DISEASE, DEMOGRAPHY, AND DIET IN EARLY COLONIAL NEW SPAIN: INVESTIGATION OF A SIXTEENTH-CENTURY MIXTEC CEMETERY AT TEPOSCOLULA YUCUNDAA

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A mid-sixteenth-century cemetery was investigated at the colonial Mixtec site of Teposcolula Yucundaa and is shown to be related to the cocoliztli pandemic of 1544–1550. This is the earliest colonial epidemic cemetery to be identified in Mexico. Through archaeogenetic and oxygen stable isotope analysis it is demonstrated that the interred individuals were local Mixtecs, and mortuary analysis sheds light on both Christian and traditional religious practices at the site. Mitochondrial haplogroup frequencies support long-term genetic continuity in the region, and carbon stable isotopes of bone collagen and enamel carbonates suggest no decrease in maize consumption during the early colonial period, despite historical evidence for a changing agricultural economy and increased wheat production at the site. The Teposcolula cemetery provides a rich and complex perspective on early colonial life in the Mixteca Alta and reaffirms the importance of archaeological and bioarchaeological evidence in investigating complex social and biological processes of the past.

Se investigó un cementerio mixteco de mediados del siglo diciseis en el sitio arqueológico de PuebloViejo de Teposcolula Yucundaa, el cual está aparentemente relacionado con la pandemia de cocoliztli de 1544–1550. Se demuestra mediante el análisis de ADNmt antiguo y de isótopos de oxígeno estable que los individuos enterrados son mixtecos locales. El análisis del tratamiento mortuorio de los entierros nos informa sobre las prácticas religiosas tanto cristianas como prehispánicas del lugar. El análisis de las frecuencias relativas de haplogrupos mitocondriales demuestra la continuidad genética que tuvo lugar en esta región. Los isótopos estables de carbono indican que no hubo un descenso en el consumo de maíz durante la primera parte de la época colonial, a pesar de que las evidencias históricas sugieren un cambio en la economía agrícola y un aumento de la producción de trigo. El cementerio de Teposcolula proporciona una rica y compleja perspectiva sobre la vida al comienzo de la época colonial en la Mixteca Alta y reafirma la importancia de la evidencia arqueológica y bioarqueológica en la investigación de procesos sociales y biológicos ocurridos en el pasado.

In the fifteenth through seventeenth centuries, collectively known as the Age of Exploration, European nations embarked on great long-distance voyages and claimed vast new, but not empty, territories as subject colonies. Among the most ambitious of these nations was Spain, whose conquistadores sought to discover, conquer, pacify, and settle new lands. Eventually, Spanish holdings came to encompass nearly half of the American continents.

In Mesoamerica, the early colonial period brought many changes to native communities: new taxation and labor requirements; missionaries, colonists, and slaves from diverse parts of the empire; epidemic disease; the introduction of wheat and other European crops; the establishment of new industries such as sericulture (silkworm-raising) and herding; and a fundamental reorganization of political, spiritual, and social power. Not all indigenous communities bore these changes well, and by the mid–seventeenth century, many once-prosperous communities had failed, victims of massive population decline, environmental degradation, and economic collapse (Melville

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1994; Miranda 1958; Romero Frizzi 1990; Terraciano 2001).

In the Mixteca Alta, historians have theorized that epidemic disease and depopulation facilitated Spanish land seizure and paved the way for intensive pastoralism by inducing labor shortfalls and creating vast stretches of fallow land. The shortage of peasant labor needed to maintain agricultural terraces and to work the rich fields of the valleys facilitated the relocation of towns to the valleys under *congregación*, a new colonial policy of forced resettlement. This in turn freed up formerly occupied mountain slopes for grazing and led to erosion, soil infertility, and the eventual agricultural collapse of what had once been described by the Spanish as the land of milk and honey (de Burgoa 1934 [1674]; Pérez Rodríguez 2006; Terraciano 2001).

The roots of this process can be traced to the sixteenth century, when Spanish missionaries and colonists first established themselves in the Mixteca; however, direct evidence of the key factors in this process is wanting. For example, although it has long been recognized that Spanish control of colonial territories greatly expanded following catastrophic population loss from introduced epidemic disease (Cook 1998; Cook and Borah 1968; Diamond 1997; Humboldt 1811; Prem 1992; Zinsser 1934), little physical evidence of the epidemics has been found. Many towns in the Mixteca were successfully relocated under congregación, but the proximate causes of these moves have not been established. Spanish missionaries and colonists were present in the Mixteca, but their numbers and influence within local communities are poorly understood. Historical records of taxation and tithing document a changing economy and the cultivation of European crops, but no archaeological studies have confirmed this fact. Direct archaeological investigation is needed in order to better understand these issues and test the conclusions drawn from the historical record.

In this article, we describe the discovery of a unique colonial cemetery at the Mixtec site of Teposcolula Yucundaa. Using mortuary and paleodemographic analysis, we draw a connection between the cemetery and the 1544–1550 *cocoliztli* epidemic and determine through oxygen stable isotope and ancient DNA analysis that the cemetery contains local Mixtecs, finding no evidence for long-distance migrants or nonindigenous individuals. We then use carbon and nitrogen stable isotope analysis to test the hypothesis that the changing colonial economy affected local cultivation and food consumption patterns and find that continuity, rather than change, characterizes the early colonial subsistence economy. Taken together, the bioarchaeological analyses performed in this study provide some of the earliest physical evidence of epidemic disease in the Spanish-controlled territories of the New World and yield new insights into early colonial indigenous culture and economy in the Mixteca.

Site Background

The archaeological site of Teposcolula Yucundaa is located in southern Mexico on a mountain ridge in the highland Mixteca Alta region of Oaxaca (Figure 1).[2] At its prehispanic height, Teposcolula Yucundaa controlled a territory of approximately 500 km^2 with an estimated population of up to 60,000 (Balkansky et al. 2000; Stiver 2001). Its urban core, with an estimated population of 7,000–8,000, covered 250 ha and was ringed by a 2-km-long raised road that enclosed numerous structures and features, including a royal compound, elaborate stone masonry civic-ceremonial buildings, multiple paved plazas, more than 30 "palaces," a ball court, and more than 1,000 residential terraces (Balkansky et al. 2000; Spores and Robles García 2007; Stiver 2001).

The late Postclassic and early colonial chronology of Teposcolula is now well established (Spores and Robles García 2007). Teposcolula was a subject of the Aztec Triple Alliance from 1458 to 1520 (Berdan and Anawalt 1997; Chimalpahin 1997 [ca. 1621]) and was later incorporated into the Spanish crown following the conquest of Tenochtitlán in 1521. At least six parties of early Spanish explorers and conquistadores passed through the region from 1520 to 1525 (Oudijk and Restall 2007), and after being briefly held in private trust (*encomienda*), Teposcolula was reclassified as a public *corregimiento* in 1531 (Chance 1978). An epidemic of smallpox struck the Mixtec Alta region in the early 1530s (Acuña 1984), and in 1538 Dominican friars successfully founded a mission (*vicaría*) at the site and constructed a large stone church and monastery complex (Spores and Robles García 2007).

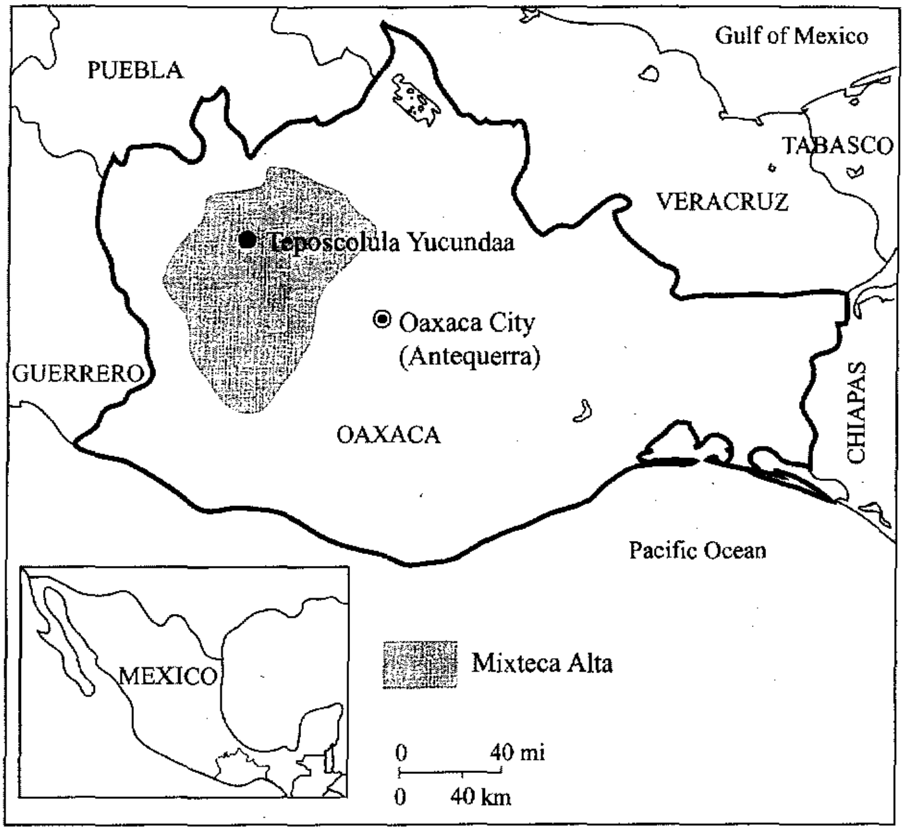

Figure 1. Location of Teposcolula Yucundaa within the Mixteca Alta region of the southern Mexican state of Oaxaca.

Following the failure of a mission at the neighboring site of Yanhuitlán in 1542, Teposcolula Yucundaa became the focal point of Dominican missionary efforts in the Mixteca Alta, hosting a high-profile Inquisition trial from 1544 to 1546 (Jiménez Moreno and Mateos Higuera 1940; Pérez Ortiz 2003) and serving as the primary residence for at least 15 different Dominican friars between 1538 and 1552 (Mullen 1975; Vences Vidal 2000). Spanish-style features began appearing in high-status Mixtec architecture at this time in the form of arched doorways, pivoting doors, and exterior wall friezes depicting European motifs (Spores and Robles García 2007). At the same time, Spanish colonists began settling in the Mixteca Alta, where they established burgeoning sericulture and livestock-herding industries. By 1544, Teposcolula was one of the largest producers of silk in the entire Mixteca, producing approximately 2,000 Spanish pounds (*libras*) of silk annually (Borah 1963).

Forced resettlement under *congregación* was introduced in the 1540s, and the Dominicans began planning the relocation of Teposcolula to a new Spanish-style town in the valley below. In 1545 or 1546 another major epidemic struck the Mixteca Alta region, and in 1552, the town was formally moved to the valley by direct order of the viceroy (Gerhard 1977; Zavala 1982). The new town, later christened San Pedro y San Pablo Teposcolula, was elevated to the status of a regional capital (*alcaldía mayor*), and records from the 1560s and 1570s document numerous Spanish residents (Calderón Galván 1988; Romero Frizzi 1990). The former mountaintop urban core of Teposcolula Yucundaa, known locally as Pueblo Viejo, has remained unoccupied to the present.

Excavation of the Grand Plaza and Churchyard

Excavations began at the site of Teposcolula Yucundaa in 2004 under the direction of Dr. Ronald Spores and Dr. Nelly Robles García. To date, many areas of the site have been explored (Figure 2), including the Dominican church and monastery, the

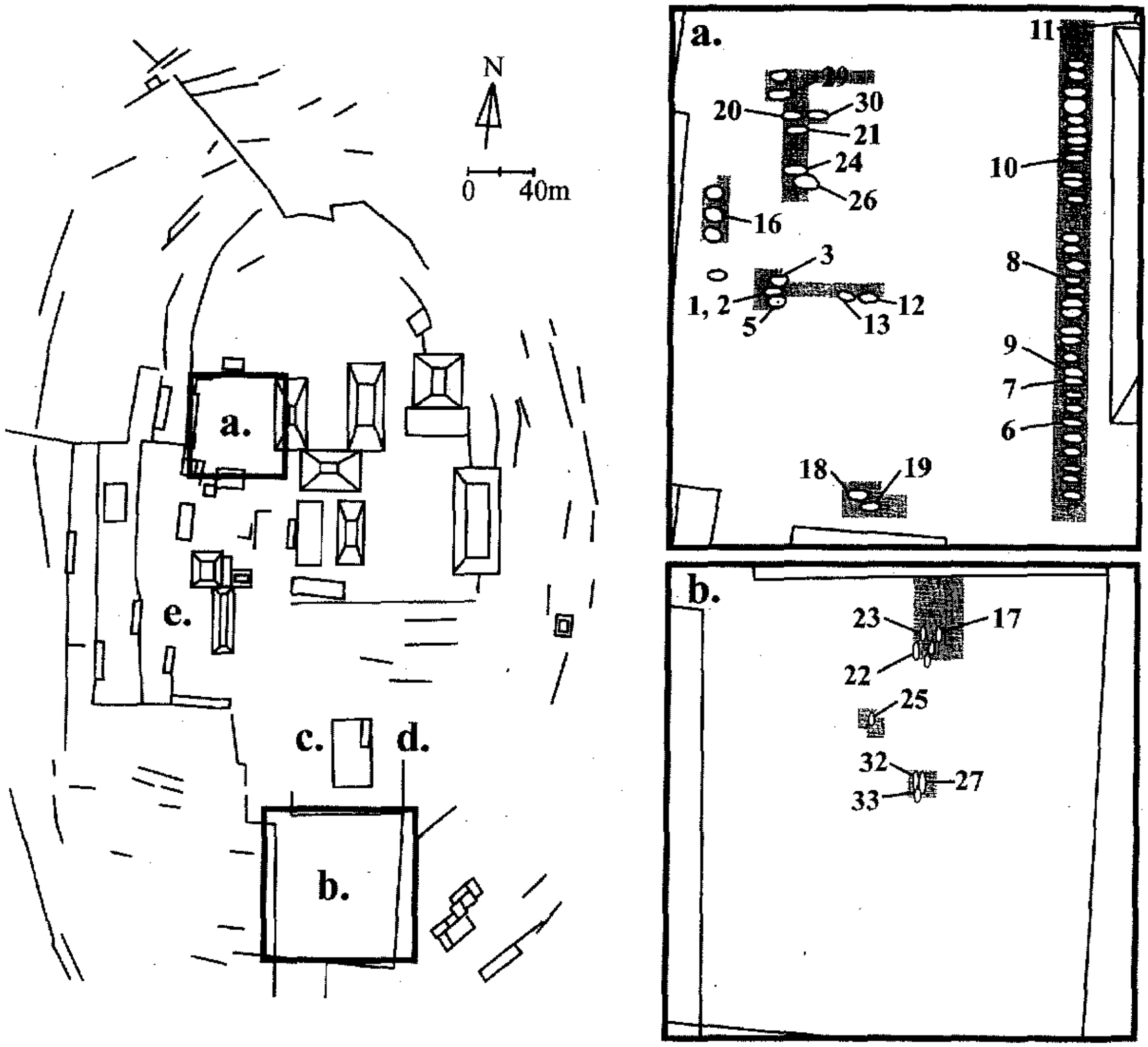

Figure 2. Central zone of Teposcolula with enlarged insets of (a) the Grand Plaza and (b) the churchyard. The (c) church, (d) monastery, and (e) royal residence are also indicated. Insets are drawn to different scales; areas explored from 2004 to 2006 are highlighted in gray, and excavated burials subjected to ancient DNA and isotopic analyses are numbered (map modified from Stiver 2001).

churchyard, administrative buildings and plazas, the royal palace, elite residences, commoner residences, and agricultural terraces (Robles García and Spores 2004, 2005, 2006; Spores and Robles García 2007). Numerous simple pit burials were found cut into the plaster floor of the Grand Plaza, the administrative center of the site. After additional excavation, it became clear that the Grand Plaza had functioned as a massive cemetery shortly before the site's abandonment in 1552 (Spores and Robles García 2007). Given the number of grave cuts observed per excavated square meter and the average number of individuals per excavated grave, the Grand Plaza cemetery may contain more than 800 individuals. Excavation of the walled churchyard revealed that it too contained burials. Given the location and treatment of the burials, the churchyard assemblage was initially assumed to also date to the colonial period (Warinner 2010); however, subsequent radiocarbon dating revealed that the interments predate the colonial period by a century (Table 1). Two additional Postclassic infant burials were recovered from residential features in outlying terraces. From 2004 to 2006, 30 burials containing 56 individuals were recovered from five areas of the Grand Plaza (Figure 2a), three areas of the churchyard (Figure 2b), and two outlying residential terraces.

Table 1. Radiocarbon Dates for Teposcolula Human Remains.

Individual Bone Collagen Sample	Sample ID	$\delta^{13}C$ (‰)	^{14}C Age (years B.P.)	Calibrated Age (A.D.)
Grand Plaza cemetery				
22	OS-83881	–7.6	365 ± 30	1448–1634
Churchyard cemetery				
32	OS-80882	–8.6	530 ± 30	1320–1440
42	OS-80885	–6.6	590 ± 25	1301–1412
45	OS-80887	–8.2	615 ± 25	1295–1400
48	OS-80888	–8.3	490 ± 30	1403–1450
Residential terrace				
29	OS-80785	–6.1	690 ± 30	1265–1389

Note: Calibration performed using OxCal 4.1, IntCal09 calibration; 95.4% confidence interval.

Methods

Collection of Mortuary and Paleodemographic Data

Mortuary data including body orientation, placement, and position were recorded for 30 burials in the Grand Plaza and churchyard, as well as two burials in outlying residential terraces, and 56 individuals were examined for age, sex, and trauma/pathology indicators. Although several studies have commented on the poor quality of bone preservation in parts of Mexico (e.g., Duncan et al. 2008; Hodges 1987; Mansell et al. 2006; Tiesler et al. 2004), the gross preservation of skeletal remains at Teposcolula was excellent, in part owing to the cool and mild climate of the high-elevation Mixteca Alta region, which is situated at the intersection of the Sierra Madre Occidental and Sierra Madre del Sur mountain ranges (Pérez Rodríguez et al. 2011).

Forty-two individuals could be assigned sex on the basis of pelvic and cranial features (Buikstra and Ubelaker 1994; Salas 1982). Age was estimated on the basis of dental development, epiphyseal union, and degeneration of the pubic symphysis and auricular surface (Buikstra and Ubelaker 1994; Krogman and Iscan 1986; Lovejoy et al. 1985; Ubelaker 1989). Fifty individuals were fully examined for age indicators, and six individuals were assigned to basic age categories on the basis of field examination. Incisor shoveling, a frequent dental trait among indigenous American and Asian populations (Scott and Turner 1997), was common. No evidence of recent trauma was observed among the skeletons, although healed limb fractures were observed in at least three individuals. In general, the individuals exhibited a low incidence of skeletal pathologies, with arthritis and dental caries being the most common pathologies observed. Only one subadult presented evidence of a life-threatening illness, an advanced infection of the cervical vertebrae and kyphosis.

Ancient DNA Extraction, Amplification, and Sequencing

All ancient DNA extraction and polymerase chain reaction (PCR) setup was performed in a dedicated ancient DNA laboratory at Harvard University. Standard ancient DNA laboratory procedures were followed throughout the extraction procedure to prevent contamination and to verify results (Warinner 2010). DNA was extracted from 48 human bone samples, and ancient DNA extracts were PCR amplified with newly developed primer sets (Table 2) designed to detect mitochondrial coding-region polymorphisms that define macrohaplogroups N and M and haplogroups A, B, C, and D (Kolman and Tuross 2000; Torroni et al. 1993).

All 48 individuals tested in this study yielded amplifiable DNA. A minimum of four mitochondrial target regions were successfully amplified for each individual, and 33 individuals amplified all five target regions in this study. Of the 227 successful amplifications, only five exhibited an ambiguous base at a single nucleotide polymorphism position of interest. These samples were reamplified and in all cases yielded a clear and unambiguous base identification. An additional 22 individuals were further subjected to reamplifica-

Table 2. Mitochondrial Coding Region Primers.

Primer	Marker	Significance	TA (°C)	Sequence (5′–3′)	Amplicon Length (bp)	Reference
NMF-10363[a]	10398 A	MHg N	49	TGGCCTATGAGTGACTACAA	118	This study
NMR-10480	10400 T	MHg M		ATGAGGGGCATTTGGTAAATAT		Kolman and Tuross 2000
AF-00635	663 G	Hg A	49	CACCCCATAAACAAATAGGTTTGG	118	This study
AR-00745				TTGATCGTGGTGATTTAGAGG		Kolman and Tuross 2000
BF-08196	8281-8289 del	Hg B	47	ACAGTTTCATGCCCATCGTC	121/112	Kolman and Tuross 2000
BR-08316				ATGCTAAGTTAGCTTTACAG		Kolman and Tuross 2000
CF-13239	13263 G	Hg C	51	CGTAGCCTTCTCCACTTCAAGT	128	This study
CR-13366				CGGTGCACATAAATAGTATGGCT		This study
DF-05150	5178 A	Hg D	51	CCTACTACTATCTCGCACCTG	125	Kolman and Tuross 2000
DR-05274				CTTCGATAATGGCCCATTTGGG		This study

[a]This primer pair amplifies a region with two ancestry informative markers. A G → A transition at nucleotide position (np) 10398 is characteristic of macrohaplogroup N, which includes haplogroups A and B, while a C → T transition at np 10400 is characteristic of macrohaplogroup M, which includes haplogroups C and D.

tion for at least one target and in all cases yielded consistent results.

Stable Isotope Analysis (C, N, O)

Bone collagen was isolated from tibia or femur shaft samples and analyzed for $\delta^{13}C$, $\delta^{15}N$, and $\delta^{18}O$ according to the methods described in Warinner and Tuross (2009, 2010), omitting the chloroform:methanol step, which is unnecessary for ancient samples. For comparative purposes, additional bone samples were collected from five prehispanic sites in the Valley of Oaxaca and analyzed for $\delta^{13}C$ and $\delta^{15}N$ (Table 3; Warinner 2010). C/N for all bone collagen samples fell within the commonly accepted range for intact, biological collagen (DeNiro 1985).

Enamel apatite was collected from third molars and analyzed for carbonate $\delta^{13}C$ and $\delta^{18}O$ according to the methods described in Warinner and Tuross 2009. The third molar (M3) is the last tooth of the dentition to form, with crown formation primarily occurring between ages 10 and 12 and eruption between ages 15 and 21 (Ubelaker 1989). Heavy dental wear and antemortem tooth loss among older adults reduced the number of third molars available for analysis. Carbonate samples from the Grand Plaza plaster floors were also sampled and analyzed to determine the $\delta^{13}C$ of local environmental carbonate sources. Because adsorbed carbonates can affect the isotopic ratios of archaeological apatites (Koch et al. 1997; Trueman et al. 2004), a duplicate aliquot of each sample was soaked for 50 minutes in a .1M acetic acid solution to remove loosely bound carbonates. Comparison of the untreated and treated apatite aliquots yielded no significant difference in either $\delta^{13}C$ or $\delta^{18}O$ ($p > .1$, ANOVA), and minimal pairwise differences between the two aliquots (.1 ± .6‰ in $\delta^{13}C$ and .3 ± 1.3‰ in $\delta^{18}O$) suggest that the archaeological enamel has undergone little exchange with carbonate sources in the immediate environment.

Mortuary and Demographic Analysis of the Teposcolula Skeletal Assemblages

Grand Plaza Skeletal Assemblage

A total of 21 simple pit burials containing 46 individuals were excavated from the Grand Plaza cemetery (Table 4). The bodies were laid supine in an east or west orientation with arms generally folded across the chest or abdomen, and some individuals had their legs crossed at the ankles. Bone beads were found in one burial, but no other clearly associated grave goods were encountered in the Grand Plaza burials (but see note for burials 21 and 26 in Table 4). Fourteen of the 21 burials contained more than one individual, with a maximum of five individuals in a single grave. In seven graves (3, 5, 6, 9, 18, 19, 31), the bodies were stacked in an alternating head-to-foot orientation. Stratigraphic analysis indicates that each grave represents a single burial deposit.

Amorphous calcium carbonate deposits (possibly precipitated from calcium hydroxide or slaked lime) were observed in several burials, most notably in burial 21, in which a thick layer was observed directly above a hollow cavity contain-

Table 3. Comparative Collagen Carbon and Nitrogen Isotopic Values from Prehispanic Populations in the State of Oaxaca, Mexico.

Site	Culture	Collagen $\delta^{13}C$(VPDB)	Collagen $\delta^{15}N$(AIR)	C/N[a]	Reference
El Paragüito	Zapotec	−7.5	8.8	3.0	This study
El Paragüito	Zapotec	−7.8	8.5	2.9	This study
Lambityeco	Zapotec	−7.9	8.9	2.8	This study
Monte Albán	Zapotec	−6.4	9.2	2.9	This study
Monte Albán	Zapotec	−7.4	10.0	2.8	Blitz 1995
Monte Albán	Zapotec	−7.2	9.7	2.8	Blitz 1995
Monte Albán	Zapotec	−9.1	10.5	2.8	Blitz 1995
Monte Albán	Zapotec	−8.1	10.5	3.1	Blitz 1995
Monte Albán	Zapotec	−8.4	9.0	2.7	Blitz 1995
Monte Albán	Zapotec	−10.1	7.2	2.4	Blitz 1995
Monte Albán	Zapotec	−8.3	9.3	2.6	Blitz 1995
Monte Albán	Zapotec	−7.7	10.3	2.9	Blitz 1995
Monte Albán	Zapotec	−9.0	9.3	2.9	Blitz 1995
Monte Albán	Zapotec	−7.4	9.8	2.9	Blitz 1995
San Miguel Albarradas	Zapotec	−6.9	6.5	2.9	This study
San Pedro Ixtlahuaca	Zapotec	−7.7	8.5	2.9	This study
Xatachio	Zapotec	−8.0	10.7	2.9	This study

[a]Reported as mass ratio. To compare to C/N reported as atomic ratio, multiply by 1.1667.

ing the skeletal remains. The use of lime, possibly to reduce putrefaction odors, has also been observed in burials at the colonial mission of St. Augustine in La Florida (Koch 1983). A fragment of leather and thin scales of textile impressions were preserved underneath some of these deposits. It is unknown if the textile impressions indicate the use of burial shrouds (*mortajas*), which were used during the sixteenth century to wrap the bodies of the dead in both Spain (Eire 1995; Foster 1960) and New Spain. Preliminary analysis identified at least two weave patterns among the fragments: a basket weave associated with individual 39 and a twill weave associated with individual 40 (Warinner 2010).

The burials within the Grand Plaza were laid out in an orderly fashion according to what appears to be a gridded plan. The burials were cut directly into the plaster surface of the plaza, which was not repaired or replastered after interment. Unlike at other early colonial cemeteries where old graves were frequently partially disinterred to make room for the new (e.g., at Huexotla, Tipu, and Santa Catalina de Guale; see references in Table 5), there is little evidence for grave disturbance in the Grand Plaza, and only two neighboring graves (burials 1 and 2) in the center of the plaza display evidence of human disturbance subsequent to burial.

Thirty-seven individuals could be assigned sex on the basis of pelvic and cranial features. The sex distribution is slightly biased toward females, who make up 59 percent of the adults whose sex could be determined. The number of infants (0), children under 12 (1), and adults 45 and older (6) is noticeably low, and there is a relatively large number of adolescents and young adults with partially or recently erupted third molars (26) compared with middle-aged adults between the ages of 25–34 (6) and 35–44 (7).

Churchyard Skeletal Assemblage

Seven burials containing eight individuals were excavated from three small test pits in the churchyard (Table 4). As in the Grand Plaza cemetery, individuals were buried in an extended supine position with the arms folded across the chest or abdomen or lying at the sides. Unlike in the Grand Plaza cemetery, however, the burials were oriented to the north or south along the same axis as the colonial church and contained only one individual each. The only exception was the burial of an adult male and an approximately two-year-old child.

Five individuals from the churchyard could be assigned sex on the basis of pelvic and cranial features: four females and one male. Notably, three of the eight individuals excavated from the church-

Table 4. Mortuary and Biological Characteristics of the Teposcolula Yucundaa Skeletal Assemblages.

							mtDNA		Enamel Carbonate[d]		Collagen			
Burial[a]	Individual	Orientation	Body Placement	Body Position	Age Class[b]	Sex[c]	MHg	Hg	$\delta^{13}C$ VPDB	$\delta^{18}O$ VSMOW	$\delta^{18}O$ VSMOW[e]	$\delta^{13}C$ VPDB	$\delta^{15}N$ AIR	C/N[f]
Grand Plaza cemetery														
1	1	W	Extended	Supine	3	M	M	C	–.9	21.4	8.8	–7.6	8.3	2.8
	2	W	Extended	Right side	4	F	N	A	–	–	9.2	–9.4	6.9	2.9
2	3	N	Semiflexed	Supine	2	I	N	A	–	–	9.9	–8.9	9.5	2.8
3	4	W	Extended	Supine	4	F	M	C	–.7	21.5	8.9	–9.9	7.6	2.9
	5	E	Extended	Supine	6	F	N	B	–.5	21.2	9.2	–8.3	8.1	2.8
5	6	N	Extended	Left side	3	M	N	A	–1.2	21.8	8.2	–7.8	8.7	2.9
	7	E	Extended	Supine	2	F	N	B	–	–	9.2	–8.1	8.6	2.9
	8	W	Extended	Right side	3	F	N	A	–.8	19.8	8.2	–8.0	8.2	2.8
	9	E	Extended	Supine	3	M	N	A	–	–	8.7	–7.8	7.8	2.8
6	10	E	Extended	Supine	3	M	N	A	–.6	20.1	8.2	–7.9	9.3	2.9
	11	W	Extended	Supine	6	F	M	C	–	–	7.7	–7.8	7.3	2.9
	12	E	Extended	Supine	3[g]	I	M	C	–	–	8.0	–7.5	9.0	2.9
7	13	E	Extended	Supine	3[g]	I	N	A	–	–	7.9	–7.8	8.1	2.8
8	14	E	Extended	Supine	4	M	N	B	–	–	8.7	–8.9	6.8	2.9
	15	E	Extended	Supine	3[g]	I	N	B	–	–	8.7	–9.4	8.6	2.8
9	16	W	Extended	Supine	5	M	N	B	–	–	7.6	–7.5	8.8	2.9
	17	E	Extended	Supine	6	M	N	B	–1.0	21.1	7.9	–8.1	9.2	2.8
	18	W	Extended	Supine	5	F	N	B	–	–	8.4	–8.7	8.2	2.8
	19	W	Extended	Supine	4	F	N	A	–	–	8.8	–8.7	8.7	2.9
	20	E	Extended	Supine	3	F	N	A	–1.3	21.8	8.8	–8.5	7.7	2.8
10	21	E	Extended	Supine	5	M	M	C	–1.2	20.3	7.8	–7.7	8.9	2.8
	22	E	Extended	Supine	4	M	M	C	–.9	20.7	7.6	–7.7	8.7	2.9
	23	E	Extended	Left side	2	I	N	A	–	–	8.6	–8.5	8.9	2.9
	24	E	Semiflexed	Supine	3	M	N	A	–	–	7.8	–7.8	8.3	2.9
11	25	W	Extended	Supine	4	F	M	D	–1.9	20.6	8.2	–8.4	9.1	2.8
12	26	E	Extended	Supine	5	F	N	A	–	–	7.7	–8.4	9.1	2.9
13	27	E	Extended	Supine	5	M	M	C	–	–	8.4	–8.8	9.4	3.0
16	30	E	Extended	Supine	3	F	N	A	–.6	21.2	8.7	–8.1	9.1	2.7
	31	E	Extended	Supine	5	F	N	A	–	–	9.6	–8.8	9.7	2.8
18	33	E	Extended	Supine	3	I	N	B	–	–	9.4	–7.7	7.8	2.8
	34	W	Semiflexed	Right side	3[g]	I	N	B	–	–	9.0	–8.6	7.5	3.0
	35	E	Extended	Supine	3[g]	I	N	A	–	–	8.7	–8.6	8.3	2.8
19	36	W	Extended	Supine	3[h]	M	N	A	–	–	9.0	–8.2	8.0	2.9

	37	E	Extended	Supine	3	F	N	B	–.7	20.9	8.5	–8.4	8.7	2.9
	38	W	Extended	Supine	3[h]	F	N	A	–	–	7.9	–8.1	9.2	2.7
20	39	E	Extended	Supine	3[h]	F	M	D	–	–	7.6	–8.1	8.3	2.8
21	40	E	Extended	Supine	6	F	N	A	–	–	7.7	–7.8	8.5	2.9
	41	E	Extended	Supine	3	F	N	A	–1.1	22.1	8.1	–8.6	7.8	2.8
24	44	W	Extended	Supine	6	F	N	A	–	–	7.6	–8.0	7.6	3.0
26	46	W	Extended	Supine	6	M	N	A	–	–	6.4	–8.4	8.6	3.1
	47	W	Extended	Supine	5	F	N	A	–	–	7.1	–8.1	7.0	3.0
29	51	E	Extended	Supine	3	F	–	–	–	–	–	–	–	–
	52	E	Extended	Supine	4	M	–	–	–	–	–	–	–	–
31	54	E	Extended	Supine	3	F	–	–	–	–	–	–	–	–
	55	W	Extended	Supine	3	I	–	–	–	–	–	–	–	–
	56	E	Extended	Supine	4	M	–	–	–	–	–	–	–	–
Churchyard cemetery														
17	32	N	Extended	Supine	3	F	M	D	–	–	10.1	–8.6	8.5	3.0
22	42	S	Extended	Supine	2	I	N	A	–	–	8.4	–6.6	10.3	3.0
23	43	N	Extended	Supine	3[h]	M	N	A	–	–	7.5	–8.2	8.4	2.7
25	45	S	Extended	Supine	5	F	N	B	–1.1	20.5	7.3	–8.2	7.3	3.0
27	48	S	Semiflexed	Left side	4	F	N	A	–.7	21.7	6.9	–8.3	8.3	3.0
32	57	S	Extended	Supine	3[h]	F	–	–	–	–	–	–	–	–
	58	S	Extended	Supine	1	I	–	–	–	–	–	–	–	–
33	59	I	Disturbed	Disturbed	2	I	–	–	–	–	–	–	–	–
Residential terrace														
14	28	I	Flexed	Seated	1	I	N	A	–	–	7.8	–5.2	11.5	2.9
15	29	SW	Flexed	Seated	1	I	N	A	–	–	9.0, 7.8	–6.1	12.0	2.7

Notes: Information not available or not measured is noted as "–". Positions are described as disturbed when the relevant skeletal elements have been displaced by bioturbation (e.g., root growth), cultural modification (e.g., partial disinterment), or significant body displacement during decomposition. Individuals are described as semiflexed when lying on the side with moderate natural leg flexion or when supine with the legs flexed to allow the body to fit in limited grave space.

[a]Burial 4 was later recognized to be bones displaced from burials 1 and 2 during the interment of burial 3.

[b]Age indicators were examined by physical anthropologists Laura Roldán (burials 1–18, 27) and Juan Carlos García Jiménez (burials 19–26, 28–33), and individuals were later assigned to one of six age ranges: 1 = 0–4; 2 = 5–14; 3 = 15–24; 4 = 25–34; 5 = 35–44; 6 = >45.

[c]Sex is recorded as female (F), male (M), or indeterminate (I).

[d]Paired enamel carbonate $\delta^{13}C$ and $\delta^{18}O$ values are reported without treatment.

[e]When duplicate samples were measured for $\delta^{18}O$, the average value is reported. The mean difference between the 10 duplicate samples was .1 ± .5.

[f]Reported as mass ratio. To compare to C/N reported as atomic ratio, multiply by 1.1667.

[g]Individual was assessed as adolescent (12–18 years). For subsequent paleodemographic analysis, this individual was placed in age class 3 (15–24 years).

[h]Individual was originally assigned an estimated age of 25 on the basis of epiphyseal fusion, pubic symphysis, and auricular surface indicators. However, subsequent dental examination revealed the presence of encrypted and/or early-stage erupting third molars, which is more typical of individuals aged 18–21. As dental developmental traits are more accurate age indicators for individuals at the adolescent/young adult transition, this individual was thus reassigned to age class 3 (15–24 years).

Table 5. Published Reports of Excavated Sixteenth-Century Cemeteries in New Spain.

Cemetery	Dates of Use	N	References
Central Mexico			
Convento de San Gabriel (Cholula)	ca. 1519[a]	671	Castro Morales and García Moll 1972; McCafferty 2000; Ocaña del Río 1985
Huexotla/Chapingo	ca. 1524–1600	60	Malvido and Viesca 1985; Malvido et al. 1986; Mansilla and Pompa 1992
San Sebastian Molango	ca. 1550–1600	71	Charlton et al. 2005
San Jeronimo	16th–19th centuries	147	Mansilla et al. 1992; Romano Pacheco and Jaén Esquivel 1985
Oaxaca			
Teposcolula Yucundaa	ca. 1538–1552	46	Spores and Robles García 2007
Yucatán Peninsula			
Campeche	16th–17th centuries	122	Tiesler and Zabala 2010
Tancah	ca. 1543–1688	20	Miller and Farriss 1979
Lamanai	ca. 1544–1641	179	Graham et al. 1989; Pendergast 1991; White et al. 1994
Tipu	ca. 1567–1638	>550	Cohen et al. 1994; Danforth et al. 1997; Jacobi 2000
Chiapas			
Coapa	ca. 1554–1680	84	Lee 1979
La Florida[b]			
San Juan del Puerto	ca. 1587–1702	5	Dickinson 1989; Larsen 1993
Nuestra Señora de Soledad (St. Augustine)	ca. 1597–1784	28	Koch 1983
Santa Catalina de Guale	ca. 1597–1680	432	Larsen 1993, 1990; Larsen et al. 1990

Notes: Includes only individuals excavated from primary contexts.
[a]Evidence of violence suggests that the cemetery contains the remains of the 1519 Cholula massacre victims; however, the cemetery may also contain individuals interred at a later date.
[b]A wealth of bioarchaeological data have been produced for colonial cemeteries in La Florida; however, most excavated La Florida cemeteries date to the seventeenth and eighteenth centuries, a time period outside the scope of this article. See Larsen 1993 for more information about these cemeteries.

yard were age five or younger. Six of the seven graves contained no grave goods. One grave, burial 27, located in the center of the churchyard, contained an exceptional number of grave goods (figurines, pendants, and beads numbering in the tens of thousands) and is presumed to be a Postclassic royal burial (Warinner 2010).

Residential Terrace Skeletal Assemblage

Two infants under the age of three were recovered from two simple pit burials in outlying commoner residential terraces. The infants were placed in a flexed, seated position, and each was accompanied by a shallow ceramic dish (*cajete*) of the Postclassic Yanhuitlan Fine Cream type.

Teposcolula Grand Plaza and Churchyard Skeletal Assemblages in Context

Prior to the arrival of Spanish missionaries, Mixtecs typically buried their dead in simple pit burials, stone-lined crypts, or family tombs located in residential compounds. Grave goods such as ceramic vessels were frequently, but not always, included. The bodies of adults were usually laid out in an extended supine position, with arms placed at the sides (Acosta 1992; Blomster 2004; Gaxiola González 1984; Robles García 1988); however, Postclassic carved stone figurines at Teposcolula also depict the dead with arms folded across the body (Warinner 2010).

Both Postclassic and colonial burials at Teposcolula Yucundaa are characterized by a general absence of grave goods, a high incidence of extended supine body positioning (76 percent), and a predominance of arm-folding across the chest or abdomen (81 percent)—a mortuary pattern that overlaps with contemporary Spanish Catholic practices (Eire 1995; Koch 1983; Rush 1941). In the Grand Plaza, the lack of a consistent body orientation and the mass burial of individuals within an extramural cemetery, however, differ from contemporary colonial Spanish practices.

In sixteenth-century Spain, most Catholics were buried within churches or chapels, or, at the very least, within consecrated walled churchyard cemeteries (Eire 1995:94; Foster 1960). Excavated early colonial cemeteries in New Spain (Table 5) conform to this pattern, with a high density of burials within and immediately surrounding the church (Malvido 1997). By contrast, colonial burials at Teposcolula Yucundaa were found exclusively in the Grand Plaza, an area otherwise associated with Mixtec civic-ceremonial functions (Spores and Robles García 2007). No burials or evidence of repaired *rompimientos* (burial cuts) were encountered within the Teposcolula Yucundaa church, and graves encountered within the walled churchyard were found by direct radiocarbon dating to predate the colonial period (Table 1). The unusual mortuary features encountered in the Teposcolula Yucundaa Grand Plaza offer few clear insights into the biological or cultural affiliations of the interred individuals, thus necessitating alternative lines of evidence, such as ancient DNA mitochondrial haplogroup testing and stable isotope–based paleomigration and paleodietary analysis.

Oxygen Isotopic and Genetic Analysis of the Teposcolula Skeletal Assemblages

Stable isotope analysis and mitochondrial haplogroup testing were employed to determine genetic affinity, assess population homogeneity, and characterize the geographic origin of individuals within the Teposcolula burial assemblages. Recent investigations in Campeche have revealed the presence of multiple ethnic groups buried within a single early colonial cemetery (Tiesler and Zabala 2010), raising the possibility that a similar pattern might be found in the rapidly developing colonial town of Teposcolula Yucundaa.

During the early colonial period, there is historical evidence for the presence of several different groups in the Mixteca Alta region that may have been present at Teposcolula in the sixteenth century, including local Mixtecs, central Mexicans, slaves of West African or Caribbean descent, and Spanish missionaries, officials, and settlers. Slaves were first brought to the region in the 1520s by Teposcolula's second *encomendero*, Juan Pelaez de Berrio, to pan for gold (Chance 1978). Throughout the 1540s at least one and as many as six Dominican friars lived in residence at Teposcolula at any given time (Vences Vidal 2000), and excavations of the Teposcolula monastery in 2005 identified at least seven small rooms that may have served as cells for resident or traveling friars (Robles García and Spores 2005; Spores and Robles García 2007). Historical records indicate that nonecclesiastical Spanish settlers also began moving to the Mixteca Alta in the late 1530s and early 1540s (Romero Frizzi 1990), but it is not known if any of these Spaniards lived at Teposcolula.

Oxygen Stable Isotopes of the Teposcolula Burials

Oxygen isotopic values of mineralized tissues have been shown to correlate with precipitation and temperature gradients (Longinelli 1984; Luz and Kolodny 1989), and thus oxygen isotopic analysis can be used to investigate archaeological histories of human migration across diverse ecological zones (e.g., Price et al. 2010; Quinn et al. 2008; Schroeder et al. 2009). Oxygen isotopes in both organic and inorganic substrates (collagen and enamel carbonate) were measured in order to assess whether the Teposcolula Grand Plaza cemetery represents a local Mixtec population or if there is evidence for nonlocal migrants at the site (Table 4).

The average $\delta^{18}O_{bone\ collagen}$ in the colonial Grand Plaza cemetery (8.4 ± .7‰) compares closely with that in the Postclassic churchyard burials (8.2 ± 1.4‰), as well as with two Postclassic low-status infant burials recovered from outlying residential terraces at Teposcolula (7.8‰, 8.4‰), suggesting that the individuals interred in the Grand Plaza are of local origin (Table 4). A comparison of Grand Plaza cemetery $\delta^{18}O_{enamel\ carbonate}$ with that measured for individuals from a variety of other sites also supports the interpretation that the cemetery does not contain long-distance migrants from Spain, Africa, the Caribbean, or other parts of Mesoamerica (Figure 3; comparative data from Bell et al. 2006; Price et al. 2010; Schroeder et al. 2009; White et al. 2000; and Wright and Schwarcz 1998). The relatively depleted $\delta^{18}O_{enamel\ carbonate}$ observed for all three Teposcolula burial assemblages is consistent with the relatively cool and wet climate characteristic of the Mixteca Alta, especially compared with that of southern Spain and the other Mesoamerican and Caribbean regions that have been analyzed.

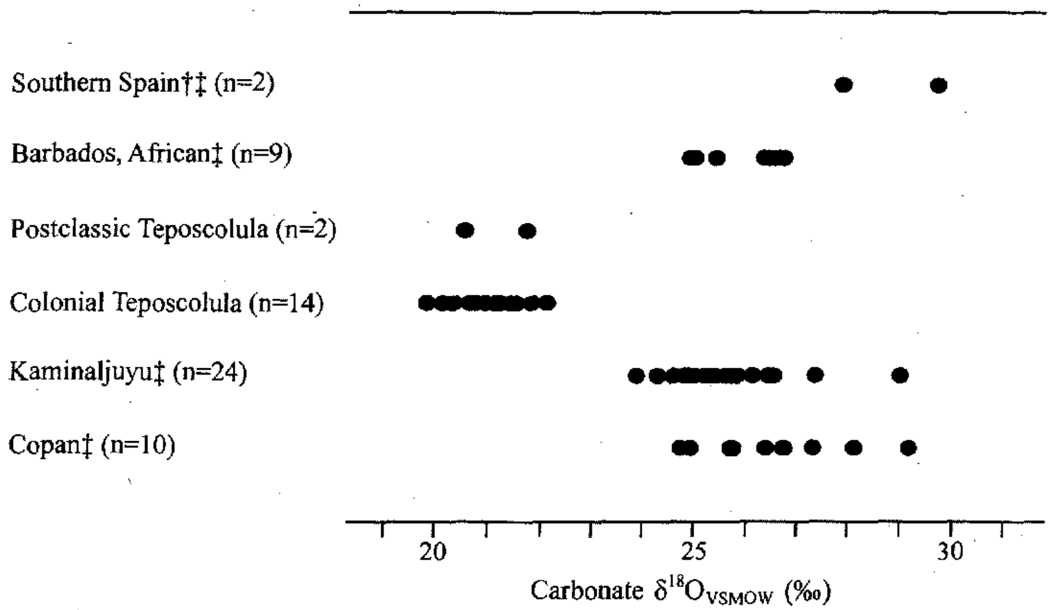

Figure 3. Enamel carbonate oxygen isotopic values. Human enamel measurements are from third molars only. †Data from modern horse enamel; no human enamel from Holocene Spain has been analyzed for carbonate $\delta^{18}O$. ‡Original $\delta^{18}O$ measured relative to VPDB; to approximate $\delta^{18}O$ on the VSMOW scale, the following transformation was performed: $\delta^{18}O_{VSMOW} = 1.03086 * \delta^{18}O_{VPDB} + 30.86$ (Friedman and O'Neil 1977; Werner and Brand 2001).

Genetic Analysis

Ancient DNA Analysis of the Teposcolula Burial Assemblages. Forty-one individuals from the Teposcolula Grand Plaza cemetery were tested for mitochondrial ancestry informative markers characteristic of the two major macrohaplogroups found outside of Africa, M and N, and the four major indigenous American haplogroups, A, B, C, and D (Table 4). Seven additional Postclassic skeletons from the churchyard and outlying residential terraces were also analyzed for comparison. All 48 individuals could be assigned to both macrohaplogroup and haplogroup, and no individuals exhibited ancestry informative markers consistent with more than one haplogroup. All individuals were found to belong to macrohaplogroups M or N, thus indicating that there are no individuals of maternal African descent in the skeletal assemblage. Further haplogroup testing of the assemblage demonstrated that all individuals exhibit markers consistent with haplogroups A, B, C, or D, indicating that there are no Europeans in the assemblage and confirming that all tested individuals are of indigenous American ancestry. This agrees with the results of the oxygen stable isotope analysis, which found no evidence for foreign-raised individuals in the cemeteries.

Ancient and Modern Mitochondrial Haplogroup Frequencies of Indigenous Populations.

Genetic studies of modern indigenous American populations have revealed continental and regional patterning in mitochondrial haplogroup frequency distributions (Malhi et al. 2002; Schurr 2004; Torroni et al. 1992; Torroni et al. 1993). The haplogroup frequency distribution of the Grand Plaza skeletal assemblage (Table 6) is typical of a Mesoamerican population, which is generally characterized by a high frequency of haplogroup A, and is distinct from the dominant C and D haplogroup pattern observed among the ancient Taino and Carib populations of the Caribbean ($p < .001$, χ^2 test for homogeneity). Within Mesoamerica, the haplogroup frequency distribution of the colonial Teposcolula Grand Plaza assemblage compares closely with that of modern Mixtecs ($p > .1$, χ^2 test for homogeneity; Table 6). The haplogroup frequency profile of the Grand Plaza assemblage indicates long-term genetic continuity in the Mixteca Alta and further supports the characterization of the Grand Plaza cemetery as containing a local, Mixtec population.

Table 6. Mitochondrial Haplogroup Frequencies of Colonial Teposcolula and Other Modern and Ancient Mesoamerican and Caribbean Populations.

		Haplogroup Frequency (%)					
Population	N	A	B	C	D	X	Reference(s)
Mesoamerica							
Colonial Mixtec[a]	41	54	24	17	5	0	This study
Modern Mixtec	123	67	23	7	3	0	4, 6, 9, 12, 15
Modern Zapotec	100	41	24	30	5	0	4, 6, 9, 15
Modern Mixe	68	38	29	24	9	0	4, 6, 9, 15
Ancient Nahua	37	62	16	5	10	0	2, 5
Modern Nahua	404	56	29	8	6	0	4, 6, 9, 10, 11, 12
Ancient Maya (Xcaret)*	24	88	4	8	0	[b]	3
Modern Maya	91	59	23	11	7	0	1, 12, 13, 14
Caribbean							
Ancient Taino**	24	0	0	75	25	[b]	8
Ancient Ciboney**	15	7	0	60	33	0	7

Note: Includes only populations with a sample size of at least 10. Excludes individuals with haplogroups indicative of European or African admixture, as well as individuals for whom haplogroup assignment was not determined. 1 = Boles et al. 1995; 2 = De la Cruz et al. 2008; 3 = González-Oliver et al. 2001; 4 = Kemp 2006; 5 = Kemp et al. 2005; 6 = Kemp et al. 2010; 7 = Lalueza Fox et al. 2001; 8 = Lalueza Fox et al. 2003; 9 = LeBlanc et al. 2007; 10 = Lorenz and Smith 1996; 11 = Malhi et al. 2003; 12 = Peñaloza-Espinosa et al. 2007; 13 = Smith et al. 1999; 14 = Torroni et al. 1992; 15 = Torroni et al. 1994.

[a]Teposcolula Grand Plaza burials.

[b]Testing for haplogroup X was not performed, and the haplogroup assignment of at least one individual from this population is given as "other" (i.e., not A, B, C, or D).

*Haplogroup frequency significantly different from Teposcolula at .05 level using $\chi2$ test for homogeneity.

**Haplogroup frequency significantly different from Teposcolula at .01 level using $\chi2$ test for homogeneity.

Evidence for a Catastrophic Event

Soren (2003) has outlined several characteristics typical of so-called abnormal, or catastrophic, cemeteries, including (1) evidence of mass burial or multiple individuals within a single grave; (2) rapid, successive vertical depositions; (3) installment in a single layer at one time or in a large cluster; and (4) corroborating historical evidence. The Teposcolula Grand Plaza cemetery meets each of these mortuary criteria, and there is additionally good historical evidence for a major epidemic in the Mixteca Alta at this time.

Mortuary Evidence

Two-thirds of the burials within the Grand Plaza contain more than one individual, with as many as five bodies within a single grave. In approximately half of the graves with multiple individuals, bodies were vertically stacked in alternating directions, perhaps as a space-saving measure. This differs from practices at other colonial cemeteries, where a single burial orientation predominates at frequencies over 90 percent (e.g., Cohen et al. 1994; Larsen 1993; Malvido and Viesca 1985; Ocaña del Río 1985). The rigidly geometric layout of the Grand Plaza cemetery also suggests a large-scale, coordinated burial effort over a short period of time, as opposed to the more loosely organized and overlapping burial patterns typically observed at attritional colonial cemeteries (e.g., Cohen et al. 1994; Koch 1983; Malvido et al. 1986).

Finally, the identification of a large indigenous colonial cemetery not associated with a church or churchyard is highly unusual and has not been previously documented. Excavated early colonial cemeteries in New Spain are typically characterized by a high density of burials within and immediately surrounding a church, and in this respect the extramural Grand Plaza cemetery is clearly anomalous.

Historical Evidence

In late 1544, an unidentified epidemic broke out in New Spain. The Codex Telleriano-Remensis represents the "great mortality" with stacks of corpses,

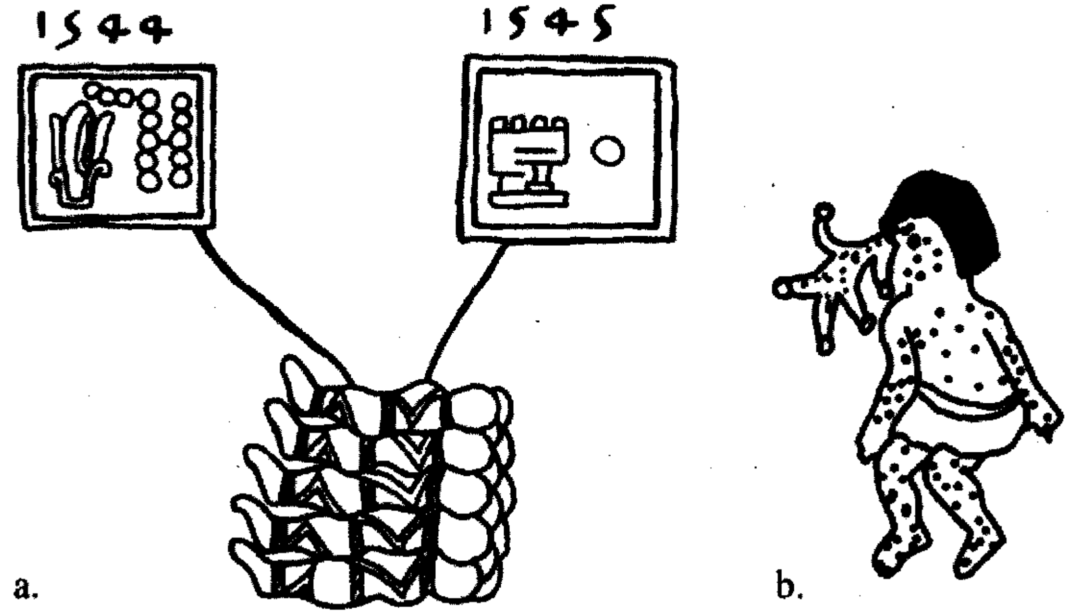

Figure 4. Depictions of the 1545–1550 epidemic in native documents: (a) Codex Telleriano-Remensis, folio 46v; and (b) Codex en Cruz (drawings by the author).

and the Codex en Cruz depicts the two most common symptoms of the epidemic: severe nosebleeds and a body rash (Figure 4). Although the nature of the epidemic is poorly understood, historical sources agree that it was devastating, with an estimated mortality rate of 60–90 percent (Cook 1998; de Mendieta 1945; de Sahagún 1956; Motolinía 1971; Prem 1992). Witnesses, both Spanish and native, had never seen anything like it before and had no name to describe it, calling it instead *pujamiento de sangre* (abundant bleeding or full bloodiness) in Spanish and *huey cocoliztli* (great pestilence) in Nahuatl (Cook 1998; Prem 1992). It is one of three sixteenth-century epidemics that can be described as a true pandemic, which spread from central Mexico to Guatemala and beyond (possibly to Peru), eventually infecting all of New Spain and perhaps lingering in Guatemala until 1563 (Lovell 1992; Newson 1992; Prem 1992).

Located along the principal trade routes between Mexico and Guatemala, the people of the Mixteca Alta became infected as well. A document from 1545 records that at the Mixtec community of Coixtlahuaca (located approximately 30 km to the northeast of Teposcolula), burial could not keep pace with the 30–40 people who were dying each day during the epidemic (Terraciano 2001), and Teposcolula's own resident Friar Bernardino de Santa María is recorded to have fallen ill at this time (Jiménez Moreno and Mateos Higuera 1940; Warinner 2010). Thirty years later, four other neighboring Mixtec communities remembered the 1545–1548 "pestilence" as the only epidemic to reach the Mixteca Alta between the early 1530s and 1577 (Acuña 1984; records for Teposcolula have been lost, see discussion in Warinner 2010). The cause of the great pestilence of 1545 is unknown but may have been epidemic typhus (Fields 2008; Humboldt 1811; Zinsser 1934), pneumonic plague (MacLeod 1973; Malvido and Viesca 1985; Orellana 1987), or a viral hemorrhagic fever (Acuña Soto et al. 2000; Acuña Soto et al. 2002; Marr and Kiracofe 2000).

Paleodemography

In addition to mortuary and historical evidence, the paleodemographic profile of the Teposcolula Grand Plaza cemetery also conforms to a catastrophic, rather than attritional, pattern (Figure 5). A sharp rise in mortality among adolescents and young adults, as seen during the 1918 influenza pandemic and in the Teposcolula Grand Plaza cemetery, is characteristic of a catastrophic event. Although straightforward comparison of mortality profiles obtained from diverse data sets is made problematic by "age-heaping" in historical data (see Chamberlain 2006) and statistical biases in age determination from osteological data (see Hoppa

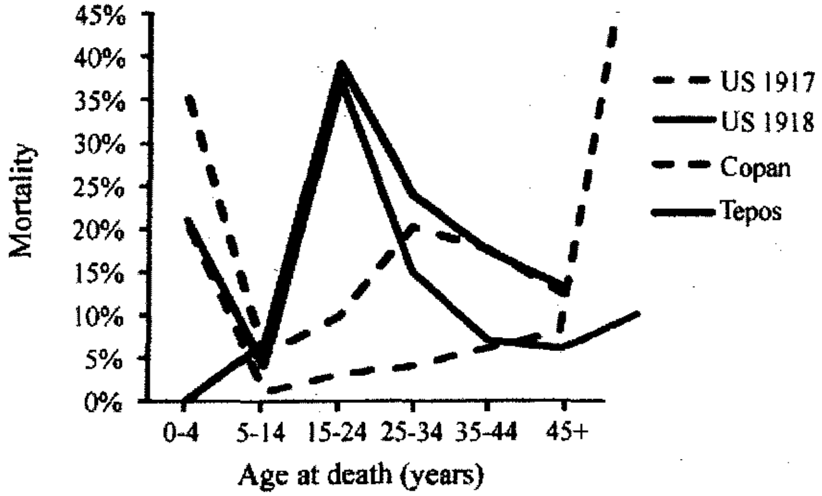

Figure 5. Comparison of attritional and catastrophic mortality profiles derived from historic and archaeological data. Gray lines signify the mortality (percent of deaths from lung infection) of a subset of the U.S. population before (dashed) and during (solid) the 1918 influenza pandemic. Black lines signify mortality (percent of excavated) in an attritional skeletal assemblage from Copán, Honduras (dashed) and the Teposcolula Grand Plaza (solid).

and Vaupel 2002), attritional and catastrophic patterns can nevertheless be discerned from both historical and bioarchaeological data (e.g., Gowland and Chamberlain 2005; Signoli 2006).

The Teposcolula Grand Plaza cemetery is characterized by a very high frequency of adolescents and young adults aged 15–24, an ordinarily healthy age group usually making up a relatively small proportion of attritional cemeteries (e.g., Hollingsworth and Hollingsworth 1971; Whittington 1989). Excessively high mortality of adolescents and young adults is a typical feature of catastrophic epidemics and has been historically documented for plague outbreaks in medieval and early modern Europe (Hollingsworth and Hollingsworth 1971; Signoli et al. 2002), as well as the 1918 influenza pandemic in the United States (Crosby 1976). Bioarchaeological evidence from European plague cemeteries shows a similar trend, although long-term alterations in the underlying age profile caused by centuries of serial epidemics have made medieval European patterns more complex and, thus, not directly comparable (DeWitte and Wood 2008; Gowland and Chamberlain 2005; Margerison and Knüsel 2002; Signoli 2006; Signoli et al. 2002; Waldron 2001; see Warinner 2010 for discussion).

The mortality profile of adolescents and young adults at Teposcolula differs markedly from that observed at the well-studied prehispanic Mesoamerican site of Copán (ca. A.D. 400–900), which is thought to be an attritional skeletal assemblage (Whittington 1989). The unusually high proportion of individuals aged 15–24 compared with those over 25, however, may also reflect additional biological and social factors, including earlier population losses from previous epidemics and interment bias reflecting differences in baptismal rates among age groups (Warinner 2010). The complete lack of children under the age of seven in the Grand Plaza assemblage is unusual and suggests that infants and young children either died early in the epidemic (before the establishment of the Grand Plaza cemetery), were systematically buried elsewhere, or received treatment that did not include burial.

Colonial Consequences

Demographic Impact

The demographic impact of epidemic disease on Teposcolula is difficult to reconstruct with any precision. On the basis of settlement survey data, Stiver (2001) estimates that the population of Teposcolula and its immediate hinterlands numbered between 20,000 and 44,500 people at Spanish contact. By contrast, a colonial census conducted just after the 1545–1548 epidemic (ca. 1548–1550) at Teposcolula records 2,934 households and 9,386 people over the age of three (Paso y Troncoso

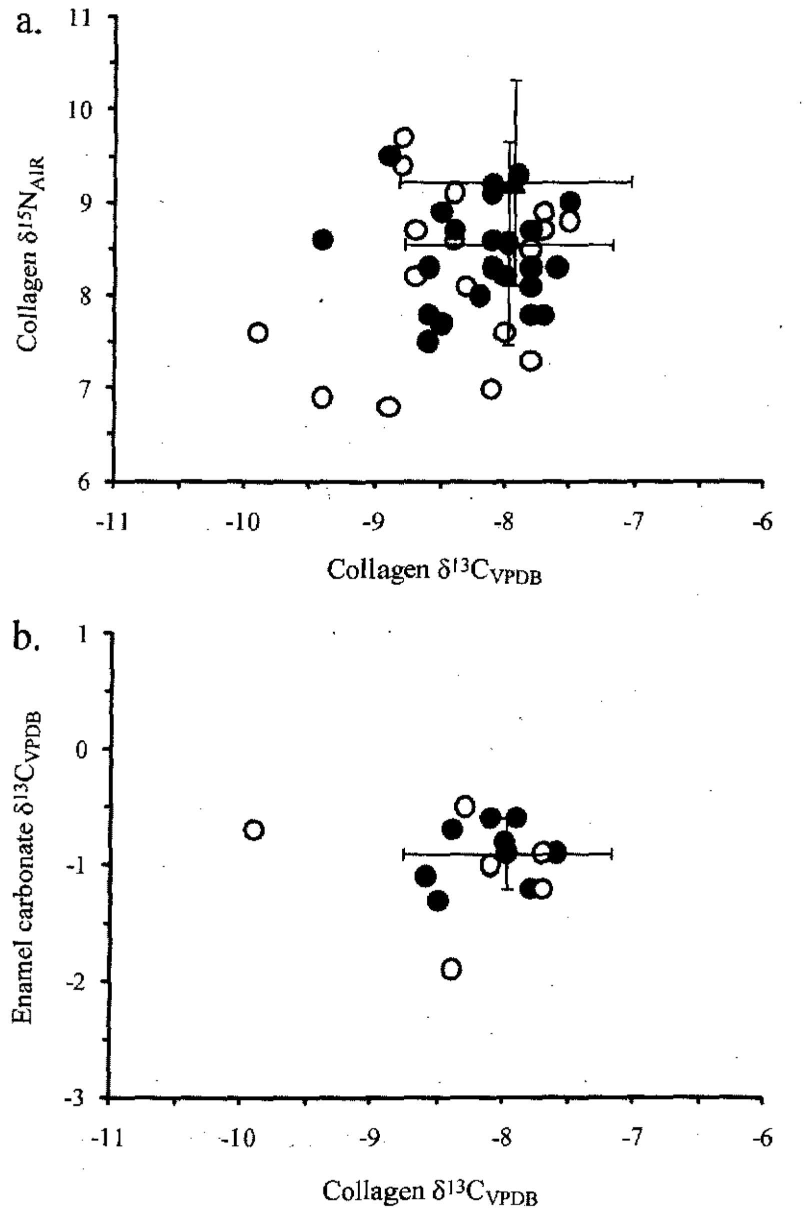

Figure 6. Distribution of bone collagen and enamel carbonate isotopic values from individuals aged 5–24 (•) and age 25 and older (○) in the Teposcolula Grand Plaza compared with Postclassic burials at Teposcolula (•) and other prehispanic populations in the Valley of Oaxaca (▲). Error bars represent ±1 SD.

1981). This dramatic difference may reflect substantial mortality and population decline during the epidemic or may result from differences in the delineation of territorial boundaries and methods used to arrive at population estimates. Although historical documents are inconclusive regarding the impact of early epidemics at Teposcolula, census records from 1570 to 1650 indicate that the population of the Teposcolula jurisdiction fell from 26,500 to 14,100 after the epidemics of 1576–1581, 1591–1592, and 1599 and reached a low point of 6,522 in 1646, a population decline of over 75 percent in less than a hundred years (Cook and Borah 1968; Gerhard 1993).

Economic Change

Alongside population decline, the Mixteca Alta also experienced rapid economic change during the early colonial period (Riquer 1990; Romero Frizzi 1990). Many Spanish agricultural species were introduced to New Spain at this time, including wheat, which Teposcolulans were required to grow from 1531 to 1563 to satisfy royal tax obligations (Pérez Ortiz 2003; Spores 1967). Historical references to wheat cultivation during this period appear primarily in connection with the provisioning of Spanish cities and monasteries (Cuevas 1975; Terraciano 2001), but it is not known when or to what degree wheat was consumed by indigenous populations during the early colonial period.

Pellicer (1990) has argued that wheat, in addition to being grown for taxation, may have also become an important fallback grain for some indigenous populations. The Mediterranean variety of wheat introduced by the Spanish was relatively frost resistant and required less water than maize (Riquer 1990) and was thus more suited to the cool climate of the Mixteca Alta, where variable frost dates and rainfall frequently led to maize crop damage or failure at communities such as Teposcolula (de la Peña 1950; Riquer 1990). With a shrinking labor supply, agricultural stability would have become increasingly important. In order to determine the importance of wheat consumption in indigenous diets at Teposcolula, carbon stable isotope values were measured from bone collagen and enamel apatite samples from individuals in the Grand Plaza cemetery (Table 4).

Carbon Stable Isotope Analysis of the Teposcolula Skeletal Assemblages

Stable isotope analysis of the Teposcolula Yucundaa skeletal assemblage supports continuity in maize consumption and an absence of significant wheat consumption during the early colonial period. If wheat consumption had correlated with historically documented wheat cultivation at Teposcolula, $\delta^{13}C$ values of collagen and enamel would be expected to be lower in the colonial Grand Plaza burials compared with the Postclassic churchyard and other prehispanic burials in the region. However, the high collagen $\delta^{13}C$ values of the Grand Plaza skeletal assemblage are instead consistent with a diet rich in C4 and CAM plant resources, such as maize, amaranth, agave, and cactus fruit (Warinner et al. 2012), and the collagen isotopic distribution of the Grand Plaza assemblage closely resembles that measured for prehispanic burials at Teposcolula and other sites in the Valley of Oaxaca (Figure 6a and Table 3). Furthermore, when broken down by age group, collagen $\delta^{13}C$ values for adults age 25 and older in the Grand Plaza are not significantly different from those of individuals aged 10–24, who grew up almost entirely during the period of wheat cultivation at Teposcolula ($p > .1$, ANOVA).

The $\delta^{13}C$ values of third molar enamel apatite also indicate dietary continuity before and after the introduction of wheat (Figure 6b). The enamel of individuals aged 18–24 formed between approximately 1534 and 1545, the period of wheat cultivation at Teposcolula, while individuals 25 and older formed their third molar enamel between approximately 1505 and 1533, the period predominantly before wheat introduction at Teposcolula. A comparison of third molar enamel apatite $\delta^{13}C$ values between individuals aged 18–24 and individuals 25 and older reveals no significant carbon isotopic differences between the two age groups ($p > .1$, ANOVA) and no isotopic difference from Postclassic values.

Thus, although minor consumption of wheat cannot be ruled out, carbon isotope analysis of bone collagen and enamel apatite indicates no evidence of a substantial shift toward wheat consumption in early colonial Teposcolula, suggesting that wheat was grown almost exclusively as a cash or tribute crop. The fact that maize continued to be the dominant staple food crop in colonial Mixtec diets, despite the practical advantages offered by a frost-resistant and drought-tolerant variety of wheat, attests to the persistent centrality and symbolic importance of maize in colonial Mixtec culture and identity.

Conclusions

Excavations at the site of Pueblo Viejo Teposcolula have yielded important insights into early colonial life at a Mixtec community undergoing rapid demographic and socioeconomic change. Mortuary and paleodemographic analysis of the Grand Plaza cemetery, the first clearly epidemic-associated sixteenth-century cemetery to be excavated in Mexico, substantiates the catastrophic mortality of the historically documented early colonial epidemics, and bone specimens collected from the cemetery provide valuable biological samples for future ancient genetic testing of the cause of this poorly understood epidemic.

Mitochondrial haplogroup typing confirms the indigenous American ancestry of the dead in Grand

Plaza cemetery, and the haplogroup frequency profile of the assemblage closely resembles that of modern Mixtecs, indicating long-term genetic continuity in the region. Oxygen isotope analysis indicates that the Teposcolula Grand Plaza cemetery is composed of a local population, and carbon and nitrogen isotope analysis supports a continued dietary reliance on C4 and CAM crops, such as maize and agave, during the early colonial period, despite historical evidence for increased wheat production at the site.

The application of an integrated bioarchaeological approach, including mortuary, paleodemographic, ancient DNA, and stable isotope analysis, has yielded important insights into early colonial life at Teposcolula Yucundaa. By bringing together multiple lines of evidence, we find both support for and divergence from conventional models of colonial social and biological change. Catastrophic population loss does seem to have been a key factor in the effective institution of congregación, but other changes attested in historical records and material culture may have been more superficial. Rather than illustrating rapid change, biological evidence relating to ancestry, migration, and subsistence paints a picture of continuity and resilience across the colonial transition, despite population losses. The Teposcolula Grand Plaza cemetery provides a rich and complex perspective on early colonial life in the Mixteca Alta and reaffirms the importance of archaeological and bioarchaeological evidence in investigating complex social and biological processes of the past.

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Note

1. The current institutional affiliation for Christina Warinner is as follows: Department of Anthropology, University of Oklahoma, Norman, OK 73019 (christina.warinner@ou.edu).

2. Teposcolula Yucundaa is a hybridized name that reflects the Mixtec, Aztec, and Spanish heritage of the site. *Teposcolula* is the hispanicized form of a Nahuatl (Aztec) word meaning "Place of the copper axes," which has several spelling variants in the colonial record, including *Tepozcollollan* (Chimalpahin 1997 [ca. 1621]) and *Tepuzculula* (Berdan and Anawalt 1997). In Mixtec, the town was called Yucundaa (Jiménez Moreno and Mateos Higuera 1940), which may be translated as "On the plain of the hill" or "Blue hill" (Alavez 1988:92; Alavez Chávez 2006:32; Restall et al. 2001:139). The Spanish renamed the town San Pablo Teposcolula (Jiménez Moreno and Mateos Higuera 1940), a name also used to refer to the town after its relocation to the valley (Calderón Galván 1988). By the eighteenth century, the new town had acquired a second patron saint and has since borne the name San Pedro y San Pablo Teposcolula. Today, the mountaintop archaeological site is known as Teposcolula Yucundaa, although locals generally refer to it as Pueblo Viejo, or "Old Town."

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