Biological Structure and Health Implications From Tooth Size at Mission San Luis de Apalachee

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ABSTRACT   This study analyzes dental metric variation to examine the biological structure of the native population at Mission San Luis de Apalachee, a late 17th century mission located in the Apalachee Province of Spanish colonial Florida. Three topics are addressed: (1) comparison of tooth sizes among adult and subadults, (2) analysis of the bio-spatial structure of skeletons within the church area, and (3) comparison of phenotypic profiles of individuals interred within coffins in the ritual nucleus of the church: the altar region. Analyses indicate that subadults had smaller average tooth sizes than adults for the posterior dentition that was particularly evident in mandibular nonpolar molars and premolars. This disparity, also documented in two other mission populations, likely represents ontogenetic stress and resulting increased mortality among those most at risk for early death. Analysis of the spatial structure of graves failed to document biological structuring by side of the aisle or by burial row, although some gross differences were evident when front, middle, and rear church burials were compared. Individuals buried in coffins within the same row were phenotypically similar to one another. However, inter-row comparisons indicated lack of phenotypic similarity among all coffin interments. These analyses suggest maintenance of kin-structured burial for elites alone within the San Luis community. Am J Phys Anthropol 132:207–222, 2007. © 2006 Wiley-Liss, Inc.

One of the most profound influences on the health, life history, evolution, and human biology in general of native populations in the Americas was the arrival of Europeans and subsequent colonization (Verano and Ubelaker, 1992; Larsen, 2001). In the North American Southeast, Spanish colonists established intensive contact through a series of Franciscan missions among native groups on the Atlantic coast (Guale) and mainland Florida (Timucua and Apalachee) during the late sixteenth through early eighteenth centuries. Historical, archaeological, and bioarchaeological research reveals dramatic changes in health, diet, and biocultural adaptation (e.g., Larsen, 1993, 2001; Larsen et al. 2001). During the Spanish occupation, there was significant movement of native groups as they were relocated to nearby (and sometimes distant) missions. This disruption, combined with labor exploitation, disease, and general decline in quality of life resulted in remarkable population decline of native communities by the early years of the eighteenth century.

In addition to the focus on biocultural adaptation, other investigations of this setting have begun to investigate microevolution and demography. For example, Griffin and coworkers used dental and cranial morphological data to analyze patterns of phenotypic variation and affinity among pre- and postcontact Guale populations along the Georgia coast (Griffin, 1993; Griffin et al., 2001). Stojanowski (2001, 2003a,b, 2004, 2005a–d), using odontometric data, adopted a regional perspective inclusive of populations further west, in Apalachee and Timucua. These investigations generated a regional perspective on the processes of microevolutionary transformation among Spanish Florida's indigenous communities in the wake of demographic collapse, highlighting the

effects of Spanish practice and indigenous adaptation in effecting short-term evolutionary trends.

Although regional analyses have dominated, contributions based on specific cemeteries have also been undertaken (Simpson et al. 1990; Stojanowski, 2005d), attempting to reconstruct specific processes and patterns of population structure as related to social phenomena within these dynamic mission communities. Simpson et al. (1990) presented data on subadult mortality bias at Santa Catalina de Guale, linking diminished subadult tooth size to physiological stress within a specific Guale community. Stojanowski (2005d) documented a similar pattern at San Pedro y San Pablo de Patale, a major mission center located in Apalachee province in the Florida panhandle. At Patale, juveniles had significantly smaller teeth than adults. This age-specific patterning likely reflects increased

subadult morbidity, subsequent disruption in amelogenesis, and ultimately early death among the most susceptible members of the population (see Sagne, 1976; Guagliardo, 1982; Larsen and Kelly, 1995). However, correspondence between presence of subadult mortality bias and pathological indicators of poor health (e.g., hypoplastic defects) was not strong. Although study of human remains from Santa Catalina demonstrated both subadult mortality bias and macroscopic indicators of morbidity (e.g. elevated anemia and infection), Patale individuals appeared to be in relatively good health, at least as health is represented by hypoplasia frequency and periosteal reaction prevalence (Storey, 1986; Stojanowski, 2005d).

Stojanowski (2005d) also examined burial organization and cemetery structure at Patale, noting differences in biological profile by burial row and side of the aisle. Results of comparative phenotypic analyses suggested sex segregation by side with maintenance of cross-aisle family oriented burial rows. Although subadult sex assessment was not possible, for rows in which both left and right side subadults were present, every individual on the left side of the aisle was smaller than every individual on the right side. This reflects the confounding effects of postmarital residence on patterns of spatial structure. The fact that the burial area was not filled, that Patale was abandoned after a relatively brief interval (approximately one generation), and that there was little evidence for epidemic-related mortality at this mission implies this mortuary structure (kin-oriented rows with sex segregation by side) may reflect a predemographic collapse "ideal," adopted rapidly by communities throughout Spanish Florida.

Several individuals at Patale treated in an atypical burial manner (partially exhumed, buried facing the rear of the church, high grave good density, and post-abandonment interments) were found to be phenotypically typical of the population. Previous hypotheses regarding *mestizo* or Spanish affinity of some of these individuals were, therefore, rejected on the assumption that *mestizos* would exhibit dental reduction (see below).

In this paper, we document and interpret phenotypic variation (tooth size) for San Luis de Apalachee (hereafter San Luis), a late 17th century mission also located within Apalachee Province. We address three specific topics. First, subadult:adult tooth size differences are evaluated to determine if growth deficits are evident among late 17th century Apalachee. Second, the general biological structure of the San Luis cemetery is evaluated and compared to that at mission Patale (Stojanowski, 2005d). As discussed further below, San Luis differs in many respects from all other missions, the most salient being the presence of several hundred Spaniards in residence and the resulting emergence of a multiethnic community. In addition, San Luis represents the Apalachee at a time when demographic collapse was actively progressing (Stojanowski, 2005c) and, therefore, reflects a different social and biological environment than mission Patale's. Third, the biological affinity of atypical burials (those interred within coffins at the front of the church) is assessed. While it is possible these individuals were Spaniards or *mestizo*, they may also have been Apalachee elite or persons holding special offices within the church.

INTRACEMETERY ANALYSIS OF BIOLOGICAL VARIATION

Analysis of cemetery structure identifies the likely composition of specific social groups or lineages within cemteries, with research targeting variation at the family group (Konigsberg, 1987; Alt and Vach, 1998) and extended lineage (bands, clans) levels (e.g., Birkby, 1982; Byrd and Jantz, 1984). Kinship analysis has received the greatest attention and has been applied in various temporal and cultural contexts in both the Old and New Worlds. Alt and Vach (1998) provide a recent summary of kinship analysis as it pertains to their long-term research program and outlined three types of research contexts that affect the methodology adopted and the expected outcome: small grave analyses, unstructured spatial analyses, and structured spatial analyses.

In small grave analyses, a nonspatial approach is used to infer whether a group of individuals buried in a well-defined grave (a tomb, well, or pueblo room block, for example) are closely related. These analyses have attempted to reconstruct pedigrees among individuals (Rösing, 1986; Spence, 1996; Velemínský and Dobisiková, 2005) or determine the probability of familial relationship based on metric similarity (Hanihara et al., 1983; Doi et al., 1985, 1986; Matsumura and Nishimoto, 1996; Shinoda et al., 1998; Shinoda and Kanai, 1999), nonmetric, rare trait co-occurrence (Sjøvold, 1976/1977; Alt and Vach, 1992, 1995a,b; Alt et al., 1995a,b, 1996a,b, 1997), or DNA lineage sequence variation (Shinoda and Kunisada, 1994; Hummel and Herrmann, 1996; Gerstenberger et al., 1999; Shinoda and Kanai, 1999; Scholz et al., 2001; Adachi et al., 2003, 2006; Ricaut et al., 2004a,b; Shimada et al., 2004).

The second type of kinship analysis attempts to identify members of kin groups without reference to spatial structure within larger cemeteries. Although methodological approaches differ, the goal of such analyses is to identify likely relatives within a larger population based primarily on probabilistic modeling of quantitative genetic variation. DNA research has been less concerted (see Stone and Stoneking, 1993; Stone, 1996) and methodological issues have received the greatest attention for nonmetric variation (e.g., Alt and Vach, 1991, 1994, 1995a,b; Alt et al., 1993; Vach and Alt, 1993). Lack of a priori subgroup definition requires more intensive statistical analysis often based on search procedures for blocks of traits and individuals indicative of kinship relationships, or nearest neighbor techniques that test for kin-oriented burial. Case (2003) presented a method based on metric digital pattern profile analysis that performed equally as well as dental discreta.

By far the most common form of kinship analysis uses independent information on spatial structure to examine patterns of within- and between-group variance and affinity. Because group membership is defined a priori, inferential statistical models such as ANOVA and discriminant function analysis are often used to investigate the degree of homogeneity within burial clusters. The null hypothesis is that biological lineages at the family level or above will demonstrate decreased within-group variation, better multivariate discrimination, and significantly different trait frequencies for morphological data classes. Examples of these approaches using craniometric data are provided by Strouhal and Jungwirth (1979), Bartel (1979, 1981), Bentley (1986), and Bondioli et al. (1984, 1986), while nonmetric, frequency-based approaches are presented in Alt et al. (1995b), Howell and Kintigh (1996), and Jacobi (1996, 1997, 2000). The present paper is similar in scope to these approaches because comparisons are drawn between spatial divisions (rows) within the San Luis church.

The majority of previous kinship research used dental morphological, and to a lesser extent cranial nonmetric, variation in a pseudo-cladistic manner. That is, focus upon rare traits requires the increased frequency of some subset of traits by chance within lineages; these traits become definitive of the lineage and act as shared, derived traits. Unfortunately, such approaches are hindered by missing data and the overarching assumption that every family will have a specific configuration of rare traits that co-occur in frequencies greater than that in the total population. Missing data patterns present obvious interpretive concerns. As noted by Rösing, "there is no method which allows kinship reconstruction in any given ancient skeleton pair. Only in the very rare cases of private traits a reconstruction is sufficiently reliable (Rösing, 1986:236)." Therefore, approaches based on metric variation that adopt a phenetic perspective provide greater flexibility.

Although poor preservation at San Luis precluded use of craniometric data, odontometric data are preferred for several reasons. Dental dimensions form early in life and are less susceptible to functional responses throughout the life of an individual and, to lesser extent, ontogenetic noise. Dental data preserve well and are observable in younger individuals allowing consideration of both adult and subadult phenotypic variation concurrently. Finally, despite previous dismissal of metric variation (Rösing, 1986), many have successfully incorporated odontometric data into analyses of kinship and cemetery structure (Hanihara et al., 1983; Bondioli et al., 1984, 1986; Doi et al., 1986; Strouhal, 1992; Matsumura and Nishimoto, 1996; Stojanowski, 2001, 2003a,b, 2005c,d; Corruccini and Shimada, 2002; Adachi et al., 2003). Hanihara et al. (1983) and Doi et al. (1986) compared interindividual similarity profiles among pedigreed Japanese populations and used these data to infer the degree of genetic relatedness among prehistoric burials from the Jomon period. They found that the pedigreed data did produce results in accordance with expectations, in other words, odontometric similarity was indicative of genetic similarity.

Even more compelling are papers that use both genetic and odontometric data in their research design. Adachi et al. (2006) found high correspondence between mtDNA and odontometric profiles in their analysis of a Jomon period double burial (16A and 16B) at the Usu-Moshiri site. Mitochondrial DNA sequence variation indicated lack of maternal relatedness among the dyad, and odontometric data returned low Q-mode correlation coefficients indicative of distant shared ancestry. Corruccini and Shimada (2002) and Corruccini et al. (2002) similarly found a good fit between results obtained from mtDNA and odontological data in their analysis of the elite tomb individuals from Huaca Loro, Peru (Shimada et al., 2004). Adachi et al. (2003) presented results of genetic and odontometric analyses of two different burials from the Usu-Moshiri site (Nos. 3A and 3B). They found mtDNA to be nonspecific as to maternal relationship, but dental data demonstrated large Q-mode correlation coefficients. In this case, the dental data not just confirmed genotypic evidence but complemented it. Therefore, use of dental size as a proxy for genotypic sequence similarity is well established in the kinship literature.

BIOCULTURAL CONTEXT

San Luis was a Franciscan mission located in the present-day city of Tallahassee, Florida. It is one of more than a dozen Spanish mission sites in Florida and Georgia subjected to extensive archaeological and bioarchaeological investigation in the last two decades (McEwan, 1993; Larsen, 1993). In addition to being the largest Apalachee population center, it represents the only post-1650 mission cemetery largely excavated within the Apalachee region. San Luis, one of the most important of the missions, served as the capital of Apalachee Province from 1656 until 1704. At its peak, some 1,400 Apalachee lived under the jurisdiction of this mission, and by the end of the seventeenth century, several hundred Spaniards (including soldiers, friars, and civilians) lived at the site. Its key political and military position, both for the Spanish government and for the indigenous population of the province, led to an integration of Spanish and native cultures during this time period. Archaeological and historical research at San Luis has been aimed at developing a social history of the community, while investigating social institutions (Boyd et al., 1951; Hann, 1988; McEwan, 1991a,b, 1992, 1993, 2000, 2001; Shapiro and McEwan, 1992; Shapiro and Vernon, 1992; Scarry, 1993; Hann and McEwan, 1998; McEwan and Larsen, 2001), technologies (Vernon, 1988; Vernon and Cordell, 1991; Cordell, 2002), plants (Ruhl, 2000), animals (Reitz, 1993), pathogens (Larsen et al., 1996; Larsen and Tung, 2002), and architecture (Shepard, 2003) introduced on the landscape of Spanish Florida.

The San Luis cemetery was identified by Gary Shapiro (1987) and subsequently excavated by two of us (CSL, BGM) (McEwan, 2001; McEwan and Larsen, 2001). The series is represented by a minimum of 210 skeletal individuals, all located within a church structure (Larsen and Tung, 2002) (see Fig. 1). The majority of burials conformed to the Catholic pattern of interment typical of the seventeenth century. Individuals were laid to rest on their backs in shallow burial pits with legs extended, heads oriented east, and feet facing the altar with their hands folded across the chest. A limited number of individuals were interred with religious and secular items, such as rosary beads and utilitarian objects (McEwan, 2001; McEwan and Larsen, 2001).

In mortuary ritual, exceptions to the standard pattern of interment or burial treatment are viewed as an indication of some form of socially relevant distinction (Thomas, 1993). Of the 210 excavated skeletons, seven exhibited such a distinction in the form of coffin burial (individuals 2, 3, 7, 8, 10a, 10b, and 11), all buried near the front of the church near its ritual nucleus, the altar. There was no apparent sex bias in the coffin burials. Four of the individuals were older adults (40+ years), and may have been "elders" of elite status living at San Luis. Individual 8, a 15-year-old, was the only juvenile interred in a coffin. In addition, two of these individuals (Individuals 2 and 3) were buried with their heads oriented west; these two individuals and Individual 1 were the only three individuals in the cemetery buried in this fashion and all were buried in Row 1 right next to each other (see Fig. 1). McEwan (2000) has suggested this unusual burial orientation may reflect a unique relationship between these individuals and the church, such as parish interpreters, sacristans, or members of the Third Order of Franciscans. Individual 3, an adult male, was unique in one other way. The presence of 0.44 caliber lead shot found near the lumbar region of his lower vertebral column suggests that he may have been killed by a gunshot wound (Larsen et al., 1996). Because this individual also had no caries, an isotopic signature suggest-
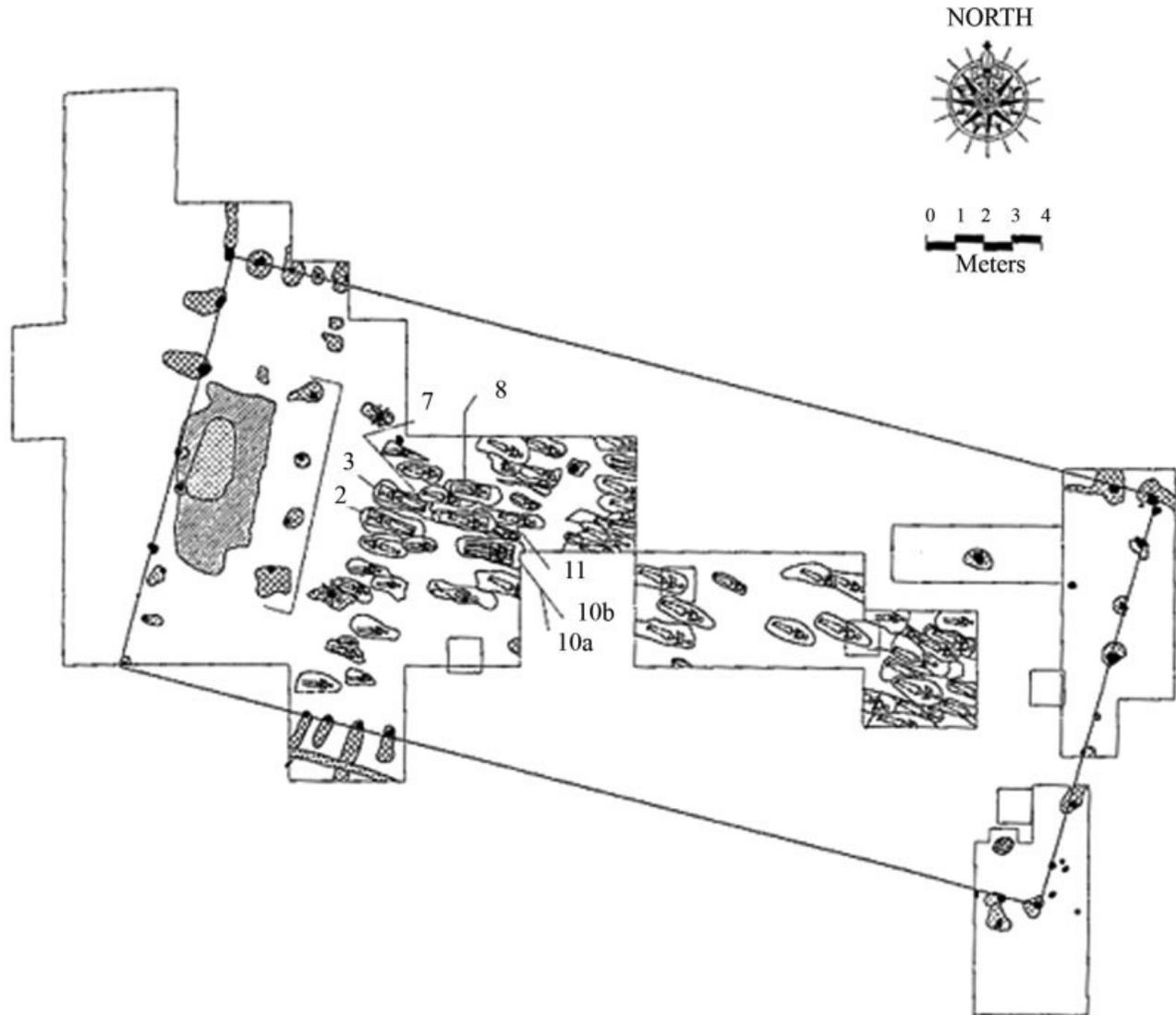
Fig. 1. San Luis de Apalachee cemetery showing location of coffin interments. Seven coffins interments are labeled by burial number. Figure modified after McEwan (2001) Figure 2. (From McEwan BG. Am Anthropol, 2001, 103, 633–644, reproduced by permission.)

ing little maize in his diet (maize was the predominant food consumed in Spanish Florida), and nonshoveled upper central incisors (Larsen et al., 1996, 2001), it has been suggested he may have been either Spanish or *mestizo*.

MATERIALS AND METHODS

Maximum mesiodistal and buccolingual crown dimensions were collected for the adult maxillary and mandibular dentition using the measurement definitions of Moorrees and Reed (1954). Measurements were recorded to the nearest 0.10 mm with Mitutoyo sliding calipers (see Stojanowski, 2001 for details). Data for all teeth, with the exception of third molars, were collected.

Individual tooth dimensions were correlated with estimated age-at-death to determine if attrition was significantly affecting crown size, even though visibly worn tooth measurements were not recorded (see Stojanowski, 2001). Three measurements returned correlation coeffi-

cients significantly different from 0 (UI1MD, $r = -0.379$; UM1BL, $r = 0.395$; LM1BL, $r = 0.376$); however, only one of these was negative (the expected direction if attrition was a causative agent). This measurement (UI1MD) was excluded from all further analyses. Sample sizes for UCBL, UI2BL, UI1BL, LCBL, LI2MD, LI2BL, and LI1BL were too small to be meaningful and these measurements were likewise excluded. Therefore, a maximum of 20 variables were used for analysis.

Univariate data were evaluated for age-dependent size differences using t tests for left and right sides, with the adult cohort populated with individuals estimated to be 18 years or greater. These analyses were based on the total sample raw data matrix with no data imputation. Power analyses were generated using Systat v. 11. Multivariate assessment of age-specific tooth size differences required several preanalysis data treatments. Sides were collapsed into a single value for each tooth type and position by selecting the maximum value if both sides were represented. Missing data imputation was required

to define the variance–covariance matrix and was based on the EM algorithm in Systat v.11. Because many of the variables were poorly represented, and many individuals were represented by only a few measurements, both variable and individual winnowing was required to estimate a nonsingular covariance determinant. The dataset was reduced to 31 of the best preserved individuals. Because imputation could not generate a solution for >4 variables, principal components were generated for four different datasets reflective of functional units of the posterior (P1 and distal) dentition: mandibular mesiodistal, mandibular buccolingual, maxillary mesiodistal, and maxillary buccolingual. For each dataset, imputation was necessary for <25% of the cels and informal comparison of means indicated no significant effects of the imputation procedure. Principal component loadings were used to examine correlations between raw variables, and t tests were used to test for significant differences in factor scores between subadults and adults.

Analysis of the biological spatial structure of the cemetery used those variables not demonstrating evidence for age-dependency. In addition, only buccolingual variables were used because they are less affected by attrition and were better represented in the San Luis sample. As presented below, the maxillary dentition demonstrated less evidence for ontogenetic disturbance and dominates the variable list for analysis of spatial structure: UM2BL, UM1BL, UP2BL, UP1BL, LM1BL. After individual and variable winnowing, 46 individuals were included. Missing values were imputed for this dataset using the EM algorithm in Systat v. 11 for less than 20% of the matrix cels. Analyses were based on the original, nonsize corrected dataset as well as a size-corrected dataset. Size was removed by dividing each measurement value by the arithmetic mean of all variables for that individual after Corruccini (1973) (see discussion of Q-mode size correction in Powell, 1995: 143, 144). Principal components were then extracted from the data matrices and factor loading scores were used for analysis.

Based on previous research at mission Patale (Stojanowski, 2005d), data from San Luis were compared by side and by row using t tests or ANOVA. Side assignments were assessed visually and, although an aisle was not clearly visible, centrally located burials were not preserved well enough for inclusion. Analysis of side structure used both the raw data as well as the nonsize corrected PC factor scores. Overcrowding at San Luis made it difficult to discern the original row structure of burials; however, vagaries of preservation and incomplete excavation allowed delineation of several broad spatial locations. Two different approaches were used. For the first, members of Rows 1–5 were delineated as well as a general mid-section and rear section of the church. This resulted in 7 categorical row variables. For the second, we considered spatial patterning in relationship to front, middle, and rear church burials, where front church burials were simply those previously assigned to Rows 1–5.

In addition to inferential analyses, bivariate plots of PCs 1 and 2 were used to assess visually the biological patterning of burials in relationship to spatial structuring by row or church area. Ninety-five percent confidence intervals for the sample means are reported. To assess the overall relationship between grave and "genetic" distances within the church area, squared Euclidean distances were estimated between individuals based on the imputed data matrix of 5 variables. Clustan v.7 was used to generate the squared Euclidean distan-

ces as well as Euclidean intergrave spatial distances. A Mantel test with 9,999 permutations generated Pearson and Spearman correlation coefficients and corresponding P-values in XLSTAT 2006 (Mantel, 1967).

To assess relationships between individuals buried in coffins, raw data were plotted in two or three dimensions and biological affinity was assessed visually. Burials 2 and 3 (in Row 1) shared three measurements in common (UP1BL, UM1BL, LP1BL). Burials 10a and b (in Row 3 or 4) shared only three measurements in common (LP1MD, LP1BL, LP2BL).

RESULTS
Subadult mortality bias

Table 1 summarizes individual age and sex data for San Luis. Descriptive statistics and hypothesis tests for raw data are presented in Tables 2 and 3 for the maxillary and mandibular arcades, respectively. There is little evidence for age bias in the maxillary dentition. Although adults were larger on average than subadults for five of ten measurements (with one tie) on the left side and for seven of ten measurements on the right side, only one of these comparisons (right M1BL) was significantly different. This result is expected by chance alone. There was no preference for size bias for polar or nonpolar teeth. Power was generally limited; only four and three measurements for left and right sides respectively had power greater than 0.50.

The mandibular dentition displayed a very different pattern. For the left side 10 of 10 measurements were larger on average for adults. Of these, two were significant at the 5% level (M2MD, M2BL) and a third at the 10% level (P2MD). For the right side eight of ten measurements were larger on average for adults. Of these, three were significant at the 5% level (M2MD, M2BL, P1MD) and three were significant at the 10% level (P2MD, P2BL, P1BL). These results exceed random expectation. Significant differences were only noted for nonpolar tooth class members on the left side, while the right produced significant differences for the P1 as well. For both sides, M1 dimensions demonstrated no size biases. For those measurements demonstrating significance at the 0.10 level or below, the percent increases in adult tooth size in comparison to subadult tooth size were as follows: right UM1BL = 7.6%, left LM2MD = 8.5%, left LM2BL = 11.8%, left LP2MD = 10.1%, right LM2MD = 9.8%, right LM2BL = 8.9%, right LP2MD = 6.2%, right LP2BL = 13.6%, right LP1MD = 7.4%, and right LP1BL = 1.8%. The average percent increase for tests significant at the 5% level was 9.3%, whereas the average percent increase for tests at the 10% level was 7.5%.

Average tooth sizes for the side-collapsed dataset are presented in Table 4. Although inferential tests were inappropriate, the pattern of differences supports an excess of tooth material among adults. The average difference across all measurements is 0.28 mm, which is beyond expected measurement error ($\sim$.10 mm). When mean differences are summed, adults demonstrate a 5.29 mm increase. This represents a 3% increase in adults when averaged throughout the dentition. Mandibular teeth alone are 4.1% larger in adults and maxillary teeth are 2.2% larger in adults, on average.

Multivariate analyses produced concordant results. Principal component loadings are presented in Table 5

TABLE 1. *San Luis de Apalachee individuals*

ID	Age	Sex	Pit no.
1	18–28	M	1
2	40+	M	2
3	35–45	M	3
10a	30–45	F	10A
10b	25–35	F	10B
29	25–40	I	29
30	5–9	I	47
32	5–9	I	49
39	A	M	10B
40	18–30	F	56
43	22–26	M	55
44	A	I	57
45	2–4	I	58
50	30–50	F	64
52	I	I	62
53	8–12	I	72
55	30–45	I	66
55.1	A	F	66
57.1	A	I	68
58	12–15	I	69
60a	A	I	71
61	14–18	I	I
62	20–35	I	93
63	12–15	I	93
67	10–14	I	74
68.1	12–18	I	75
70	7–12	I	93
73	8–12	I	77
74	4–7	I	77
75	8–11	I	70
76	8–12	I	70
77	15–25	I	74
80	20–35	I	51
82	A	I	48
83	20–30	I	63
84	25–35	I	63
85	15–20	I	72
87	18–25	I	72
90	25–35	I	80
91	25–40	I	81
94	A	I	82
95	30–45	I	82
102	A	F	66
121	3–7	I	58
125	30–45	F	103
132	1–2	I	94
133	12–15	I	95
134	8–12	I	99
135	4–8	I	99
136	2–4	I	96
137	20–35	F	97
138	A	F	98
138.1	A	I	98
139	25–35	F	100/97
140	25–45	M	98
142	25–35	F	102
143	A	F	100
144	18–30	F	100
145	35–50	F	101
147	18–25	I	102
152	16–24	I	105
153	18–25	I	106
158	11–16	I	109
160	6–10	I	109
166	A	M	111
176	25–35	I	125
178	25–35	F	136
179	12–20	F	111
185	25–35	I	136
186	22–28	I	I

and statistical tests are presented in Table 6. For mandibular mesiodistal dimensions, the first PC represents a general size component and differs significantly between adults and subadults. PC2 (premolar vs. molar size) and PC3 (uninterpetable) do not differ significantly between age cohorts. For mandibular buccolingual dimensions, the first PC also represents a general size component and is significantly different between age cohorts. PC2 (premolar vs. molar size) and PC3 (polar vs. nonpolar tooth size) do not differ significantly. For maxillary mesiodistal dimensions (only performed with 3 variables) no significant differences were noted for PC1, which also reflects overall tooth size. Finally, for maxillary buccolingual dimensions, the PC loadings are similar in correlation pattern to the mandibular buccolingual factor scores. However, none of these PCs were significantly different. Therefore, both univariate and multivariate analyses indicate a significant decrease in subadult tooth size in the mandibular dentition with a strong preference for nonpolar teeth. This is consistent with the field theory of dental development and with previous correlation and heritability research that suggests polar teeth are more ontogenetically stable than more distal members of the tooth class (Potter et al., 1968, 1976, 1983; Alvesalo and Tigerstedt, 1974; Potter and Nance, 1976; Townsend and Brown, 1978a,b; Corruccini and Potter, 1980; Dempsey et al., 1995).

Cemetery structure

Analysis of cemetery structure used both raw variables (UM2BL, UM1BL, UP2BL, UP1BL, LM1BL) and principal components factor scores extracted from these variables. Variable loadings were generated based on the raw data matrix as well as a size-corrected data matrix and are presented in Table 7. For the uncorrected dataset, PC1 represents overall dental size, PC2 represents premolar versus molar size, and PC3 is loading negatively on maxillary polar tooth size. For the size-corrected dataset, PC1 represents premolar versus molar size, PC2 was uninterpretible, and PC3 is loading negatively on maxillary polar tooth size.

Sex segregation by side was not demonstrated by expected differences in tooth size on different sides of the aisle. No significant differences were noted for the raw variables and the pattern of size difference was not consistent as to side (P values: UM2BL = 0.499, UM1BL = 0.350, UP2BL = 0.322, UP1BL = 0.667, LM1BL = 0.770). Principal components (uncorrected) were also nonsignificant when analyzed by side of the aisle (P-values: PC1 = 0.124, PC2 = 0.190, PC3 = 0.114).

Analysis of PC factor scores based on the size-corrected dataset failed to produce significant differences in phenotypic profile by burial row (P-values: PC1 = 0.464, PC2 = 0.081, PC3 = 0.466). However, when the church area was divided into three sections (front, middle, and back), collapsing Rows 1–5 into a single unit in recognition of the commingling and disturbance in this part of the cemetery, the results are slightly different. For the uncorrected dataset, PC1 was significantly different between burial segments (P-value = 0.031) and multiple comparisons indicated that individuals in the front of the church had significantly larger teeth than those in the middle or rear of the church. This could reflect sex or age bias if the high status altar burials tended to be male or if subadults tended to be buried in the rear of the church such as at Santa Catalina de

TABLE 2. Descriptive statistics and t tests for maxillary data by age cohort

| | | Left | | | | | | | | Right | | | | | | |
| | | Sub | | | Adult | | | | | Sub | | | Adult | | | |
	n	Mean	SD	n	Mean	SD	P-value	Power	n	Mean	SD	n	Mean	SD	P-value	Power
M2MD	3	9.27	1.30	9	10.69	0.81	0.19	0.99	5	10.41	0.91	10	10.42	0.66	0.97	0.05
M2BL	3	11.22	0.79	10	10.61	0.28	0.55	0.96	5	10.83	0.71	11	11.45	0.61	0.13	0.75
M1MD	8	10.69	0.87	11	10.53	0.55	0.65	0.27	8	10.03	0.69	15	10.96	0.65	0.28	1.00
M1BL	8	11.06	0.95	12	11.74	0.67	0.11	0.76	10	11.03	0.86	16	11.87	0.55	0.01	0.99
P2MD	5	7.09	0.56	14	7.31	0.41	0.47	0.31	5	7.27	0.53	16	7.34	0.61	0.81	0.07
P2BL	5	9.67	0.78	16	9.67	0.66	0.99	0.00	9	9.69	0.84	16	9.62	0.62	0.81	0.06
P1MD	5	7.18	0.29	11	7.15	0.92	0.92	0.05	6	6.95	0.74	12	6.96	0.35	0.98	0.05
P1BL	6	9.33	1.02	14	8.98	0.84	0.49	0.23	7	9.22	0.78	13	9.30	0.61	0.81	0.07
CMD	2	7.47	1.19	7	8.33	0.35	0.49	0.89	6	8.56	0.93	5	8.53	0.31	0.94	0.05
I2MD	3	7.23	0.57	3	7.28	0.61	0.91	0.05	7	7.52	0.34	2	7.27	0.83	0.74	0.20

TABLE 3. Descriptive statistics and t tests for mandibular data by age cohort

| | | Left | | | | | | | | Right | | | | | | |
| | | Sub | | | Adult | | | | | Sub | | | Adult | | | |
	n	Mean	SD	n	Mean	SD	P-value	Power	n	Mean	SD	n	Mean	SD	P-value	Power
M2MD	4	10.64	1.24	20	11.54	0.78	0.07	0.95	4	10.66	1.12	17	11.71	0.73	0.03	0.99
M2BL	4	9.03	0.79	18	10.10	0.64	0.01	1.00	5	9.59	0.72	18	10.44	0.55	0.00	1.00
M1MD	9	11.48	1.02	16	11.82	0.51	0.37	0.40	8	11.76	0.87	12	11.63	0.58	0.71	0.09
M1BL	9	10.22	0.94	17	10.49	1.02	0.53	0.16	8	10.48	0.77	17	10.66	0.54	0.56	0.17
P2MD	5	7.34	0.88	14	8.08	0.52	0.04	0.95	6	7.27	0.60	15	7.72	0.46	0.07	0.81
P2BL	4	8.01	0.42	14	8.45	0.64	0.21	0.58	6	7.84	0.67	17	8.91	0.59	0.06	1.00
P1MD	7	7.31	0.54	14	7.54	0.48	0.32	0.31	7	6.91	0.70	19	7.42	0.42	0.03	0.95
P1BL	6	7.96	0.60	15	8.09	0.57	0.65	0.11	5	7.36	0.59	20	7.49	0.72	0.08	0.10
CMD	3	7.13	1.45	2	7.28	0.02	0.88	0.06	5	6.94	0.83	4	7.14	0.60	0.70	0.09
I1MD	2	5.78	0.67	3	5.98	0.39	0.69	0.09	2	5.91	0.08	2	5.58	0.22	0.18	0.74

TABLE 4. Sides-combined average tooth size for adults and subadults

	Adult	Subadult	Difference
UM2MD	10.63	9.98	0.65
UM2BL	11.51	10.98	0.53
UM1MD	10.73	10.81	−0.08
UM1BL	11.74	11.05	0.69
UP2MD	7.30	7.26	0.04
UP2BL	9.59	9.65	−0.06
UP1MD	7.17	7.08	0.09
UP1BL	9.21	9.14	0.07
UCMD	8.42	8.56	−0.14
NM2MD	11.61	10.91	0.70
NM2BL	10.30	9.54	0.76
NM1MD	11.76	11.72	0.04
NM1BL	10.64	10.45	0.19
NP2MD	7.90	7.41	0.49
NP2BL	8.41	7.88	0.53
NP1MD	7.49	7.20	0.29
NP1BL	8.10	7.77	0.33
NCMD	7.21	7.15	0.06
NI1MD	5.92	5.81	0.11
Sum	175.64	170.35	5.29
Average	9.24	8.97	0.28

Guale de Santa Maria. PC2 was not significant (*P*-value = 0.614); however, PC3, representing reduced maxillary polar teeth, was significant (*P*-value = 0.016). Multiple comparisons indicated the middle of the church had significantly different proportions of polar and nonpolar teeth in comparison to the front and rear sections.

Analysis of size-corrected principal components produced mixed results. PC1 was marginally not significant (*P*-value = 0.098), PC2 was significantly different (*P*-value = 0.037), and PC3 was not significantly different (*P*-value = 0.924). Unfortunately, the factor loadings for PC2 were not clearly interpretable; however, some component of shape is represented that differed in the mid-church burials.

Bivariate plots of PC1 and PC2 revealed limited evidence for an organized biological structure by church section. Ordination of PCs for the uncorrected dataset is presented in Figure 2. Although front, middle, and rear church burials were not discretely distributed, there does appear to be a clustering tendency among front church burials along PC1 (size). Ninety-five percent CIs for the sample mean support the fact that front church burials (filled circles) tended to have larger teeth than middle (×) or rear (+) church burials. Ordination of PCs for the size-corrected dataset produced similar patterning (see Fig. 3) with front church burials demonstrating a general clustering tendency. In fact, with the exception of one outlier from the front of the church, the distribution of front church burials is relatively discrete. There is no separation of middle and rear church burials from one another. These patterns are not robust when the front church burials are plotted by individual burial row (see Fig. 4) and these figures indicate a general tendency toward kin-structured burial but nothing as organized or systematic as documented at mission Patale (Stojanowski, 2005d).

Matrix correlation analysis produced similar results. Although the Pearson correlation coefficient between burial and Euclidean distance matrices was significantly different from 0 (*P*-value = 0.013), the correlation itself was small and negative ($r = -0.076$). Because two distances are being compared (rather than a distance and a similarity measure), the negative correlation indicates decreasing "genetic distance" with increasing spatial dis-

TABLE 5. Principal components analyses of culled San Luis data set

Var	Mand MD			Mand BL			Max MD			Max BL		
	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2	PC
P1	0.869	−0.236	−0.242	0.863	−0.388	0.299				0.946	0.250	−0.125
P2	0.729	−0.618	0.123	0.898	−0.304	−0.268	0.941	0.163	−0.213	0.932	0.323	0.012
M1	0.823	0.354	0.432	0.861	0.416	0.261	0.874	−0.485	0.036	0.885	−0.408	−0.219
M2	0.801	0.455	−0.294	0.905	0.276	−0.268	0.963	0.284	0.184	0.925	−0.191	0.325
Eigen	2.60	0.77	0.35	3.11	0.49	0.30	2.58	0.34	0.08	3.40	0.37	0.17
% Var	65	19	9	78	12	8	86	11	3	85	9	4

TABLE 6. Principal components analyses t tests by age cohort

PC	n	Mean	SD	n	Mean	SD	P-value
Mandible MD							
PC1	7	−1.01	2.00	24	0.29	0.95	0.021
PC2	7	0.12	1.03	24	1.44	0.80	0.800
PC3	7	−0.34	2.03	24	0.09	1.11	0.462
Manible BL							
PC1	7	−0.96	1.60	24	0.28	1.15	0.029
PC2	7	−0.14	1.12	24	0.04	1.42	0.763
PC3	7	0.24	1.43	24	−0.07	1.34	0.597
Maxilla MD							
PC1	7	−0.03	1.35	24	0.09	0.89	0.358
PC2	7	−0.10	1.38	24	0.03	0.89	0.775
PC3	7	0.77	0.99	24	−0.23	0.90	0.018
Maxilla BL							
PC1	7	−0.47	1.77	24	0.14	1.20	0.306
PC2	7	0.68	1.55	24	−0.19	1.24	0.129
PC3	7	−0.59	2.13	24	0.16	1.01	0.196

TABLE 7. Principal components analyses used for analysis of cemetery structure

Variable	Raw data			Size-corrected		
	PC1	PC2	PC3	PC1	PC2	PC3
UM2BL	0.942	0.154	0.111	0.516	0.410	0.751
UM1BL	0.894	0.323	−0.293	0.805	0.268	−0.518
UP2BL	0.897	−0.371	0.203	−0.825	−0.525	0.156
UP1BL	0.873	−0.423	−0.231	−0.876	0.434	−0.151
LM1BL	0.924	0.290	0.191	0.758	−0.634	0.034
Eigenvalue	4.11	0.53	0.23	2.94	1.11	0.88
% Variance	82	11	5	58	22	18

tance throughout the cemetery. This is not consistent with kin-structured burial. The Spearman correlation was similarly negative and small in magnitude ($r = -0.065$), but significantly different from 0 (P-value = 0.039).

Affinity of coffin burials

The multivariate plot comparing tooth size for Burials 2 and 3 is presented in Figure 5. Both burials are centrally located and very similar in tooth size and shape, at least as measured by these 3 variables. This suggests an Apalachee affinity and is consistent with expectations that high status individuals were closely related. However, individual 10a (also buried in a coffin) was not closely affiliated with either Burial 2 or 3. This suggests that not all individuals associated with coffin burial were closely related. The multivariate plot for Burials 10a and b is presented in Figure 6. As with Burials 2 and 3, these individuals buried in coffins right next to each other in Row 3 or 4 are very similar in dental profile and well within the 95% confidence interval for the sample. If burial in the front of the church and burial within a coffin imply an elite or unique status within the community, then the tooth size data suggest close biological affinity among individuals buried within the same row near the front of the church. Lack of affinity among coffin burials interred within different rows suggests access to elite or unique status areas was not restricted to a single biological lineage.

DISCUSSION
Age-specific tooth size differences

The presence of significantly reduced teeth in subadults is consistent with the hypothesis that those indi-
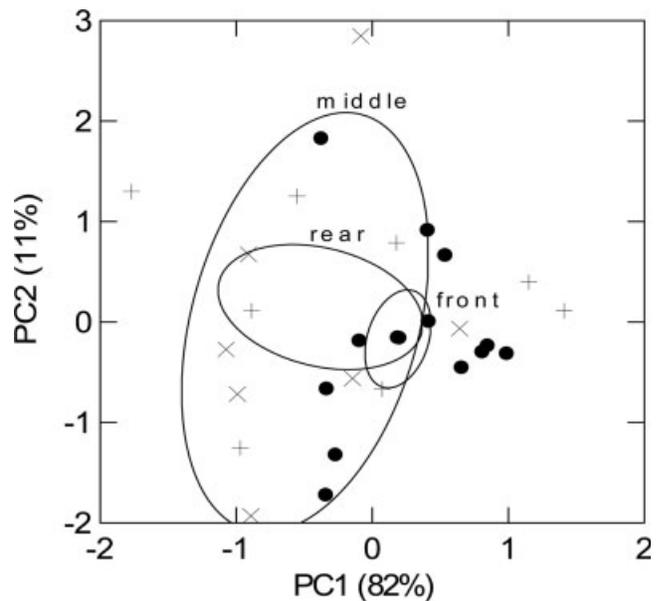

Fig. 2. Ordination of PCs 1 and 2 based on uncorrected dataset: (●) front, (×) middle, (+) rear.

viduals who were most stressed suffered growth disruption and ultimately had a reduced lifespan (see Sagne, 1976; Guagliardo, 1982; Simpson et al., 1990; Larsen and Kelly, 1995). Although tooth size is strongly genetically controlled (Kieser, 1990), under circumstances involving environmental stress—from poor diet, disease, and other negative factors—teeth reduce in size (see overview in Larsen, 1997). This variation is reflected in myriad studies of dental heritability and twin and sibling correlations (see review in Kieser, 1990; Stojanowski, 2005c). It is unlikely that smaller teeth led to reduced longevity, however. Rather, small teeth are symptomatic of environmental perturbation that contributed to smaller teeth and earlier death (McKee, 1989; McKee and Lunz, 1990; Larsen, 1997).
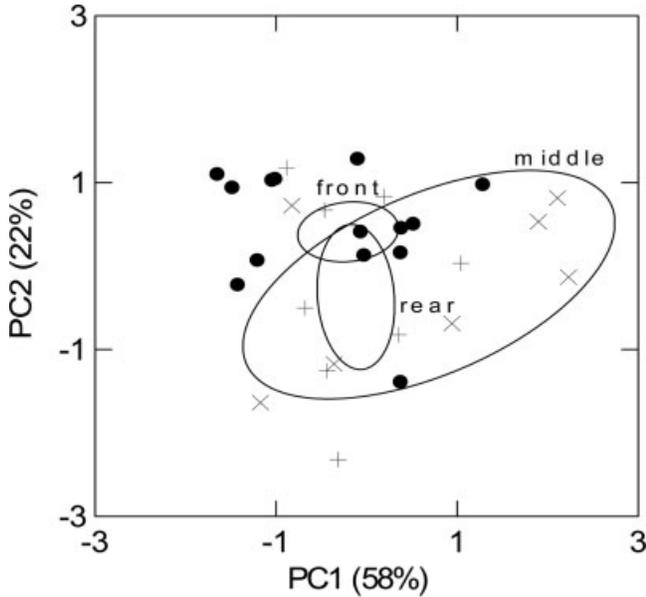
Fig. 3. Ordination of PCs 1 and 2 based on size-corrected dataset: (●) front, (×) middle, (+) rear.
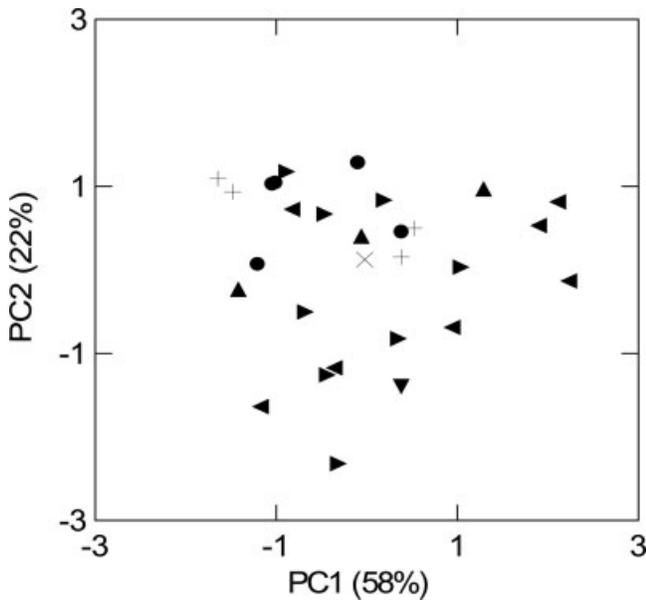

Fig. 4. Ordination of PCs 1 and 2 based on size-corrected dataset. (●) Row 1, (×) Row 2, (+) Row 3, (▲) Row 4, (▼) Row 5, (◄) middle of the church, (►) rear of the church.
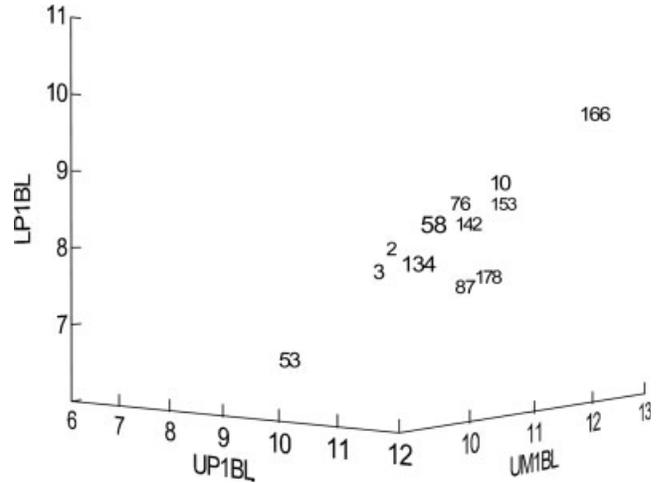

Fig. 5. Multivariate plot of tooth size for UP1BL, UM1BL, and LP1BL presenting phenotypic similarity between coffin burials 2 and 3. Note position in center of distribution and equivalent icon size suggesting close correspondence between these two individuals along all three dimensions.
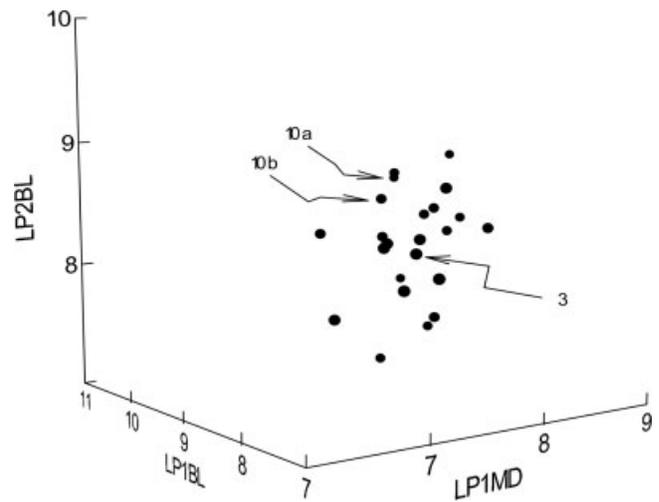

Fig. 6. Multivariate plot of LP1MD, LP1BL and LP2BL presenting phenotypic similarity between coffin burials 10a and 10b. Note the relatively close correspondence between these burials and the lack of correspondence between 10a and b and individual 3 (also a coffin burial).

A health-related interpretation for smaller teeth in subadults at San Luis is consistent with the general decline in quality of life and increase in morbidity and mortality recorded for the missions in Spanish Florida (Larsen, 1983, 1993, 2001; Larsen et al., 2001). Indeed, the same pattern of tooth size difference between juveniles and adults was documented at the mission setting of Santa Catalina de Guale on the Georgia coast (Larsen, 1983; Simpson et al., 1990), which, like San Luis and the other missions, saw declining quality of health and increased mortality and morbidity. Stojanowski (2005d) documented a similar pattern at mission Patale, also an

Apalachee mission, which predates San Luis (Jones et al., 1991).

There is surprisingly little documented evidence of age-specific tooth size differences within a population in the anthropological or clinical literature (see Guagliardo, 1982; Kieser et al., 1985). However, the relationship between diet, morbidity and generalized stress, and the reduction of phenotypic structures is well established from experimental models, studies of secular trends, and clinical data on tooth growth disturbance. In dietary terms, experimental models on rodents suggest high sugar and carbohydrate consumption and diminished calcium consumption can reduce adult tooth size, whereas high fat and protein consumption is associated with increased dental size (Holloway et al., 1961; Lozupone and Favia, 1989; Nakano et al., 1992). Maternal

caffeine consumption has a more complex effect on tooth size (Nakamoto et al., 1985).

A similar dietary interpretation is usually offered to explain secular trends in tooth size between parents and offspring or between different generations within the same population (Hanna et al., 1963; Goose, 1967; Garn et al., 1968a; Lavelle, 1972, 1973; Ebeling et al., 1973; Uemura et al., 1983; Kieser et al., 1987; Suzuki, 1993; Harris et al., 2001). "Westernized" diets (Suzuki, 1993), or in some cases, stabilized diets (Harris et al., 2001) result in improved dental development and corresponding increases in average tooth size through time. Protein, lipid, and total calorie intake seem to increase dental size and result in secular increases after the introduction of different dietary regimens. That tooth size is affected by early childhood illness is attested to by multiple studies of longitudinal growth of children treated for cancer with chemotherapy, irradiation or stem cell transplantation (Kaste et al., 1997; Näsman et al., 1997; Hölttä et al., 2002, 2005).

In addition, nongenetic factors such as microelemental composition, for example, fluoride, boron, and molybdenum (Møller, 1967; Keene, 1971; Wang et al., 2002), and maternal environment, in particular maternal smoking (Heikinnen et al., 1992, 1994, 1997) and low birth weight (Gyulavari, 1966; Fearne and Brook, 1993), have also been associated with dental size reduction. Maternal smoking, alcohol use, and obesity lead to asymmetry in the dentition as well (Kieser, 1992; Kieser et al., 1997). Using mouse models, Larson and Bader (1976) found that between 33 and 70% of phenotypic variance in tooth size was attributable to maternal effects. Garn et al. (1979, 1980) found highly significant effects of maternal environment: hypothyroidism, maternal diabetes, and large birth size are associated with increased tooth size among offspring, whereas maternal hypertension, low birth weight, and decreased crown–heel length were associated with reduced dentitions. That both deciduous and permanent dentitions were affected indicates the early input of hormonal or nutritional variation during gestation has long-term consequences for dental development. Therefore, the inference that the most morbid individuals within a population would exhibit decreased longevity along with reduction in phenotypic variables, including the dentition, is consistent with the corpus of literature.

Two mitigating factors remain to be explained, however. The first is that all variables are not size-biased in subadults, the expectation if maternal effects, with long-term growth consequences, were the cause of dental reduction. In fact, the maxillary dentition shows no signs of size bias while the mandibular favors nonpolar teeth. Kieser et al. (1985) documented a similar pattern of posterior reduction, but in the maxillary dentition. Our results are consistent with the large corpus of data supporting Butler's field theory and the ontogenetic stability of key or polar teeth within the tooth row. Unfortunately, small sample sizes reduced the power of, or completely excluded, many of the anterior dentition analyses; however, the pattern does suggest a differential effect focusing on the posterior dentition with no preference for either mesiodistal or buccolingual diameters. Therefore, the inferential model we propose (morbidity and reduced longevity) must target specific ages. Using the dental formation standards of Gustafson and Koch (1974), the data for crown completion, when both mesiodistal and buccolingual dimensions would have been formed, indi-

cates mean ages of formation of 3 years for M1, 6 years for C and P1, and 7 years for P2 and M2. That the M1 was completely unaffected by the size bias suggests onset of stress after age three that may have been most intense in the 5–7 year age range.

The second unmitigated factor is the uniform increase in tooth size throughout the contact period (Stojanowski, 2001, 2005c). For Apalachee, individuals from the Patale mission have larger teeth on average than late precontact individuals, and individuals at San Luis have larger teeth than those at mission Patale (Stojanowski, 2001, 2005c). Data from the province of Guale revealed a similar pattern (Stojanowski, 2001, 2005c), despite the fact that the coastal (Guale) and inland (Apalachee) populations were experiencing the effects of demographic collapse at different times, with Apalachee lagging by as much as two generations (see Stojanowski, 2005c). Although all populations were experiencing some form of demographic stress, and pathology data generally support such a conclusion, it seems contradictory that tooth size would increase through time under conditions of declining population health, particularly when each population exhibits age-specific mortality bias. To accommodate these divergent signatures (declining health, universal subadult mortality bias, and increasing average tooth size through time), a more complex stress model or a microevolutionary model must be adopted.

One possible explanation is that general body size increased during the mission period and this had an effect on average tooth size within the Apalachee population. Such an explanation was favored by Scott (1979) in an analysis of tooth size trends through 10,000 years along the coast of Peru. Ruff and Larsen (1990, 2001) documented an increase in body size in La Florida populations, which they argue represents access to more calories but from poorer quality foods in at least some of the mission settings. Here body size differs from stature, the former referring to weight or mass not necessarily height, which is poorly correlated with tooth size in humans (Garn and Lewis, 1958; Filipsson and Goldson, 1963; Garn et al., 1967, 1968b; ; Lavelle, 1974, 1977; Henderson and Corruccini, 1976; Fischer-Brandies and Butenandt, 1988 and see Hinton et al., 1980). This is intriguing because some Apalachee had access to European sources of protein, for example, beef, chicken, and pork, on a regular basis during the mission period, particularly after the 1670s (Reitz, 1993) and increased protein and fat intake has been related to secular tooth size (and body size) increases (e.g., Suzuki, 1993). That elites had access to and controlled sumptuary items is consistent with their strategy to maintain power during the colonial period; clothing and foodstuffs were two of the primary means of displaying ostentation (Worth, 2002). However, as a unicausal explanation for both within-population size bias and secular size increase, this interpretation requires the presence of a distinct class system with dietary correlates, but is not inconsistent with the limited stable isotopic data from San Luis (Larsen et al., 1996) demonstrating that a presumed elite Apalachee individual (see below) had very little maize in his diet. This implies that nonelites became increasingly more stressed while elites benefited from their provisioning with Old World sources of protein. Such an explanation, while intuitive, is at odds with other secular trend research, suggesting that it is improvement in the health of the poorest segments of the population that lead to
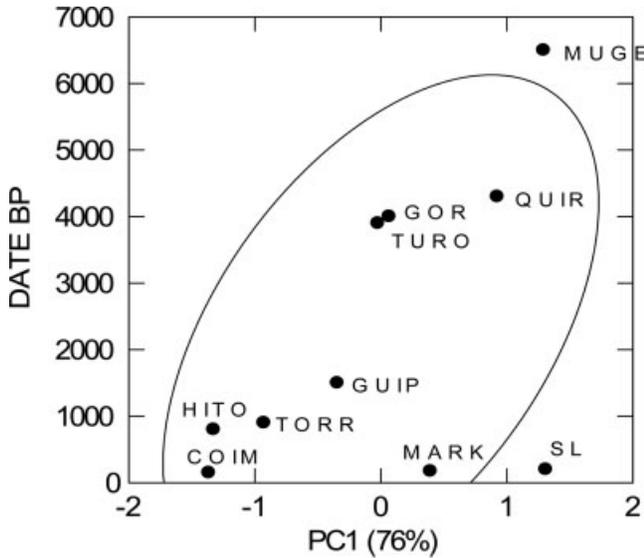
Fig. 7. Plot of PC1 by date bp for a series of Iberian samples and the English cemetery at the St Marks River. San Luis demonstrates the largest loading along PC1, which represents overall dental size. Iberian data are all smaller in tooth size, particularly those that are roughly contemporaneous with San Luis. Note: SL, San Luis; Mark, St Marks cemetery; COIM, Coimbra; HITO, Santa María de Hito; TORR, La Torrecilla; GUIP, Guipúzcoa; GOR, Gorafe; TURO, Túro del Mal Pas; QUIR, San Quirze de Galliners; MUGE, Muge. See Dittmar et al. (1998) for further discussion of Iberian comparative data.
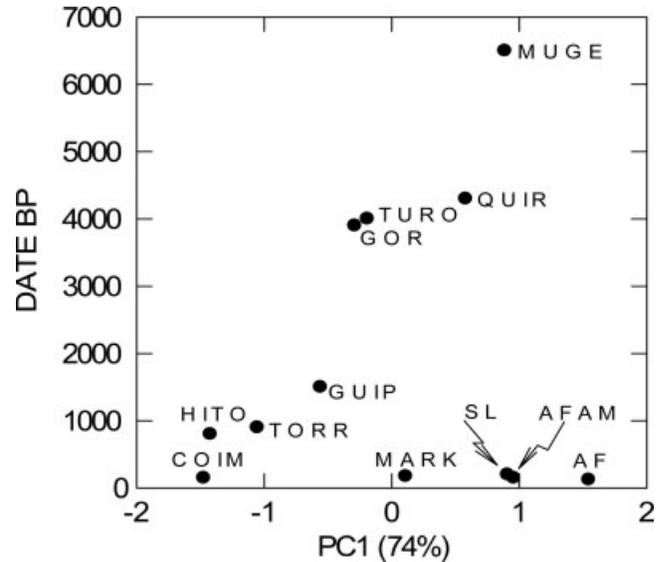
Fig. 8. Plot of PC1 by date bp for a series of Iberian, English, and African or African American samples. Note: SL, San Luis; Mark, St Marks cemetery; COIM, Coimbra; HITO, Santa María de Hito; TORR, La Torrecilla; GUIP, Guipúzcoa; GOR, Gorafe; TURO, Túro del Mal Pas; QUIR, San Quirze de Galliners; MUGE, Muge; AFAM, African American; AF, west African. See Dittmar et al. (1998) for further discussion of Iberian comparative data.

overall average size increases through time (Harris et al., 2001).

The preceding discussion assumes an environmental explanation. However, two microevolutionary interpretations must also be considered: gene flow with populations with larger average tooth size than the Apalachee, or directional selection for larger teeth. The former is not supported by the majority of comparative tooth size data and does not explain the age-specific differences in tooth size. Europeans have, on average, less complex and smaller teeth than Native American populations (Kieser, 1990; Scott and Turner, 2000; Hanihara and Ishida, 2005). Although there exists no contemporary comparative New World Spanish odontometric data, there is comparative data from the Old World Iberian peninsula (6,400–100 yBP; Dittmar et al., 1998) and from an English cemetery located at the mouth of the St. Marks River in Apalachee Province (early 19th century; Dailey et al., 1972, and this study). Mean tooth sizes (excluding UI1MD) for nine sites from Spain and Portugal and the St. Marks cemetery were incorporated into a principal components analysis with data from San Luis. The first principal component, explaining 76% of the variation in the data set, generated all positive loadings for the individual variables and therefore is reflective of overall size within the dentition. Sample factor scores are plotted in Figure 7 by estimated sample age. San Luis has larger teeth on average than any of the comparative samples, including those from the European Mesolithic (the Muge site; Dittmar et al., 1998). This figure nicely illustrates the temporal decrease in average tooth size among European populations (e.g., Frayer, 1977), which further substantiates the expectation that Spaniards living in colonial Florida would have had smaller teeth than their in-

digenous neighbors. Excluding San Luis, the correlation between sample age and PC1 factor score was large ($r = 0.824$) and significantly different from 0 ($P = 0.003$); the result is not robust to the inclusion of San Luis in the linear model ($r = 0.477$, $P = 0.138$). Therefore, Spanish admixture would result in temporal decreases in average tooth size within mission communities. This is clearly not the case in either Apalachee or Guale (Stojanowski, 2001, 2005c).

African slaves were also resident in La Florida and probably would have had larger teeth than the Apalachee (Kieser, 1990; Hanihara and Ishida, 2005) but see Harris and Rathbun (1989). Although comparative African slave data from Spanish Florida is unknown, individuals from the J. Lawrence Angel collection (17th through 19th century African Americans) and from west African populations from the American Museum of Natural History and the National Museum of Natural History were included in the PC summary analysis (see Fig. 8). The first PC represents overall size in the dentition and supports the assumption that Africans, but not necessarily African Americans, had larger teeth on average than the Apalachee at San Luis. It is interesting that African Americans are midway between west African and English populations, reflective of population history and extent of admixture between Europeans and Africans in the New World. However, Harris and Rathbun (1989) reported excessively small tooth sizes in a series of slaves from a colonial South Carolina plantation and they explicitly rejected a stress model such as that proposed here. Therefore, some caution is warranted in interpreting these comparative data. Unfortunately, there is no mention of slave presence at San Luis and it is difficult to determine the extent of admixture between these populations, if it occurred at all. Francisco Pareja's

Confessionario suggests the practice was common, at least in neighboring Timucua villages (Milanich and Sturtevant, 1972).

The second microevolutionary explanation is natural selection. Directional selection for larger tooth size is consistent with both subadult mortality bias and secular trends for increased tooth size and is therefore the most unified explanation. Although natural selection is often overlooked in the clinical and short-term trend literature, others have proposed selection as a mechanism of tooth size change in prehistoric populations, albeit under circumstances involving greater time depth. Sciulli and colleagues (Sciulli et al., 1988; Sciulli and Mahaney, 1991) presented evidence for tooth size selection over several thousand years in the Ohio Archaic based on the phenotypic drift-selection rate tests of Lande (Lande, 1976; Turelli et al., 1988). Although selection was favored over genetic drift, no casual explanation related to fitness benefits of tooth size was offered. Christensen (1998) used a similar methodology and compared tooth size data through 3,000 years of Oaxacan prehistory. He also found evidence for natural selection for dental reduction and favored the role of dental pathology (selective compromise) in effecting dental reduction in a lineage increasingly utilizing a cariogenic diet. Both Hinton et al. (1980) and Perzigian (1975) documented changes in tooth size in Amerind populations over extended time periods crossing thresholds in food procurement strategies. Both papers suggested attrition-related selection was the most likely cause of differential fitness. In all cases, the proposed causal mechanism was inferred but not directly observed in relationship to differential fertility such that selection inferences remain problematic. This is particular apropos for the mission period when we know mortality resulted from epidemic disease, interpersonal violence, raiding and revolts, and onerous labor demands by the colonial government. None of these can be linked to the dentition in a comprehensive model of fertility or mortality, particularly given the 50–100 year time span sampled. Therefore, even if selection were mathematically possible, as an explanatory mechanism it suffers from identifiability of cause deficiencies.

Biological structure of the San Luis cemetery

This analysis documents a different bio-spatial burial pattern at San Luis in comparison to mission Patale (Stojanowski, 2005d). At Patale, the dental data suggested size (sex) segregation by side of the aisle and burial rows associated with specific family groups. That the size differences by side were apparent even within-row suggested the early contact period Apalachee were maintaining kin-specific burial rows in which the sexes were segregated (Stojanowski, 2005d). Family plots have been identified in Maya Spanish colonial missions (Jacobi, 1997, 2000) and are consistent with cultural practices in other Iberian contexts, for example the use of sepulturies in Basque cemeteries (see Douglass, 1969). Although perfect correspondence between phenotype and burial row was not expected, and postmarital residence and resulting co-burial of affinal kin precludes this result theoretically, the overall interpretation of burial structure at San Luis was one of disorder. This contrasts with Patale's cemetery structure (Stojanowski, 2005d) and reflects the different social and political climate at the time each death assemblage was accumulating. After 1650, the Apalachee came under increasing pressure

from the Spanish colonial government to participate fully in the La Florida economy. Repartimiento labor requirements increased, contact with alien populations intensified, and the rate of demographic collapse accelerated. This difference is most clearly represented by the extreme overcrowding at San Luis, which was not present at Patale (Jones et al., 1991). Using estimated population sizes and dates of mission use, Stojanowski (2005c:122) calculated the rate of burial as a percentage of the estimated living population of each mission. The rate of burial at San Luis (1.4%) was much higher than at Patale (0.8%), which reflects escalating mortality during the late 17th century and is consistent with historical accounts of epidemics affecting the province at this time (Hann, 1988:175). Multiple sources of bioarchaeological data are reflective of increased morbidity and mortality at San Luis including burial density, presence of secondary and commingled burials, and frequencies of nonspecific stress markers (Larsen et al., 2001). Patale demonstrated patterns consistent with a healthier, less demographically stressed population (Storey, 1986; Larsen, 2001; Larsen and Tung, 2002). That some distinctions were evident in the San Luis PC factor plots in the three, but not seven, group model may imply that kin-structuring was practiced at San Luis initially, perhaps briefly after the mission was founded, but was abandoned in the wake of epidemic disease. Burial in the *campo santo* superceded individual family ownership of specific grave locations.

On the other hand, the front church burials demonstrated reduced homogeneity and some degree of distinction in comparison to middle and rear church burials. This result is consistent with the analysis of biological affinity of individuals buried in coffins near the altar. The combination of this atypical mortuary treatment, grave placement, and close biological affinity of the burials near the church altar suggest that rank had its privileges even in death. A relationship between rank and burial placement is also suggested by the abundance of grave goods concentrated in this area (McEwan, 2001:640). High status altar burials have been documented in at least one other Florida mission (Larsen, 1993) and in Maya contexts (Jacobi, 1997, 2000), including specific use of coffin burials (Miller and Farrish, 1979; Saul, 1982; Larsen, 1993). Therefore, our findings from Spanish Florida indicate some consistency in Spanish New World Catholic mortuary rites.

Although within-row coffin interments were phenotypically similar, there was no evidence of affinity between individuals buried in coffins in different rows. This implies that these status markers (altar proximity and coffin interment), which may represent Apalachee elite or individuals with more intimate church relationships, may not have been restricted to the narrowest subset of high-ranking lineages. Burial placement for elites may have been ascribed within row (close relatives of elite standing were buried in similar rows), but achieved in the general orientation of graves within the church (somewhere near the altar). Confirmation that Individual 3 was phenotypically typical of the Apalachee indicates the embracing of an acculturated lifestyle among some San Luis elites. This individual had no caries, an isotopic signature indicative of limited maize consumption and did not escape an apparently violent death via gunshot wound (Larsen et al., 1996). The triangulation of multiple data sources suggests this presumed elite lived and died as an ethnic Spaniard.

CONCLUSIONS

Bioarchaeological analysis of phenotypic variation at mission San Luis revealed some marked consistencies and differences with contemporaneous and pene-contemporaneous mission populations throughout La Florida. Comparison of subadult and adult tooth size produced a familiar pattern of subadult mortality bias, which may reflect ontogenetic disturbance or directional selection for larger tooth size. This pattern was previously documented at both mission Patale and Santa Catalina de Guale. Although coffin burials did appear to represent the contiguous burial of closely related individuals near the altar end of the church, the overall structure of graves at San Luis was less patterned than that previously documented at mission Patale. There were no significant side or row differences in dental profile and bivariate plots failed to produce a recognizable spatial pattern. The "ideal" mortuary program present at Patale, with orderly kin-structured rows and sex segregation by side, so quickly embraced by indigenous converts in Spanish Florida, was apparently abandoned by the residents of San Luis. This likely reflects the urgency of the situation they found themselves in, with escalating morbidity and mortality and burgeoning conflict with populations external to the Spanish system. That elites maintained burial spatial contiguity is testament to their elevated status both before and after death.

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