

# Biodistance Analysis of the Moche Sacrificial Victims from Huaca de la Luna Plaza 3C: Matrix Method Test of Their Origins

Richard C. Sutter<sup>1\*</sup> and John W. Verano<sup>2</sup>

<sup>1</sup>Department of Anthropology, Indiana University–Purdue University, Fort Wayne, IN 46805

<sup>2</sup>Department of Anthropology, Tulane University, New Orleans, LA 70118

**KEY WORDS** epigenetic dental traits; human sacrifice; bioarchaeology; northern Peru

**ABSTRACT** The purpose of this study is to test two competing models regarding the origins of Early Intermediate Period (AD 200–750) sacrificial victims from the Huacas de Moche site using the matrix correlation method. The first model posits the sacrificial victims represent local elites who lost competitions in ritual battles with one another, while the other model suggests the victims were nonlocal warriors captured during warfare with nearby polities. We estimate biodistances for sacrificial victims from Huaca de la Luna Plaza 3C (AD 300–550) with eight previously reported samples from the north coast of Peru using both the mean measure of divergence (MMD) and Mahalanobis' distance ( $d^2$ ). Hypothetical matrices are developed based upon the assumptions of each of the two competing models regarding the origins of

Moche sacrificial victims. When the MMD matrix is compared to the two hypothetical matrices using a partial-Mantel test (Smouse et al.: *Syst Zool* 35 (1986) 627–632), the ritual combat model (i.e. local origins) has a low and nonsignificant correlation ( $r = 0.134$ ,  $P = 0.163$ ), while the nonlocal origins model is highly correlated and significant ( $r = 0.688$ ,  $P = 0.001$ ). Comparisons of the  $d^2$  results and the two hypothetical matrices also produced low and nonsignificant correlation for the ritual combat model ( $r = 0.210$ ,  $P = 0.212$ ), while producing a higher and statistically significant result with the nonlocal origins model ( $r = 0.676$ ,  $P = 0.002$ ). We suggest that the Moche sacrificial victims represent nonlocal warriors captured in territorial combat with nearby competing polities. *Am J Phys Anthropol* 132:193–206, 2007. ©2006 Wiley-Liss, Inc.

The purpose of this study is to report and compare epigenetic tooth cusp and root traits for Moche human sacrificial victims from Huaca de la Luna Plaza 3C with those previously reported for other prehistoric north coast populations (Sutter and Cortez, 2005) in order to test competing models regarding the victims' origins. For more than 25 years, scholars have intensively researched Moche sacrifice through studying both their realistic iconography (Hocquenghem, 1987; Alva and Donnan, 1993; Donnan and McClelland, 1999; Castillo, 2000; Bourget, 2001; Donnan, 1978, 2004) and, more recently, their osteological remains (Cordy-Collins, 2001; Verano, 2001a,b,c; Shimada et al., 2005; Sutter and Cortez, 2005). Despite this research, a number of questions regarding the nature of Moche sacrifice remain unresolved: Why and under what circumstances did the Moche practice human sacrifice? Who was being sacrificed by the Moche? Were the sacrificial victims Moche or from other competing polities? While some scholars have relied heavily upon ethnographic and ethnohistoric analogies to interpret Moche iconographic depictions of one-on-one combat, others have drawn more extensively from bioarchaeological data and mortuary theory (Verano, 2001a,b,c; Sutter and Cortez, 2005).

The Moche was a mixed economy, socially stratified society that dominated the north coast of Peru during the Early Intermediate Period and early Middle Horizon (AD 200–750) (Fig. 1). Although debate regarding the emergence and sociopolitical organization of the Moche exists, it is widely recognized that the Moche developed in some of the north coast valleys from the pre-existing Gallinazo, and that there were at least two separate spheres of

Moche influence: one in the north which has been characterized as a loose confederation of culturally similar polities (Shimada, 1994), and another in the south, often described as being characterized as militaristic and expansionist in nature (Conklin and Moseley, 1988; Wilson, 1988; Shimada, 1994; Billman, 1999; Donnan, 1997, 2001, 2004). For the southern sphere of influence, it is generally accepted that the seat of influence was the Huacas de Moche (Moche) site located 6 km inland in the Moche Valley itself. Using a five phase relative chronology largely based upon a ceramic sequence, most archaeologists posit that the southern Moche emerged during Moche I and II and began to expand outside of the Moche Valley during Moche III and IV, followed by environmental degradation and subsequent collapse during Moche V (Shimada et al., 1991; Billman, 1999).

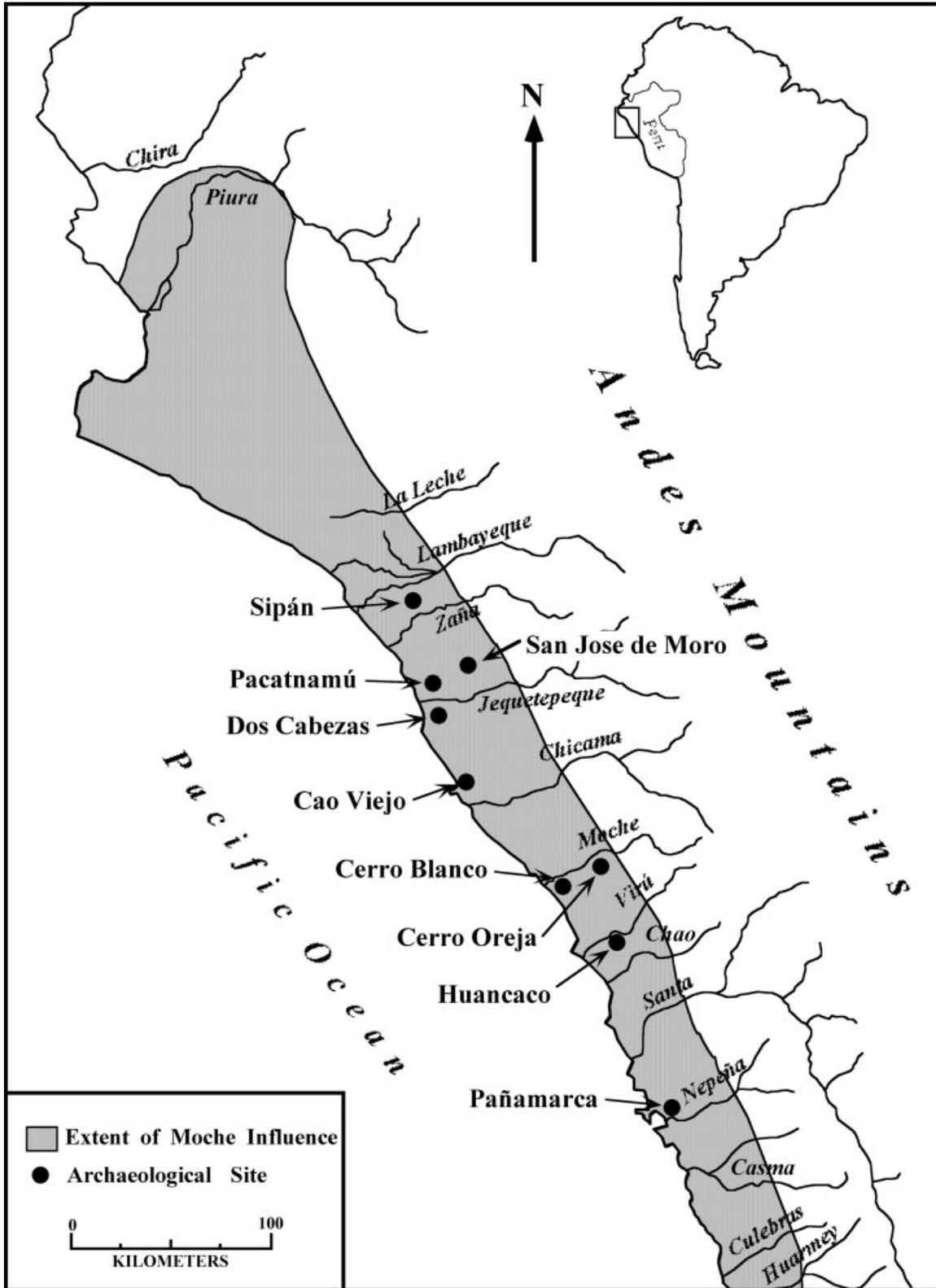
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\*Correspondence to: Richard C. Sutter, Department of Anthropology, Indiana University–Purdue University, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805. E-mail: sutterterr@ipfw.edu

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**Fig. 1.** Selected archaeological sites within the region of study: The north coast of Perú (used by permission from the University of Chicago Press, *Current Anthropology* 46(4):521–549).

A number of competing models have been proposed to explain Moche human sacrifice, largely based upon iconographic interpretations and ethnohistoric analogies.

These models, discussed in greater detail in Sutter and Cortez (2005), include 1) staged ritual one-on-one combat among elite Moche warriors with the losers of these bat-

bles being sacrificed during a bloodletting sacrificial ceremony (Hocquenghem, 1987; Alva and Donnan, 1993; Topic and Topic, 1997; Castillo, 2000; Bourget, 2001; Donnan, 2004, 2005; Shimada et al., 2005); 2) the killing of non-Moche enemy combatants (Proulx, 1982; Wilson, 1988: 66); and 3) the sacrifice of nonlocal Moche captured in combat with competing Moche polities located in nearby valleys (Kutscher, 1955; Schaedel, 1972; Verano, 2001a,b,c; Sutter and Cortez, 2005). Discovering which of these models best explains who the Moche sacrificial victims were has the potential to change our current understanding of the emergence and expansion of the southern Moche polity.

### Previous research on the physical remains of Moche sacrificial victims

Until recently, much of the archaeological evidence for Moche sacrifice was in the form of attendant burials interred with elites (Strong and Evans, 1952; Ubbelohde-Doering, 1983; Alva and Donnan, 1993). While Cordy-Collins (2001) reports 13 severed skulls located in a room at the site Dos Cabezas located in the Jequetepeque Valley, most of the recent attention on Moche sacrificial victims has focused on those from the pyramid Huaca de la Luna Plaza 3A at the Huacas de Moche site. Bourget's (1997, 2001) excavation of these remains uncovered at least six discrete events containing ~75 individuals dating to the terminal occupation of the site. Some of the skeletal remains were imbedded in mud, suggesting that victims were sacrificed during periods of torrential rain; others were found in layers of windblown sand, indicating that they were deposited during more typical dry conditions.

Analysis of the osteological remains from Huaca de la Luna Plaza 3A indicates that victims were killed by slitting the throat, correlating well with Moche artistic depictions of prisoner sacrifice (Verano, 2001a,b,c). The victims were healthy males between 15 and 35 years of age. Many exhibited previously healed injuries consistent with combat, suggesting that they may have been warriors with substantial prior experience. Some also showed fractures of ribs, scapulae, and ulnae that were in the early stages of healing at the time of death: apparently wounds sustained in combat or following capture. These healing injuries indicate that some period of time elapsed between their capture and eventual sacrifice at the Huacas de Moche pyramid Huaca de la Luna. Treatment of the victims' remains, which were left to decompose on the surface rather than being given proper burial, suggests a lack of respect. This denial of ritual burial is more consistent with treatment of enemies than with the sacrifice of local elite warriors who lost ritual battles (Verano, 2001a,b,c).

Ongoing excavations within the plaza at Cao Viejo, a coastal site located on a natural terrace on the north side of the Chicama Valley, Peru, have also uncovered at least two adult male sacrificial victims who also exhibit similar perimortem treatment and manner of disposal as those documented at Huaca de la Luna Plaza 3A (Verano, 2005). The pattern that emerges from the Dos Cabezas, Cao Viejo, and Huacas de Moche sites is that the capture, torture, sacrifice, dismemberment, and informal disposal of adult male warriors was not an isolated or anomalous event as some have suggested (Bawden, 2005), but instead represent a broader cultural practice performed at some Moche sites.

Investigations on the genetic affinities of the Moche sacrificial victims are in the beginning stages. Sutter and Cortez's (2005) biodistance comparisons of epigenetic dental traits for the Huaca de la Luna Plaza 3A remains with those from seven other north coast mortuary samples indicates the Plaza 3A victims did not originate from the local population and were the most distinct sample analyzed in their study. A subsequent study by Sutter (in press a) that examined the same eight aforementioned mortuary samples in addition to an Andean Paleoindian sample and two late Archaic period samples using a broader suite of dental traits confirmed that among the eight Early Intermediate Period samples, the sacrificial victims from Huaca de la Luna Plaza 3A were outliers.

However, Shinoda et al. (2002) and subsequently Shimada et al. (2005) report mitochondrial DNA (mtDNA) data for both Moche and post-Moche Sicán skeletal remains from a number of north coast sites. Shimada et al. (2005) report that all 45 human remains from the Moche Valley (i.e., Huacas de Moche's urban sector, elite platform burials, and sacrificial victims from Huaca de la Luna Plaza 3A) are characterized by Haplogroup A, while Moche and post-Moche Sicán remains from valleys north of the Moche Valley exhibit far more Haplogroup variability. Based upon their results, these scholars contend that the victims from Huaca de la Luna Plaza 3A were drawn from the local population and do not represent foreign warriors. However, Shimada's (2004) preliminary results for five Moche and four Gallinazo individuals from the Santa Valley indicate that they too belonged to mtDNA Haplogroup A. This, Shimada tentatively suggests, indicates that the southern Moche and Gallinazo exhibit very little genetic variability. Based upon these preliminary results Shimada posits that south of the Chicama Valley, prehistoric north coast populations of coastal Peru may have been a coherent breeding population that went through a genetic bottleneck at some time in their recent past. Within the context of an Andes-wide survey of dental trait variability using 44 prehistoric mortuary samples, Sutter (in press b) also concludes that all Early Intermediate Period samples he examined for the north coast of Peru represent a relatively coherent breeding population.

### Location and context of the Huaca de la Luna Plaza 3C victims

Huaca de la Luna Plaza 3C is located at the Huacas de Moche site, southeast of the principal platform of the Huaca de la Luna Platform I (Fig. 2). It is one of a number of courtyards, small enclosures, and corridors that lie between Platform I and the west flank of Cerro Blanco (Tufinio, in press a; Uceda, 2001; Uceda and Tufinio, 2003). The remains of sacrificial victims and fragments of ceramic prisoner vessels were found in a small enclosed patio in the eastern half of Plaza 3C, which seems to have functioned as a repository for these materials (Tufinio, in press b).

The potential importance and function of Plaza 3C first became evident in 1996, when a test pit placed in the southeast corner of Plaza 3C by Orbegoso (1998) encountered a deposit of partially articulated human skeletal remains with abundant cut marks, suggesting that they were the remains of sacrificial victims (Verano, 1998). To more fully document their context, area excavations of Plaza 3C were conducted from 1999 to 2001 under the direction of Moises Tufinio and Verano (Verano, 2001b,c, in press; Verano and Tufinio, in press).

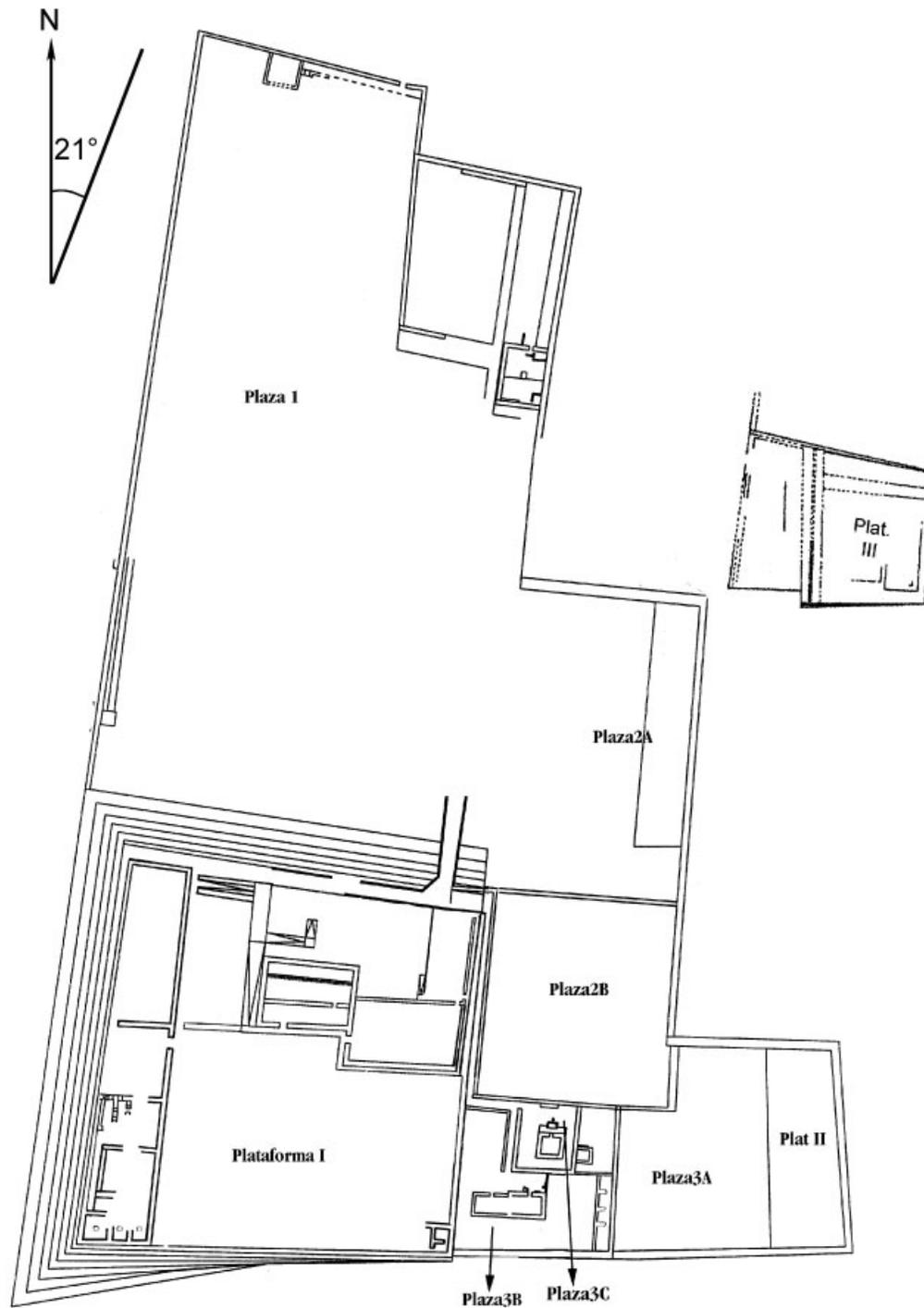


Fig. 2. Plan view of Huaca de la Luna.

These excavations recovered the remains of a minimum of 61 individuals, including complete and partial skeletons, articulated limbs, trunks, hands, feet, and hundreds of isolated bones, accompanied by broken ceramic vessels in the form of seated prisoners (Fig. 3).

The demographic composition of the Plaza 3C remains is similar to that of Plaza 3A, consisting exclusively of adolescent and young adult males. The manner in which victims were killed was the same (slitting of the throat),

and there are other similarities, such as fractures of the forearm, scapula, and ribs that were in the early stages of healing at the time of death. Apparently these were wounds received in combat or following capture, and indicate that captives were kept for a period of at least several weeks before being sacrificed at the Huaca de la Luna (Verano, 2001a,b,c).

A construction sequence for the Huaca de la Luna has been determined from extensive archaeological excava-



**Fig. 3.** Adult male human sacrifices from Huaca de la Luna Plaza 3C (photo by John Verano).

tions conducted over more than a decade by the Proyecto Arqueológico Huaca de la Luna (Uceda, 2001; Uceda and Tufinio, 2003). Plaza 3A corresponds to the last construction phase of the *huaca*, dating to the mid-seventh century A.D. Plaza 3C was constructed and used during earlier phases, and had been buried and built over by the time of construction of Plaza 3A. Plaza 3C itself shows two distinct periods of use, demarcated by a well-prepared clay floor that divides the plaza into two distinct construction phases. Remains of sacrificial victims were found both below and above the floor. Calibrated radiocarbon dates of rope fragments and insect remains directly associated with sacrificial victims above and below the floor suggest that construction and use of Plaza 3C extended over more than three centuries, from c. A.D. 200 to c. AD 550 (Verano, 2003). Combined with the evidence from Plaza 3A, it is now clear that the sacrifice of captives was a deeply rooted tradition at the Huaca de la Luna, intimately linked to the ritual function of the architectural complex.

## MATERIALS AND METHODS

This study examines epigenetic tooth root and cusp trait variability for the Huaca de la Luna Plaza 3C sample and compares it to data for eight previously reported Early Intermediate Period and early Middle Horizon (AD 200–750) samples from the north coast of Peru (Table 1). The composition and chronological associations of these samples is described in greater detail in Sutter and Cortez (2005). The samples used here include 31 individuals from Moche cemetery H45CM1 at Pacatnamú, located in the Jequetepeque Valley. Four mortuary samples come from the Moche Valley site Cerro Oreja located 61 km inland. The Cerro Oreja samples include 65 Early Horizon (800–200 BC) Salinar Phase individuals, 128 from the stratigraphically determined early Gallinazo occupation of the site, 93 from the mid-

dle Gallinazo occupation, and 76 individuals from the most recent Gallinazo occupation of Cerro Oreja. For the Huacas de Moche site, 37 higher status individuals from the urban sector were examined in addition to 63 individuals from burials at Huaca de la Luna Platforms I and II. Sacrificial remains examined include 42 specimens from Huaca de la Luna Plaza 3A, while—reported here for the first time—24 victims' dentitions were examined from Huaca de la Luna Plaza 3C.

Importantly, for purposes of comparability with a previous study by one of us, the dentitions of individuals recovered from Huaca de la Luna Plaza 3C were analyzed using the same procedures in Sutter and Cortez (2005). Huaca de la Luna Plaza 3C dentitions were visually examined and scored for the full battery of tooth cusp and root traits provided by the ASU Dental Anthropology System using standardized plaques and descriptions (Turner et al., 1991). In the context of the previous study by Sutter and Cortez (2005), only seven dental traits were found to be free of significant inter-trait correlations and nonsignificant associations with sex, while retaining an adequate sample size (i.e. >10) for at least 25% of the mortuary samples. For these reasons and for purposes of comparability with the previous study, the same seven dental trait frequencies are used in this study. For this study, we examined the matrix of tetrachoric correlations among the seven traits we use. All correlations were low (>0.18) and nonsignificant.

In order to make dental trait scores reported here comparable to those reported in other studies, teeth were scored according to the 'individual count' method described by Turner and Scott (1977). In cases where an individual exhibited asymmetry in the expression of a given trait the greatest level of expression is used. Each trait's frequency was arcsine-transformed according to recommendations made by Green and Myers-Suchey (1976). Arcsine-transformed dental trait frequencies were then used to estimate phenetic relatedness among

TABLE 1. Nine prehistoric mortuary samples from the north coast of Peru examined by this study

Mortuary sample	Abbrev	Sample size	Location of site	Coastal distance	Time period
Cerro Oreja-Salinar	CO-SAL	65	Moche, Coastal Valley	61 km	Early-Early Intermediate ~100 BC
Cerro Oreja-Gallinazo 1	CO-G1	128	Moche, Coastal Valley	61 km	Early-Early Intermediate ~AD 1
Cerro Oreja-Gallinazo 2	CO-G2	93	Moche, Coastal Valley	61 km	Middle-Early Intermediate ~AD 100
Cerro Oreja-Gallinazo 3	CO-G3	76	Moche, Coastal Valley	61 km	Middle-Early Intermediate ~AD 200
Urban Sector-Huacas de Moche	HM-US	37	Moche, Coastal Valley	6 km	Late-Early Intermediate ~600 AD
Platforms I & II-Huacas de la Luna	HLL-PLATS	63	Moche, Coastal Valley	6 km	Late-Early Intermediate ~600 AD
Pacatnamú-H45CM1	PACAT	31	Jequetepeque, Coast	1 km	Late-Early Intermediate ~600 AD
Plaza 3A Sacrificial Victims-Huacas de la Luna	HLL-P3A	42	Moche, Coastal Valley	6 km	Late-Early Intermediate ~600 AD
Plaza 3C Sacrificial Victims-Huacas de la Luna	HLL-P3C	24	Moche, Coastal Valley	6 km	Late-Early Intermediate ~200-550 AD

the mortuary samples using C.A.B. Smith’s mean measure of divergence (MMD) according to the formula:

$$MMD = \frac{\sum_{i=1}^r (\theta_{1i} - \theta_{2i})^2 - [1/(n_{1i} + 1/2) + 1/(n_{2i} + 1/2)]}{r}$$

where  $r$  is the number of traits used in the comparison,  $\theta_{1i}$  and  $\theta_{2i}$  are the transformed frequencies in radians of the  $i$ th trait in the two groups being compared, and  $n_{1i}$  and  $n_{2i}$  are the numbers of individuals scored for the  $i$ th trait in the two groups.

It should be noted that the MMD can produce negative values (Harris and Sjøvold, 2004). This occurs when there is very little or no difference in the arcsine-transformed frequencies across a number of traits for the populations being compared. In such cases, the estimated variance of the measure of distance for a given trait (i.e., the bracketed term in the numerator of the MMD equation) will be subtracted from a zero or near-zero value for the squared difference in the arcsine-transformed trait frequencies. While negative MMD values are not meaningful in a statistical sense, they do indicate that the populations being compared are similar for the traits being considered. According to recommended analysis of the MMD (Harris and Sjøvold, 2004), negative MMD values were changed to zero prior to subsequent multivariate analyses of the biodistance matrix.

The variance for MMD values was calculated using the equation:

$$Var_{MMD} = \frac{2}{r^2} \sum_{i=1}^r (1/(n_{1i} + 1/2) + 1/(n_{2i} + 1/2))^2$$

Once the variance of the MMD is found, the standard deviation of the MMD can be calculated using the equation:

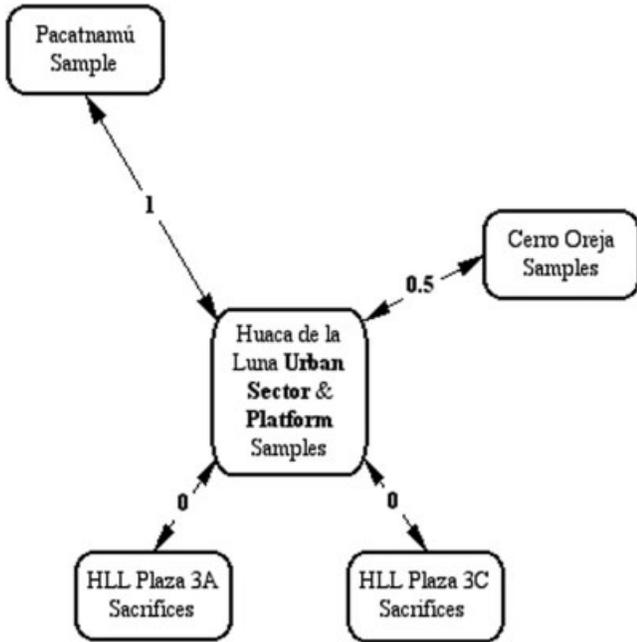
$$sd_{MMD} = \sqrt{Var_{MMD}}$$

Although the primary goal of this study is not to determine the significance of biodistances among sample comparisons, but rather to use biodistance measures to test competing models regarding the origins of the Moche sacrificial victims, the MMD is significant at approximately the 0.05 level when it exceeds its standard deviation by 2.00 (Harris and Sjøvold, 2004).

We also calculated the Mahalanobis’ generalized distance ( $d^2$ ) for binary epigenetic traits (Konigsberg, 1990) to estimate the biodistance between two mortuary sites  $i$  and  $j$ . This distance is determined using the following equation:

$$d_{ij}^2 = (z_{ik} - z_{jk})' T^{-1} (z_{ik} - z_{jk}),$$

where, as Konigsberg (1990:60) explains, “ $z_{ik}$  represents the threshold value corresponding to a trait frequency of  $p_{ik}$  for trait  $k$  in site  $i$ ;  $z_{jk}$  is the threshold value for trait  $k$  in site  $j$ ; and  $T$  is a pooled tetrachoric correlation matrix between the  $k$  traits.” The Mahalanobis’ generalized distance has been demonstrated to represent the minimum genetic distance between two groups being compared (Williams-Blangero and Blangero, 1989). The significance of each  $d^2$  value is determined using the follow-



**Fig. 4.** Illustration of model matrix values for the ritual combat (tinkuy) model for the origins of the Moche sacrificial victims from Huaca de la Luna. This model posits that the Moche sacrificial victims represent local warriors who participated in staged battles for blood-sacrifice ceremonies. Accordingly, the victims were from the Huacas de Moche site and represent the losers of these staged battles.

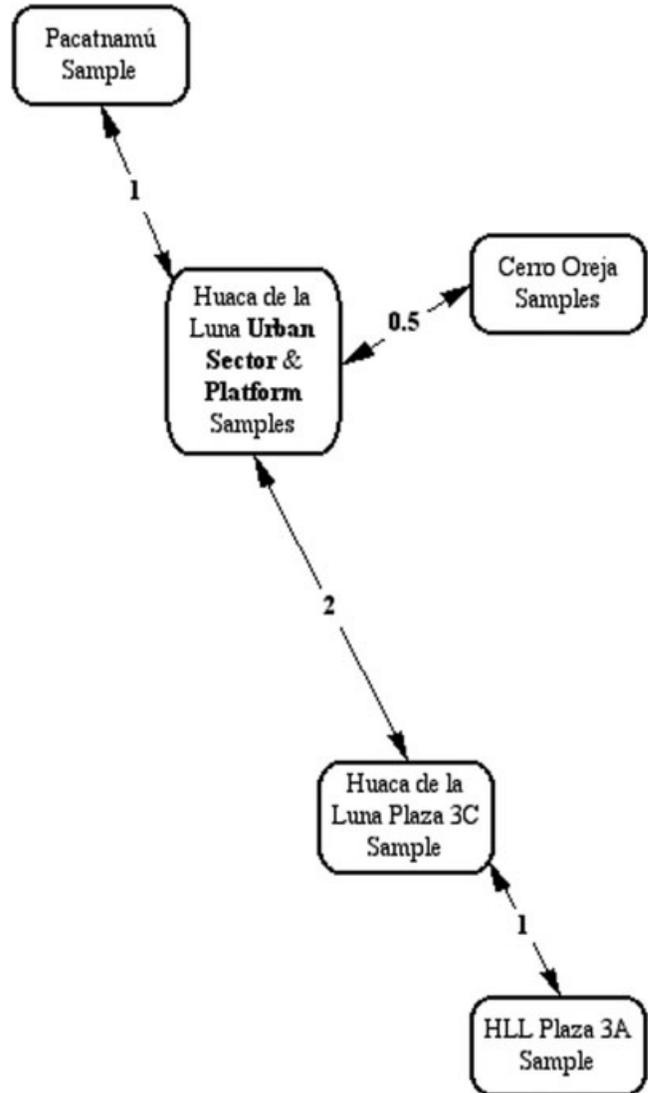
ing equation provided by Droessler (1981):

$$F = \frac{T - g - p + 1}{p} \cdot \frac{N_1 N_2}{(N_1 + N_2)(T - g)} \cdot d^2$$

where  $T$  represents the total number of individuals examined across all samples,  $g$  is the number of mortuary samples,  $p$  is the number of variables, and  $N_1$  and  $N_2$  represent the number of individuals examined for each sample during the calculation of  $d^2$ . For this equation, the  $F$  statistic has  $p$  and  $(T - g - p + 1)$  degrees of freedom. Because the number of observations made for each trait within any given sample tends to differ for the nonmetric dental traits examined, we used the nearest whole number for the average number of observations across traits for a given sample (Konigsberg et al., 1993).

Both the MMD and Mahalanobis'  $d^2$  matrices were analyzed using both hierarchical clustering procedures (Aldenderfer and Blashfield, 1984) and nonmetric multidimensional scaling (MDS) analysis (Kruskal and Wish, 1984). Hierarchical cluster analysis produces two-dimensional tree diagrams of nested groupings that often depict visually interpretable results based upon phenetic relations among the samples being compared, while nonmetric MDS is also a useful procedure for producing interpretable graphical representations of complex distance matrices using the number of dimensions specified by the investigator (Kruskal and Wish, 1984).

We also compared the matrices for each biodistance measure using the matrix correlation method so as to test each of the competing models regarding the origins of the Moche sacrificial victims. These models are tested



**Fig. 5.** Illustration of model matrix values for the nonlocal origins model for the origins of the Moche sacrificial victims from Huaca de la Luna. This model suggests that Moche sacrificial victims were enemy combatants captured and killed during territorial expansion into regions adjacent to the Moche Valley.

by developing simple hypothetical design matrices for the expected biodistance relationships of each model—a technique that is well understood and widely used in biological sciences (Mantel, 1967; Konigsberg, 1990; Wadde, 1994; Sokal et al., 1997; González-José et al., 2001a,b). Both the partial correlation and level of significance for each model is then determined by comparing each of the hypothetical matrices with each of the biodistance matrices by computing 999 random permutations using the Smouse et al. (1986) extension of the Mantel test. This extension of the Mantel test allows one to test between the biodistance matrix and one of the hypothetical matrices, while controlling for the effects of other matrices.

For this study we test two simple design matrices where the relative biodistances vary only for the comparisons of the two Moche sacrificial samples with the non-sacrificial samples. For the ritual combat model, which

TABLE 2. Frequencies and number of observations for dental traits among nine prehistoric samples from the north coast of Peru

	CO-SAL <sup>a</sup>		CO-G1 <sup>a</sup>		CO-G2 <sup>a</sup>		CO-G3 <sup>a</sup>		HM-US <sup>a</sup>		HLL-PLATS <sup>a</sup>		PACAT <sup>a</sup>		HLL-P3A <sup>a</sup>		HLL-P3C <sup>b</sup>	
	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
<i>Maxilla</i>																		
3MMETA	0.30	20	0.18	34	0.19	21	0.29	14	0.21	14	0.67	9	0.63	8	0.09	23	0.07	14
1MPARA	0.21	34	0.18	67	0.12	41	0.08	37	0.06	17	0.00	26	0.10	20	0.38	24	0.11	9
UP2CA	0.03	30	0.00	60	0.00	44	0.00	37	0.00	27	0.00	24	0.00	22	0.08	26	0.00	20
UI1WING	0.71	21	0.68	28	0.81	26	0.84	19	0.81	21	0.46	26	0.50	22	0.57	23	0.38	16
UI1SHOV	1.00	29	1.00	36	1.00	24	1.00	28	1.00	11	0.80	5	0.88	16	0.68	19	0.90	10
<i>Mandible</i>																		
LM3CA	0.00	34	0.05	60	0.02	46	0.03	38	0.05	19	0.11	27	0.05	21	0.24	21	0.06	18
LI1SHOV	0.94	35	0.97	36	0.95	19	0.88	17	0.80	5	0.83	12	0.58	12	0.67	21	0.50	16

<sup>a</sup> Frequencies previously reported by Sutter and Cortez (2005).

<sup>b</sup> Trait frequencies reported for the first time here.

TABLE 3. Matrix of mean measure of divergence values, their standard deviations, and number of standard deviations for the mean measure of divergence values for nine prehistoric north coast samples from Peru

	CO-SAL	CO-G1	CO-G2	CO-G3	HM-US	HLL-PLATS	HLL-P3A	PACAT	HLL-P3C
Cerro Oreja–Sal, Moche Valley ~100 BC	–								
Cerro Oreja–G1, Moche Valley ~AD 1	–0.01 0.08 –0.15	–							
Cerro Oreja–G2, Moche Valley ~AD 100	–0.02 0.10 –0.25 –0.36	–0.03 0.08	–						
Cerro Oreja–G3, Moche Valley ~AD 200	–0.02 0.11 –0.16 –0.05	–0.01 0.09 –0.05	–0.05 0.11	–					
HM-Urban Sector, Moche Valley ~AD 600	–0.01 0.16 –0.06	–0.01 0.14	–0.05 0.16	–0.08 0.17	–				
HLL-Platforms, Moche Valley ~AD 600	0.20 0.16 1.28	0.22 0.14	0.21 0.15	0.15 0.16 0.92	0.11 0.21 0.50	–			
HLL-Plaza 3A, Moche Valley ~AD 600	0.26 0.11 2.29	0.24 0.10	0.26 0.11	0.27 0.12	0.16 0.17	0.27 0.17	–		
Pacatnamú, Jequetepeque Valley ~AD 600	0.14 0.14 1.00	0.20 0.12	0.18 0.14	0.11 0.15	0.05 0.20	–0.04 0.19	0.18 0.15	–	
HLL-Plaza 3C, Moche Valley ~AD 200–55	0.18 0.15 1.20	0.17 0.13	0.17 0.15	0.16 0.16	0.05 0.21	0.16 0.20	0.04 0.16	0.06 0.19	–
		1.24	1.13	0.99	0.22	0.79	0.23	0.30	

Italicized values are significant at the 0.05 level.

implies that the sacrificial victims represent local warriors, a hypothetical matrix was constructed, that predicts the sacrificial victims would be indistinguishable from the other two Huacas de Moche mortuary samples (Fig. 4), while those from Cerro Oreja—given their proximity—receive a distance on 0.5. The Pacatnamú sample, given its location in the Jequetepeque valley, receives a distance of 1.0.

Given that both the nonlocal Moche combat and territorial warfare models both suggest a nonlocal origin for the sacrificial victims, we constructed a single hypothetical matrix to represent the predicted biodistances among the samples (Fig. 5). For this model, the Urban Sector and Huaca de la Luna Platforms samples from Huacas de Moche have a distance of 0.0 from one another, while the Cerro Oreja and Pacatnamú sample values also remain the same as in the first model, having predicted distances of 0.5 and 1.0, respectively. Given that the southern Moche polity would be expected to have warlike relations with geographically closer populations ear-

lier in its expansion, we predict that the Huaca de la Luna Plaza 3C sample would be genetically more similar to the other samples given its temporal placement between AD 200 and 550. Therefore, we assign the Huaca de la Luna Plaza 3C sample a hypothetical distance of 2.0 from the Huaca de la Luna Urban Sector and Platform samples. The Plaza 3A sample, given its relatively more recent antiquity, is predicted to be from a more distant and genetically distinct population relative to the local Huaca de la Luna samples and is assigned a distance of 3.0 and a distance of 1.0 from the sacrificial victims from Plaza 3C.

**RESULTS**

Dental trait frequencies for the Huaca de la Luna Plaza 3C sample and the other eight previously reported prehistoric north coast samples are presented in Table 2. Inspection of the matrix of MMD matrix indicates that

TABLE 4. Matrix of generalized Mahalanobis'  $d^2$  for nine prehisotric north coast samples from Peru

	CO-SAL	CO-G1	CO-G2	CO-G3	HM-US	HLL-PLATS	HLL-P3A	PACAT	HLL-P3C
Cerro Oreja–Sal, Moche Valley ~100 BC	–								
Cerro Oreja–G1, Moche Valley ~AD 1	0.93	–							
Cerro Oreja–G2, Moche Valley ~AD 100	0.71	0.68	–						
Cerro Oreja–G3, Moche Valley ~AD 200	1.17	1.30	0.84	–					
HM-Urban Sector, Moche Valley ~AD 600	1.51	1.52	1.14	0.80	–				
HLL-Platforms, Moche Valley ~AD 600	2.67	2.72	2.62	2.22	2.14	–			
HLL-Plaza 3A, Moche Valley ~AD 600	2.63	2.63	2.57	2.74	2.10	2.82	–		
Pacatnamú, Jequetepeque Valley ~AD 600	2.16	2.48	2.28	1.85	1.91	1.20	2.73	–	
HLL-Plaza 3C, Moche Valley ~AD 250–500	2.63	2.71	2.49	2.36	1.72	2.39	1.70	2.23	–

Italicized values are significant at the 0.05 level.

TABLE 5. Mantel test results for comparisons between the MMD and  $d^2$  matrix

	Mantel $r$	Significance
MMD $\times d^2$	0.845	0.001

all biodistance comparisons with the Huaca de la Luna Plaza 3C mortuary sample are positive but nonsignificant (Table 3). Among the MMD values, it is apparent that the Huaca de la Luna Plaza 3C sample is most similar to the sacrificial victims from Plaza 3A (0.05), followed by the mortuary samples from Huaca de Moche Urban Sector (0.05), and Pacatnamú (0.06). The Plaza 3C sample is most distinct from the Cerro Oreja Salinar sample (0.18) with the Cerro Oreja Gallinazo 1 and 2 (an MMD of 0.17 for comparisons with both) and Cerro Oreja 3 and Huaca de la Luna Platforms samples (0.16 for comparisons with both) being only slightly more similar. While the MMD data provide us with an idea as to whether the observed biodistances are significant, the nonsignificant results cannot help us distinguish among the competing models, especially if the sacrificial victims were drawn from a genetically similar nearby population.

Similar results to those achieved using the MMD are apparent upon inspection of the matrix of  $d^2$  values (Table 4). Although most biodistances are nonsignificant, the  $d^2$  values are significant for comparisons between the more ancient sacrificial sample from Huaca de la Luna Plaza 3C (AD 200–550) and the Cerro Oreja–Salinar, Gallinazo 1 and Gallinazo 2 samples, while the more recent Moche sacrifices from Huaca de la Luna Plaza 3A (~AD 600) produced significant distances for all but the comparisons with the Huacas de Moche–Urban Sector sample and the sacrifices from Huaca de la Luna Plaza 3C.

Results of the Mantel test indicate that biodistances from both the MMD and  $d^2$  are highly correlated and significant ( $r = 0.845, P = 0.001$ ) (Table 5). A number of other studies also report that the MMD is highly correlated with other measures that are commonly used in biodistance studies (Constandse-Westermann, 1972; Sneath and Sokal, 1973; Finnegan and Coopriider, 1978; Gonzalez-José et al., 2001a,b). Indeed, a recent study that directly compared the MMD and Mahalanobis' generalized distance found the two measures produced very similar results (Hecht Edgar, 2004), while another study showed that the levels of significance associated with the MMD are slightly more conservative than model-bound techniques (Hallgrímsson et al., 2004).

Closer inspection of biodistance comparisons between the Huaca de la Luna Plaza 3C and the two local Huacas

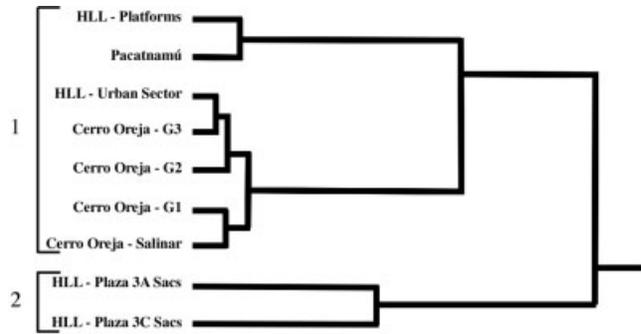
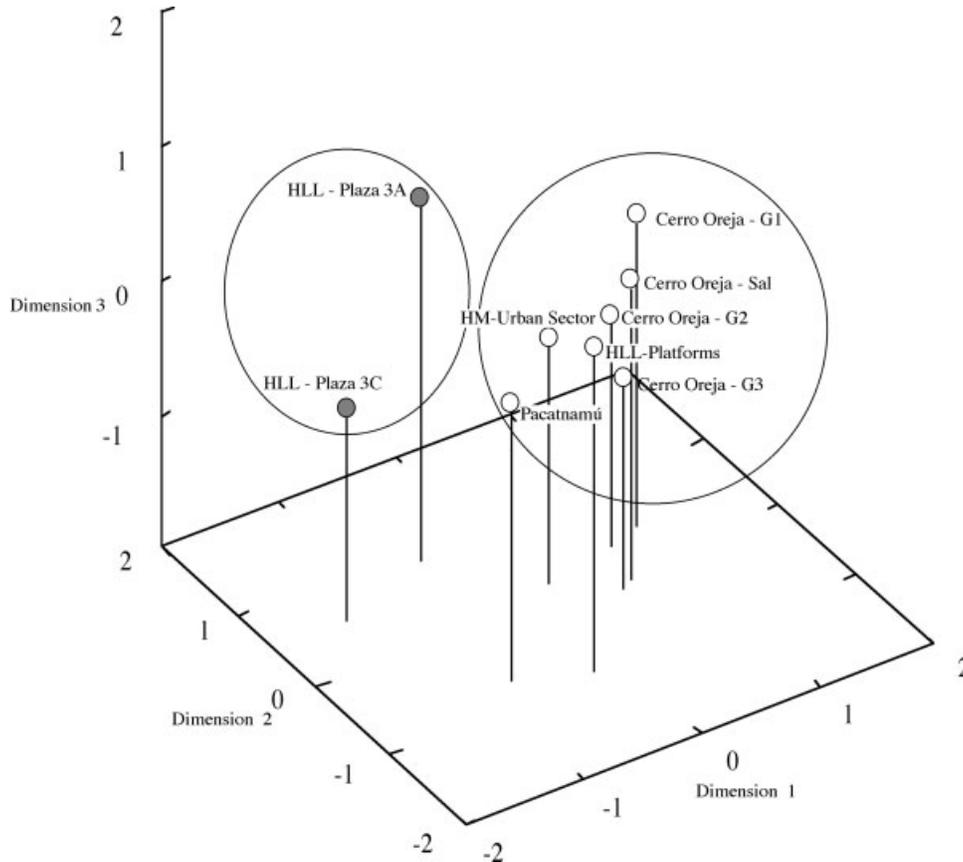


Fig. 6. The hierarchical clustering diagram of the mean measure of divergence matrix for nine prehistoric north coast of Perú. The first cluster is composed of the four samples from Cerro Oreja, the local Moche samples from the Huaca de la Luna Urban Sector and the local elites from the Huaca de la Luna Platforms, and the sample from Pacatnamú. Importantly, both sacrificial victims samples from Huaca de la Luna Plazas 3A and 3C are outliers in the second cluster, indicating these two samples are more similar to one another and least like the other seven north coast samples.

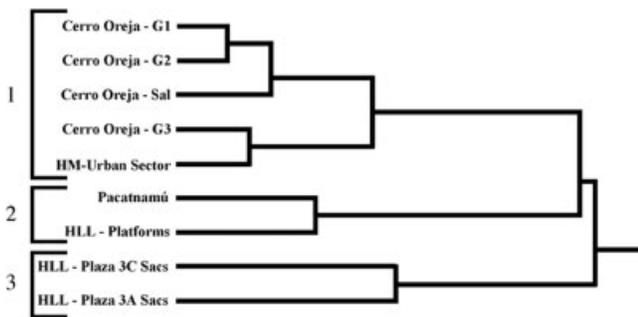
de Moche samples (from both the urban sector and Huaca de la Luna platforms) indicate they are smaller than (more similar) the local Moche population than MMD values for comparisons between the Plaza 3A sacrificial sample and local Huacas de Moche samples. These differences imply that the Plaza 3A sample was drawn from more distant, genetically distinct north coast populations than was the Plaza 3C sample.

Examination of the resulting hierarchical clustering diagram (Fig. 6) reflects the differences present in MMD matrix. The hierarchical clustering procedure produced two clusters: the first cluster consists of all four of the mortuary samples from Cerro Oreja (Cerro Oreja–Sal, Cerro Oreja–G1, Cerro Oreja–G2, and Cerro Oreja: G3), the Huaca de la Luna Urban Sector and Platform samples, and the sample from Pacatnamú, while the second cluster consists of the two sacrificial samples from Huaca de la Luna Plazas 3A and 3C.

Similar groupings are apparent upon inspection of the multidimensional scaling diagram of the MMD matrix (Fig. 7). In this case, the final stress of the three dimensional MDS solution is 0.0135, while the proportion of variance explained by the solution is 0.999. Three groupings are apparent in multidimensional space: the first group consists of the four samples from Cerro Oreja and the mortuary sample from the urban sector at Huaca de la Luna; the second grouping contains the platforms



**Fig. 7.** The multidimensional scaling solution of mean measures of divergence values for nine mortuary samples from the north coast of Peru. All mortuary samples from Cerro Oreja, Pacatnamú, and both the urban sector and platforms at Huaca de la Luna are represented by open circles and are closely located in the solution indicating close phenetic relations among these Early Intermediate Period (AD 200–700) samples, while the Plaza 3A and Plaza 3C mortuary samples composed of sacrificial victims from Huaca de la Luna are represented by filled circles relatively closer to one than the other seven samples. These results indicate that the sacrificial victims from Huaca de la Luna Plazas 3A and 3C were not drawn from the local Moche population.



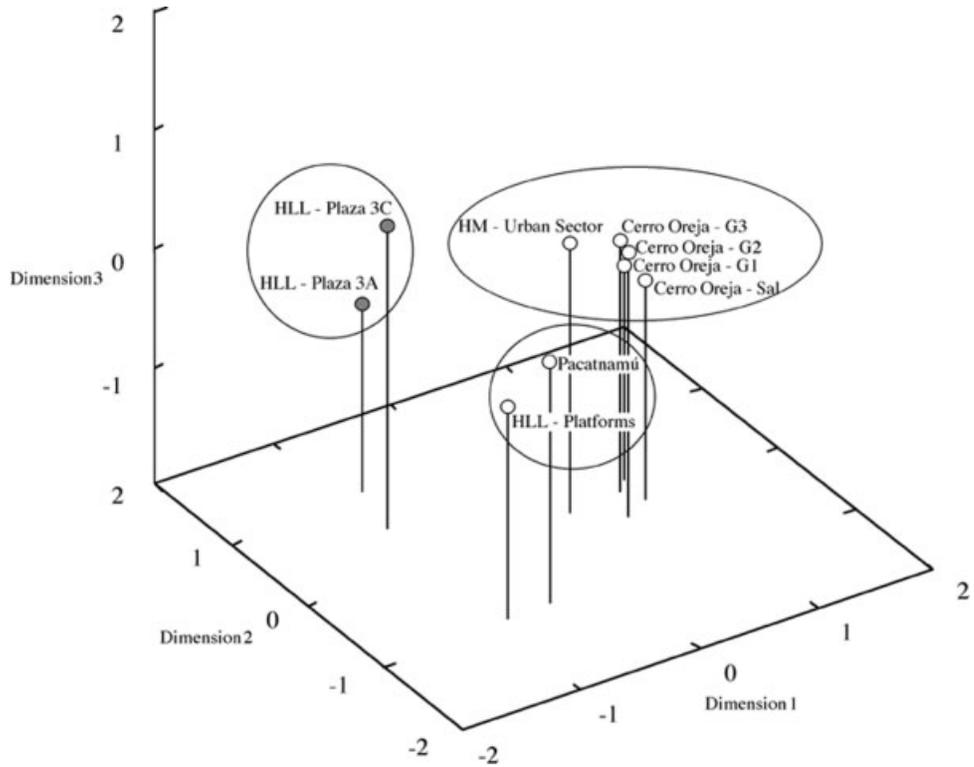
**Fig. 8.** The hierarchical clustering diagram of Mahalanobis' generalized distance matrix for nine prehistoric north coast of Perú. The first cluster is composed of the four samples from Cerro Oreja and the local Moche sample from the Huaca de Moche Urban Sector; the second cluster consists of the local elites from the Huaca de la Luna Platforms sample and the sample from Pacatnamú; while the third cluster contains both sacrificial victims samples from Huaca de la Luna Plazas 3A and 3C suggesting that the Moche sacrificial victims represented by these two samples are more similar to one another and least like the other seven north coast samples.

sample from Huaca de la Luna and the mortuary population from Pacatnamú; while the third grouping consists of the two sacrificial samples from Huaca de la Luna plazas 3A and 3C.

Hierarchical clustering diagram of the  $d^2$  matrix (Fig. 8) produced broadly similar results to those discussed above for clustering of the MMD matrix; however, some differences are apparent. Clustering of the  $d^2$  matrix produced three clusters: the first cluster consists of all four of the mortuary samples from Cerro Oreja (Cerro Oreja–Sal, Cerro Oreja–G1, Cerro Oreja–G2, and Cerro Oreja–G3), and the Huacas de Moche Urban Sector; the second cluster consists of the Pacatnamú and Huaca de la Luna–Platform samples; while the third cluster consists of the two sacrificial samples from Huaca de la Luna Plazas 3A and 3C.

These three groupings apparent in the hierarchical cluster diagram are also discernable in the MDS diagram of the Mahalanobis'  $d^2$  matrix (Fig. 9). In this case, the final stress of the three dimensional MDS solution is 0.0167, while the proportion of variance explained by the solution is 0.998. Three groupings are apparent in multidimensional space: the first group consists of the four samples from Cerro Oreja and the mortuary sample

**Fig. 9.** The multidimensional scaling solution of Mahalanobis' generalized distance values for nine mortuary samples from the north coast of Peru. All mortuary samples from Cerro Oreja, Pacatnamú, and both the urban sector and platforms at Huacas de Moche are represented by open circles and are closely located in the solution indicating close phenetic relations among these Early Intermediate Period (AD 200–700) samples, while the Plaza 3A and Plaza 3C mortuary samples composed of sacrificial victims from Huaca de la Luna are represented by filled circles relatively closer to one than the other seven samples. Three groupings are apparent from inspection of the MDS solution.



**TABLE 6.** Partial Mantel test results for comparisons between the MMD matrix and two competing models' hypothetical matrices

Model for victims' origins	Mantel <i>r</i>	Significance
Local origins (ritual battle)	0.134	0.163
Nonlocal (captured warriors)	0.688	0.001

from the Urban Sector at Huacas de Moche; the second grouping contains the platforms sample from Huaca de la Luna and the mortuary population from Pacatnamú; while the third grouping consists of the two sacrificial samples from Huaca de la Luna plazas 3A and 3C. When compared to the MDS solution for the MMD matrix, the groupings present in the solution for the  $d^2$  matrix are more tightly clustered.

In order to distinguish whether a local or nonlocal model of origin best explains the Moche sacrificial victims from plazas 3A and 3C, we examine the results of the matrix correlations. Results of the partial Mantel test for each of the competing models (Table 6) indicate that—when the effects of the nonlocal origins model are held constant—the design matrix for ritual combat among local contestants produces a small statistically nonsignificant correlation ( $r = 0.134, P = 0.163$ ), while the design matrix for a nonlocal origin for the sacrificial victims from plazas 3A and 3C—when the effects of the local origins model are controlled for—produces a high and statistically significant result ( $r = 0.688, P = 0.001$ ). The matrix correlation results suggest that sacrificial individuals from Huaca de la Luna Plazas 3A and 3C sample were drawn from nonlocal populations while the nonsignificant MMD comparisons indicate that the two Moche sacrificial samples were drawn from populations that were phenetically similar to the local Huaca de Moche popula-

**TABLE 7.** Partial Mantel test results for comparisons between  $d^2$  matrix and two competing models' hypothetical matrices

Model for victims' origins	Mantel <i>r</i>	Significance
Local origins (ritual battle)	0.210	0.212
Nonlocal (captured warriors)	0.676	0.002

tion. Once again, similar results were achieved when we examined the matrix correlations between the Mahalanobis' generalized distance and each of the hypothetical matrices (Table 7). The design matrix for ritual combat among local contestants produces a small and nonsignificant correlation ( $r = 0.21, P = 0.212$ ), while the design matrix for a nonlocal origin for the sacrificial victims from plazas 3A and 3C produces a relatively higher and statistically significant result ( $r = 0.676, P = 0.002$ ).

**DISCUSSION**

Most scholars working in northern Peru have asserted that Moche iconographic depictions of one-on-one combat between apparently Moche warriors are a clear indication that these battles were simply ritual in nature and that the Moche warriors who participated in these battles were drawn from the local Moche population (Alva and Donnan, 1993, 1994: 33; Bawden, 2005; Bourget, 2001: 94; Castillo, 2000; Donnan, 1978, 2001, 2004, 2005; Hocquenghem, 1987; Shimada, 1994; Shimada and Corruccini, 2005; Shimada et al., 2005). Some even contend that Moche depictions of the parading of nude bound warriors and their subsequent sacrifice and informal disposal may not have been disrespectful (Donnan, 2004: 139; Shimada and Corruccini, 2005: 541). However, there

are numerous ethnohistoric accounts from the Andes describing one-on-one combat between the Incas and other enemy groups (Sarmiento de Gamboa, 1999), the removal of the prisoner warriors' clothing, weaponry, and objects of value followed by the denigrating parading of captured prisoners in the principal plaza in Cuzco (Betanzos, 1996), the Incas' torture, flaying, and mutilation of enemy warriors' bodies (Betanzos, 1996; Cieza de León, 1959; Huamán Poma de Ayala, 1978; Sarmiento de Gamboa, 1999), and leaving enemy warriors' and traitors' dead bodies unburied under punishment of death (Betanzos, 1996; Cieza de León, 1959; Huamán Poma de Ayala, 1978). Although separated in time by nearly 1,000 years, the ethnohistorically documented treatment of enemy warriors by the Inca is almost identical to both the mortuary and iconographic data currently available for the Moche. In contrast, those individuals sacrificed during Inca festivals or as attendant burials were adorned with high quality objects and buried in formal graves (Betanzos, 1996; Cieza de León, 1959; Cobo, 1990; Huamán Poma de Ayala, 1978; Sarmiento de Gamboa, 1999), while the bodies of Inca warriors who were killed in battle were returned to the Incas' capital, mummified, and returned to their families (Betanzos, 1996). On the other hand, Moche attendant burials follow the Inca's burial practices for attendant burials. Further, abundant evidence regarding "typical" mortuary treatment of both Moche elites and commoners also exists from undisturbed tombs (Donnan, 1995). Contrary to many Moche scholars' assertions, ample ethnohistoric and archaeological evidence exists to suggest that both the pre- and post-mortem treatment of Moche sacrificial victims accords with a lack of respect.

Based upon the results reported by this study we tentatively suggest that the sacrificial victims from Huaca de la Luna Plaza 3C represent adult male warriors taken in combat with nearby competing polities (Moche or Gallinazo or both), while individuals of the Plaza 3A sample likely came from competing polities located in more distant valleys. When the chronological placement of the two sacrificial samples analyzed by this study is taken into account, we suggest that this explanation is entirely consistent with the model of warriors captured during combat by the southern Moche with nearby competing polities. According to the ritual combat model which posits local origins, we would expect that the sacrificial samples should be closely related to the Huacas de Moche Urban Sector and Huaca de la Luna Platform samples. Instead, the hierarchical clustering diagrams from both the MMD (Fig. 6) and Mahalanobis' generalized distance (Fig. 8) place the sacrificial samples from Huaca de la Luna Plazas 3A and 3C in a separate isolate cluster. Similarly, the three-dimensional MDS for the MMD (Fig. 7) and Mahalanobis' generalized distance (Fig. 9) clearly indicate the Moche sacrificial victims represented by Huaca de la Luna Plaza 3A and 3C samples form outliers in multivariate space relative to the other seven north coast samples considered by this study. Further, partial Mantel results for both the MMD (Table 6) and Mahalanobis' generalized distance (Table 7) produced low and nonsignificant correlations with the local origins model, while producing high and statistically significant correlations with the nonlocal origins model. These results strongly suggest a nonlocal origin for the Moche sacrificial victims.

When considered in light of the victims' demographic profile, both the pre- and peri-mortem injuries they sus-

tained, their mortuary treatment, and Moche war and sacrificial iconography, the biodistance results and matrix correlation analyses from this study strongly support the notion that these sacrificial victims represent adult male warriors captured in battle during the southern Moche's expansion into adjacent territories.

This scenario for the Huaca de la Luna victims from Plazas 3A and 3C is consistent with our current knowledge of the emergence and expansion of the southern Moche polity (Bourget, 2004; Chapdelaine, 2004; Millaire, 2004; Shimada, 2004). As Shimada (2004) correctly points out, the expansion of the southern Moche did not occur in a single campaign but instead probably occurred over hundreds of years and likely included a multitude of both military and nonmilitary strategies, including alliance formation, the settlement of sparsely populated regions of valleys to the south (Millaire, 2004), and the coexistence of Moche administrative apparatus in the presence of pre-existing Gallinazo polities (Bourget, 2004). Because of the gradual and varied nature of southern Moche expansion, one would expect that sacrificial victims during the early stages (Moche I and II) of southern Moche expansion to represent warriors captured by the Moche to be from polities in adjacent valleys (i.e. Chicama, Virú?), while those sacrificed during the later stages of the southern Moche polity (Moche III–V) would come from more distant regions that were brought under the influence of the polity (i.e. Chao, Santa, Nepeña?). Unfortunately, at present no adequate Early Intermediate Period mortuary samples are available from these valleys.

Further, we feel that the currently available mtDNA evidence supports this scenario. While the mtDNA of Huaca de la Luna Plaza 3C remains have not yet been analyzed, the Huaca de la Luna and Santa Valley data reported by molecular investigations (Shimada, 2004; Shimada et al., 2005) suggests that both Moche and Gallinazo populations within the valleys of the southern Moche sphere were genetically similar and likely represented members of the same breeding population. The mtDNA results are consistent with studies of both dental (Sutter, in press a, in press b) and craniometric variation (Dricot, 1976, 1977; Verano and DeNiro, 1993) for north and central coast Peruvian skeletal samples, which suggest that there was substantial gene flow among coastal valleys in pre-Colombian times.

## CONCLUSIONS

When the weight of the biodistance data are considered in light of the osteological, iconographic, ethnohistoric and mortuary data, it suggests that the Moche sacrificial victims from Huaca de la Luna at the Huacas de Moche site were nonlocal enemy combatants. While the biodistance techniques employed by this study cannot identify the origins of individuals, we find no support for the notion that the victims were local Moche who were sacrificed following ritual battles. Such a scenario does not conform to the ethnohistoric record, mortuary treatment, and biodistance data presented by this study.

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