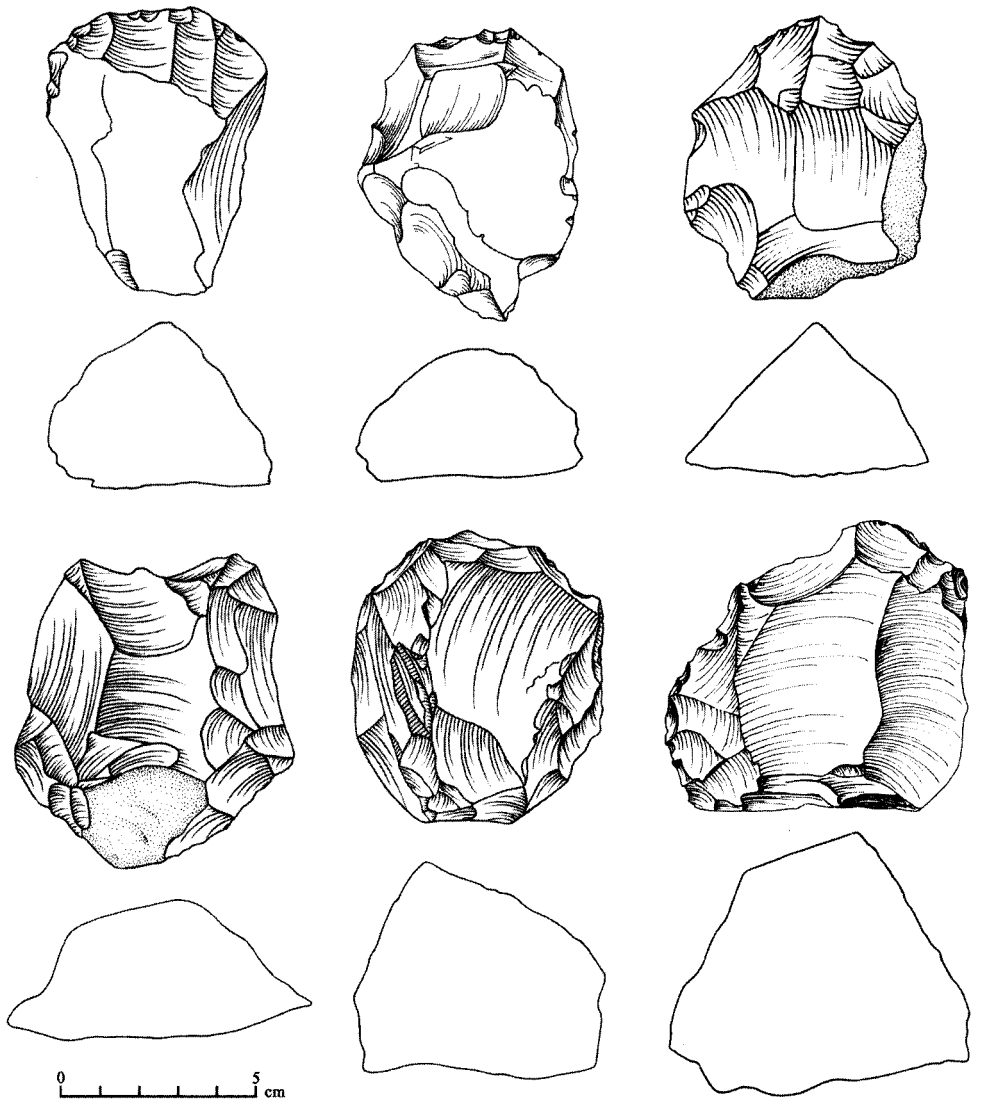


Figure 9. Samples of *raspadores* from El Palmillo: top, from Terraces 1162 and 335; bottom, from Terraces 1163, 507, and 925.

tion. The frequency of stone tools, spindle whorls, and bone tools can illuminate not just the presence of cloth production but differential participation in various steps of the process between households.

These tools (and evidence of their production) are not uniform among the terraces. Lower terraces (particularly Terrace 1162) have extremely high proportions of flakes to final tools. One of the middle terraces (Terrace 925) possessed a higher number of both soft stone abraders with striations and *raspadores* than other terraces (Feinman et al. 2002:266–268). These findings suggest that some terrace dwellers may have provided formal tools for fiber extraction while others focused, but not exclusively, on different steps of cloth production or maguey processing.

Not all terrace residents participated in the same way in cloth production. It appears that two residential complexes (Terrace 925 and Platform 11) were slightly more active in weaving than spinning, whereas the inhabitants of Terrace 507 were more active in spinning than weaving. These differences

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are suggested by relatively low whorl counts but higher frequencies of bone tools, on the one hand, and low bone tool and high whorl counts, on the other. Further, some terrace inhabitants were likely more involved in sewing than weaving or spinning, such as Terrace 507, where a relatively large number of needles are present (Table 6).

Although whorls and bone tools are found on all terraces, the frequencies of each indicate that households may have emphasized particular cloth production activities. Not all households participated in the same combination of craft activities, and even within a single craft activity, intensity of participation in the different steps of manufacture varied. The findings reinforce previous studies at El Palmillo that indicate that different terrace dwellers participated in different suites of activities including cloth production, chipped-stone tool production, and the working of xerophytic plants. Across the excavated terraces, the intensity with which these activities were practiced (and the origin and quality of the materials used) varies extensively (Feinman and Nicholas 2004a, 2007; Feinman et al. 2002, 2007). The diversity of household activities particularly within groups of similar status but also between higher- and lower-status households indicates significant economic interdependence among the site's residents. This cooperation between householders is further evidenced by shared architectural features such as stairs, ramps, retaining walls, side walls, and even passageways that facilitated communication and required cooperation to build and maintain (Feinman and Nicholas 2004b; Feinman et al. 2008; Kowalewski et al. 2006).

These elements of craft production, multicrafting, and differential participation indicate that households likely relied on a combination of activities and that the residents of the site were far from self-sufficient. They would have engaged in trade both within and beyond the site to meet their basic needs (Feinman and Nicholas 2007:112). The dispersion of craft activities (most households produced some goods for exchange) coupled with evidence for cooperation and economic interdependence between households within the site and beyond leads us to question whether any governing authority would have had the resources to control production and exchange at the site. When a large number of the site's households engaged in exchange to meet daily needs, it is hard to imagine that such networks could have been centrally managed. In addition, evidence for broader regional exchange networks exists in the distribution and diversity of exotic goods. Most of the excavated houses contained materials such as shell (mainly found in elite contexts) or obsidian (found more frequently in elite contexts but still present in nonelite households) that would have to have been obtained through extraregional trade; the presence of a large number of whorls best suited for cotton also indicates the importance of materials from other regions (Feinman and Nicholas 2007:110). The residents of El Palmillo had a subsistence strategy that required participation in a diversity of economic networks that included both local and regional exchanges.

Discussion

Our analyses of cloth production at El Palmillo correspond with a model of diverse and flexible domestic production and marketplace exchange (Feinman and Nicholas 2010) that in many ways has more in common with descriptions of the mid-twentieth-century rural economy in the Valley of Oaxaca (e.g., Beals 1970, 1975). These domestic-scale economic strategies have roots in earlier Formative-era economies, which also have evidence of household production (Flannery 1976; Flannery and Marcus 2005), perhaps mediated through marketplace exchanges (Feinman et al. 1984; Winter 1984). At El Palmillo, production for exchange varied in intensity and product but was present in every household regardless of status. Household strategies and flexibility are key aspects of our model.

At the site level, the range of whorl weights at El Palmillo serves to illustrate that many varieties of fiber were utilized, but production intensity and materials (fiber) were related to status. An abundance of whorls best suited for maguey, likely employed for both fine *ixtle* and cordage, provides indications that locally available resources were widely exploited by site residents; however, the presence of a large number of cotton whorls clearly points to economic connections beyond eastern Tlacolula. This array of findings demonstrates a subsistence strategy reliant on intrasite exchange and an effective exploitation of diverse, widely available local resources supplemented by longer-range

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exchanges through which nonlocal materials were obtained and household products were distributed.

Marcus (2004:262–263) argues that archaeologists need to "determine the degree of elite control and commoner autonomy rather than assuming absolute elite control." The data from El Palmillo provide the basis for addressing this issue. Our findings indicate that higher-status residents of El Palmillo were not primarily administrators of craft production but were active participants. They produced goods using less abundant, imported materials (such as cotton), which speaks to their heightened access to materials but not special administrative authority. Further evidence of their participation is that the highest concentrations of whorls are found in elite residences during the latest occupation of the site. Even as the lower terraces were being abandoned during the Late Classic period (Feinman and Nicholas 2011a), high-status residents continued to be actively engaged in production and exchange, perhaps attempting to strengthen long-distance ties as the site's population dwindled and intrasite exchange opportunities decreased. Further, despite the political reorganizations of the Late Classic and Early Postclassic periods, some economic relationships may have remained intact or even grown stronger, setting the stage for the increased movement of goods over long distances during the Postclassic (Feinman 1999).

The craft activities at El Palmillo illustrate the central economic role of maguey and other xerophytic plants. Fiber production, evidenced through spindle whorls and bone tools, is only one economic activity that exploits this plant. In fact, a highly integrated multicrafting strategy at El Palmillo appears to center around exploiting a variety of maguey species for a range of subsistence needs. The production of chipped-stone tools including *raspadores* was an important craft activity at El Palmillo (Feinman et al. 2002). Such tools were employed for maguey-processing activities including making pulque and fiber extraction. Thus maguey cultivation for consumption and craft production are closely intertwined at El Palmillo, making the dichotomy between craft activities and agricultural endeavors artificial or arbitrary. Cultivation and crafting were part of the same site-wide subsistence strategy rather than separate, complementary activities. This central role of maguey raises it from a starvation food to a mainstay of everyday subsistence activities and may hold clues to understanding the increasing concentration of the population in eastern Tlacolula following the fall of Monte Albán (Feinman and Nicholas 2005).

Conclusions

We have analyzed a large sample of spindle whorls from the site of El Palmillo not only to document the production of different fiber/cloth materials at the site but to discern salient features of the Classic period economy at El Palmillo and more generally in the Valley of Oaxaca. We have documented that all studied households at El Palmillo spun fiber, yet each household spun a different suite of fibers. Even high-status households participated in this activity (spinning), although their economic focus was slightly different (geared more toward cotton) from that of commoner residents. At the same time, all households were involved in a range of economic pursuits (including multicrafting) and produced some of the goods that house residents needed, but not all. Thus all households, elite and commoner, were dependent on intrasite and intraregional exchanges. Most Classic period households at El Palmillo were neither self-sufficient nor seemingly reliant on maize, indicating degrees of interhousehold and intercommunity interdependence not typically envisioned in traditional models of the prehispanic, highland Mesoamerican economy (especially for times prior to the Aztec Empire). Although our sample of houses is drawn from just one site in eastern Tlacolula, the observed trends and patterns are in line with patterns found at other Classic period settlements in the region (Feinman and Nicholas 2010, 2011b).

Diversification in household craft activities is a strategy of flexibility that operates within environmental and cultural constraints. That strategy fosters degrees of domestic interdependence as opposed to centrally directed or managed economies. Demand is not predictable or easily planned for but, instead, highly variable. Adaptable household economic strategies, seen through multicrafting, would have been most compatible with an economic system where demand was variable and unpredictable as opposed to directed. Economies based on domestic multicrafting and household interdependence with complex mechanisms of socioeconomic integration and product

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distribution have been documented in ethnographic accounts of the Oaxaca Valley during the early to mid–twentieth century but have thus far not been marshaled as a general construct or model for understanding prehispanic economies (Beals 1970; Cook 1970). The highly variable and unpredictable nature of the environment of the Oaxaca Valley, particularly in the Tlacolula arm, lends itself to diversified, small-scale subsistence and crafting strategies that are intertwined with a range of integrating socioeconomic mechanisms operating at multiple scales.

Although we have looked mainly at spindle whorls, we have integrated this focus with other findings to question long-extant conceptualizations of prehispanic Mesoamerican economies. This study has reconsidered the nature of status, command or directed production, and the economic underpinnings of political leadership in Mesoamerica. If political power was not grounded in the centralized control and direction of economic production and distribution, we should begin to consider new economic parameters and models that form the basis for understanding how elite and nonelite were interconnected over time and space in this prehispanic world.

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