Craniometic Variation in the Azapa Valley: Reply to Sutter and Mertz (2004)

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Recently, Sutter and Mertz (2004) presented the results of a nonmetric cranial trait variation analysis in the Azapa Valley, Chile, concluding "that no significant prehistoric gene flow occurred in the Azapa Valley" on the basis of insignificant distances between eight samples spanning a chronologic interval of over 5,000 years. However, contradicting the idea of microevolutionary stasis which, according to Sutter and Mertz (2004), could be the result of "the data reduction techniques employed," a dendrogram generated using the nonsignificant distances as input revealed the existence of a "degree of breeding isolation between prehistoric coastal and inland populations." The possibility of the observed effect having been caused by differential gene flow from the highlands into the Azapa Valley, as suggested by the great majority of professional archaeologists working in the area and by craniometric studies conducted by us, was overlooked by Sutter and Merz (2004).

Citing numerous publications of our research team supposedly aimed at assessing prehistoric genetic affinities in the Azapa Valley, Sutter and Mertz (2004) argued that we used "different combinations of variables, different statistical procedures, and different mortuary samples" for studying craniometric variation. Of more than 11 publications cited, only three were directly concerned with the Azapa Valley. The other papers explored different bioanthropological questions such as migrational patterns along the Peruvian coast, the peopling of South America, trans-Andean migrations, the peopling of Chile, and the effect of environmental factors on craniometric variation. Given this variety of topics, it seems natural that different variables, statistical procedures, and samples were used. Furthermore, we were interested in the underlying genetic variation that variables revealed, and not in the measurements themselves.

Sutter and Mertz (2004) asserted that our studies did not control for sex (S), observational error (OE), or artificial cranial deformation (ACD), and that we contended "that eastern highland populations replaced preexisting Azapa Valley peoples."

Our first publication (Rothhammer et al., 1982), concerned with craniometric variation in the Azapa Valley, included a separate treatment for males and females. We showed that within skeletal samples, males presented a greater similarity to females of their own group than to females of other groups. Furthermore, distances increased gradually with time in males and females, shape contributing substantially more. In the remaining publications, the S effect was removed by linear regression.

OE is difficult to control when published figures are used. When measurements were obtained by different members of our group, observers repeated all measurements in a small subsample of skulls until discrepancies were resolved (Rothhammer et al., 1982). Furthermore, we discussed in detail which measurements would be more affected by OE (Rothhammer and Silva, 1990).

The effect of ACD was initially studied in several publications between 1975–1982. We decided, on the basis of these studies, to select a group of facial measures which were shown to be less affected. For example, the average variation accounted for by the seven facial measures most frequently used by us amounts to only 0.52% when the classification of Anton (1989) is used (Table 1). This variation is negligible when compared to other sources of environmental variation such as climate, hypoxia, or diet (Rothhammer and Silva, 1990). Sutter and Mertz (2004) provided several references to studies in which it was shown that ACD influenced facial measurements, including an abstract presented at the 2002 American Association of Physical Anthropology (AAPA) Meeting (Rhode, 2002), in which skulls from the Azapa Valley were analyzed. With the exception of this last study, these references are of moderate interest because the results were not obtained in the Azapa Valley. As concerns the study of Rhode (2002), no information about statistical procedures was provided, thus making the evaluation of the importance of these findings difficult.

TABLE 1. Effect of artificial cranial deformation on craniofacial variability in Azapa Valley

Measurement	F-value	*P*	$R^2 \times 100$
Minimum frontal breadth	1.05	0.3081	0.6834%
Bizygomatic breadth	1.28	0.2590	0.8373%
Nose height	1.22	0.2703	0.7988%
Nose breadth	0.11	0.7414	0.0719%
Orbital breadth	0.68	0.4111	0.4449%
Orbital height	0.65	0.4212	0.4262%
Palatal length	0.80	0.3715	0.5258%

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Finally, the statement by Sutter and Mertz (2004) that we contended that eastern highland populations replaced preexisting Azapa Valley peoples during the Formative surprised us. We have held, ever since the beginning of our craniometric studies, that migration is primarily responsible for the chronological decrease of kinship observed in the Azapa Valley after the Archaic period. This conclusion was again stated in our most recent article on the subject (Rothhammer et al., 2002). It is very different to conclude that gene flow is responsible for microevolutionary change, than to hypothesize that population replacement took place.

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Colonization vs. Demic Expansion in the Azapa Valley, Chile: Reply to Rothhammer et al.

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Rothhammer et al. suggest that I have somehow distorted their conclusions, and that my coauthor and I ignore both archaeological and their own craniometric studies that suggest directional gene flow from the adjacent *altiplano* (high-altitude planes) to the east. I am pleased to respond to Dr. Rothhammer et al. I point out here that my disagreement is not with whether differential gene flow occurred from the eastern highlands of Bolivia and Chile into the coastal Azapa Valley. Rather, my differences are with the magnitude of the gene flow they report (which I suspect is due to both temporally and spatially influenced biases in their craniometric data) and the archaeological implications their studies have had. As I shall explain below, I feel that the scholarly disagreement has resulted (in part) from a misreading of my published conclusions on this topic and differences in interpretation that are analogous to their saying that the glass is half-full, while I say it is half-empty.

To begin with, my colleagues downplay the context within which their research has occurred, and do not accurately describe the thinking of archaeologists working in northern Chile over the past 25 years. More specifically in question is the nature of cultural changes detected in the Azapa Valley during the beginning of both the Formative and Middle Horizon periods. Between roughly 1975–1995, archaeological work in northern Chile explicitly operated under the ethnohistorically based model of "verticality." This model suggests that pre-Inca cultural changes and variability in coastal valleys (such as the Azapa Valley) were due to the arrival of colonists from adjacent highlands. Using this paradigm, archaeologists working in northern Chile have traditionally overlooked the abundance of artifact evidence pointing to local cultural developments during the Middle Horizon, and suggested that the relatively few nonlocal artifacts of *altiplano* origin were evidence of *direct colonization* of the valley by Middle Horizon Tiwanaku peoples from the nearby highlands.

Within the context of this paradigm, Rothhammer et al. reported significant differences in craniometrically derived biodistances, using both their own and previously published data for both deformed and undeformed skulls among mortuary populations in the Azapa Valley (Cocilovo et al., 2001; Rothhammer and Santoro, 2001; Rothhammer et al., 2002; Soto et al., 1975; Varela and Cocilovo, 2002). Although they correctly state that the publications my coauthor and I discussed cover a variety of microevolutionary topics, they have never failed to make explicit statements regarding prehistoric population dynamics in the Azapa Valley, Chile. My colleagues explicitly argue that migration from the adjacent highlands accounts for their biodistance results (Rothhammer et al., 1983, p. 164, 1989, p. 405), and that these migratory events *were not* simply gene flow. Instead, they argued for the arrival of *altiplano* "populations" (Soto et al., 1975, p. 77; Rothhammer et al., 1983), "groups" (Varela and Cocilovo, 2002, p. 264), "migrants" (Rothhammer et al., 1986, p. 117; Rothhammer and Santoro, 2001, p. 64), or "individuals" (Varela and Cocilovo, 2002, p. 265), in accordance with the model of verticality (Soto et al., 1975, p. 77), claiming that "es evidente que el origen de los grupos ariqueños debe buscarse en el Altiplano" (Rothhammer et al., 1983, p. 164) ("it is evident that the origin of [prehistoric] Arican groups should be searched for in the *altiplano*;" translation my own). In craniometric studies investigating changes in kinship within the prehistoric Azapa Valley, they claimed, "It seems, however, very likely that long range migration is

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primarily responsible for the observed chronologic decrease of kinship" (Rothhammer et al., 1982a, p. 395), while in discussing their own previous work, they stated:

> "Se adelantó la hipótesis de la acción de migraciones de amplio rango sobre la zona como el principal factor responsable en la determinación del parámetro b, que indica la tasa de evolución del parentesco con el tiempo y la acción de presiones sistemáticas (migración y selección)" (Cocilovo and Rothhammer, 1999, p. 215).

> "[We] advanced the hypothesis that large-scale migrations were the principal factor responsible for the determination of parameter b, which is the indicator of the evolution of kinship over time and the action of systematic pressures (migration and selection)."

Given such definitive statements, it is unclear how my coauthor and I have misrepresented their conclusions. While my colleagues have occasionally made more conservative statements suggesting the possibility of ethnic mixture (*miscegenación étnica*) in the prehistoric Azapa Valley (Rothhammer et al., 1982b, p. 280, 1986, p. 117), they have repeatedly claimed that the large-scale immigration of *altiplano* colonists was the principal factor for both prehistoric genetic and cultural change in the Azapa Valley, as opposed to local populations who produced local (sometimes highland-inspired) ceramics and textiles.

My assertion is that both the magnitude and statistical significance reported by Rothhammer et al. are likely due to interacting temporal and spatial factors that unduly influenced their biodistance results, as opposed to accurately "representing underlying genetic variability." They have repeatedly asserted that the craniofacial measures they choose do not vary significantly among undeformed, annular, and tabular forms of deformation for the Azapa Valley crania they have measured. However, they have never accounted for the interaction between spatial and temporal components of cranial deformation for Azapa Valley crania. A number of scholars (Munizaga, 1980; Sutter, 2005a), including Cocilovo and Costa-Junqueira (2001, p. 213), described the spatial and temporal variability in cranial deformation practices for the Azapa Valley. While most Early and Middle Archaic period skulls exhibit no deformations, annular deformations become prevalent among Late Archaic skulls, and predominate among post-Archaic coastal skulls, while tabular forms of deformation are far more frequent among post-Archaic inland mortuary populations. The data provided in their Table 1 only consider the effect of deformation on the seven measures they report, and fail to account for the interaction among the aforementioned variables.

My criticisms that the degrees of craniometrically derived biodistance differences between Archaic period and subsequent populations and differences between later coastal and inland mortuary populations are likely due to cranial deformations are valid concerns, as indicated by a number of studies which demonstrated that both annular and tabular deformations significantly influence facial measures (Anton, 1989; Cheverud et al., 1992; Kohn et al., 1993). Indeed, the study by Rhode and Arriaza (2006) on both deformed and undeformed skulls from the Azapa Valley found that at least 6 of 9 facial measures employed by Rothhammer et al. are significantly influenced by cranial deformations. Their statistical procedures are now published, and I will let their research speak for itself. To include deformed crania in craniometric biodistance studies ignores the universal practice by contemporary scholars of using only undeformed crania. So as to decrease the likelihood of scholarly scrutiny of their results and conclusions, I would suggest that they exclude craniofacial measures for deformed skulls, so as to determine the correspondence with their results using only undeformed crania. I suspect they will find that the magnitude of biodistance values among Azapa Valley mortuary populations will be nonsignificant through time, in accordance with other scholars' craniometric results for Azapa Valley mortuary populations.

Further, the authors have misread my own conclusions. I have consistently found nonsignificant dentally (Sutter, 1997, 2005a) and cranially (Sutter, 2005a; Sutter and Mertz, 2004) derived biodistances among all Azapa Valley mortuary populations I have examined. Within the context of the study in question, my colleagues take issue with my coauthor and me, stating that we did not note clear temporal trends among our biodistance results (Sutter and Mertz, 2004, p. 140), and suggesting that we deny that any gene flow occurred from the adjacent highlands. However, we also referenced studies where I reported clear temporal trends that suggest nonsignificant levels of gene flow into the Azapa Valley from the adjacent highlands, which resulted from a broader north-to-south pan-Andean demographically driven expansion (Sutter, 1997, p. 251–260, p. 266–272, 2000, p. 64–65, 2005b). To state otherwise, as my colleagues have done (Moraga et al., 2005, p. 171; Rothhammer et al., 2002, p. 260), misrepresents my published work.

More recent archaeological research reveals that if there were Middle Horizon Tiwanaku enclaves in the Azapa Valley, they were small and limited in number (only three small sites have been identified), and skeletal collections are not available from these heavily looted sites (Goldstein, 1995). Most Azapa Valley "Tiwanaku" ceramics are overwhelmingly locally produced and part of a broader *post-Tiwanaku* coastal valley tradition called Cabuza or Loreto Viejo (Owen, 1993; Sutter, 1997, 2000, 2005a), while purportedly imported Tiwanaku textiles were produced using local (not highland) weaving techniques and dyes that are part of a broader coastal textile tradition (Boytner et al., 2002). Additionally, it should be made clear that the Azapa Valley lacks other key Tiwanaku cultural traits (e.g., domestic ceramics, ceremonial and domestic architecture, and mortuary practices) that were found in association with Tiwanaku colonies in the Moquegua Valley, Peru (Goldstein, 1993).

Rothhammer et al. and I have independently documented the same persistent coastal-inland genetic differences among prehistoric mortuary populations of the Azapa Valley, and have suggested that gene flow from the highlands likely explains the changes among inland populations. Based on biodistances derived from cranial measures that include deformed skulls, Rothhammer et al. argue that this gene flow was significant and resulted from multiple large-scale migrations of highland colonists, and see the glass half-full. My data simply do not agree with the magnitude of gene flow into the Azapa Valley reported by my colleagues. Using nonmetric traits and nonsignificant biodistances, I argue that these changes

resulted from low levels of demographically driven gene flow into the valley, and see the glass half-empty.

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