INVESTIGATIONS OF ANCIENT HUMAN TISSUE

Chemical Analyses in Anthropology

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CHAPTER 8

Locals or Foreigners?
Morphological, Biometric, and Isotopic Approaches to the Question of Group Affinity in Human Skeletal Remains Recovered from Unusual Archaeological Contexts

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Michael J. DeNiro

INTRODUCTION

Archaeologists occasionally discover human remains that appear unusual in some respect, either in terms of their morphological characteristics or the context in which the remains are found (e.g., "dedicatory burials", isolated skulls, mass graves). An important question that arises from such discoveries is whether the remains represent members of the local population or some outside group (Baraybar 1987; Fowler 1984; Seeman 1988; Shaer 1978). If diagnostic artifacts are not recovered in association with the human remains,
the physical anthropologist has traditionally been asked to render a judgement (Willoughby and Hooton 1922; Webb and Snow 1945).

The most common approaches to assessing the population affinity of an unknown individual or group involve morphological or biometric comparisons between the unknowns and possible source populations. Morphological methods range from simple visual assessment (Stewart 1979:227–34; Ubelaker 1989:119–120) to observations on discrete skeletal or dental traits (Greene 1967; Buikstra 1976; Lane and Sublett 1972). Biometric methods most often employ measurements of the craniocfacial skeleton, which has been shown to be a sensitive indicator of population differences (Howells 1969; Dreossler 1981; Gill 1984). Multivariate statistical techniques such as linear discriminant function and canonical variate analysis have proven to be useful analytical tools for approaching such questions, given their ability to manipulate multiple samples and variables simultaneously (Giles and Elliot 1962; Howells 1972, 1973; Rightmire 1970a, 1970b; Jantz 1972, 1973).

Another potential approach that has not been exploited is the identification of population outliers through chemical or isotopic analysis of bone. Such a technique could be useful in cases where the individuals in question are suspected to have consumed a substantially different diet from the population to which they are being compared. To our knowledge, there had been only one previous attempt to use this application of isotopic analysis when we conducted this investigation. The initial attempt was made by van der Merwe (1982), who experimented with the use of $^{13}$C/$^{12}$C ratios of bone collagen to determine the population affinities of an aberrant burial he excavated in 1970 at an Iron Age village site in South Africa. More recently, Katzenberg (1992:116) addressed the potential of stable isotope analyses for purposes of identifying migratory patterns and place of residence.

The Pacatnamu Mass Burial

The present study concerns a group of skeletons excavated at the archaeological site of Pacatnamu, on the North Coast of Peru (Figure 1). Pacatnamu is a large Middle Horizon and Late Intermediate Period (A.D. 600–1400) ceremonial center situated on a blufftop overlooking the Pacific Ocean at the mouth of the Jequetepeque River Valley. From 1983–87, the site was the focus of a multidisciplinary study directed by Christopher B. Donnan and Guillermo A. Cock of the University of California, Los Angeles, in cooperation with the Peruvian National Institute of Culture (Donnan and Cock 1986).

One of the authors of the present paper (JWV) participated as physical anthropologist for the project.

The site of Pacatnamu consists of a complex of mud brick pyramids, platforms and walled compounds that cover an area of approximately one square kilometer (Figure 2). The site is bounded on the west and south by steep cliffs, and on the east by a massive outer wall. The central architectural complex is divided roughly in half by a wall and trench complex that runs northwest-southeast across the site. This complex was constructed some time around A.D. 1100 as part of a larger network of defensive walls that surround and subdivide the site (Donnan 1986b). The inner wall and trench functioned to
limit access to the western half of the site to one of three causeways that cross the trench.

In 1984, during clearing and profiling of one of the three causeways, the skeletal remains of 14 adolescent and young adult males were discovered in the bottom of the trench (Verano 1986). The skeletons lay in three superimposed groups, each separated from the one below by a layer of windblown sand and debris. Insect remains found associated with the skeletons, as well as evidence of surface weathering on some bone surfaces suggest that none of the three groups had been promptly buried, but that each had remained exposed for a period of time estimated between 15 days and several months before being covered by sand and debris (Verano 1986; Faulkner 1986). The skeletons showed evidence of extensive perimortem trauma, including stab wounds, cut marks, blows to the head, decapitation, and forced disarticulation of limbs. The pattern of injuries and deposition of the bodies suggest some form of ritual sacrifice and mutilation of the victims, followed by purposeful exposure of their remains. Although it was not possible to estimate how much time elapsed between the deposition of each group of bodies, architectural features of the trench and diagnostic ceramic sherds found in the rubble surrounding the skeletons provide an outside range of between about 1050 and 1400 A.D. A radiocarbon determination on bone collagen from two of the skeletons in the uppermost group gave a date of approximately A.D. 1100.1

All fourteen skeletons were of adolescent or young adult males. As a group they showed robust skeletal morphology and appeared to pertain to healthy and active individuals. However, four of the skeletons showed evidence of old wounds. These included healed rib fractures in two individuals, a healed depressed fracture of the skull in another, and a healed fracture of the neck of the femur in another. Given their age and sex distribution and evidence of previous injuries, as well as the location in which the skeletons were found (the bottom of a defensive trench), it is possible that these individuals were war prisoners who were sacrificed and then deposited in the trench. Warfare, the taking of prisoners, and the sacrifice and mutilation of prisoners are common themes in ancient North Coast Peruvian art, making such an interpretation plausible (Verano 1986:134). However, no evidence was found which would

Figure 2. Air photo of Pacatnamu. The location of the mass burial is indicated by the circle labeled “MB.” Photo courtesy of Servicio Aerofotográfico Nacional, Lima.
exclude the possibility that these individuals were drawn from the local population at Pacatnamu.

Unfortunately, no objects were found with any of the skeletons that might serve to identify them either as members of the local population or as foreigners. The problem is a complex one, as the stratigraphic relationship of the three groups of skeletons indicates that three distinct temporal events are represented, and it is quite possible that the three events reflect distinct activities and types of victims. In fact, analysis of the pattern of perimortem injuries in the skeletons revealed that the four individuals in the uppermost group (Group I) showed significant differences from the ten individuals in the lower two groups (Groups II and III) in the types of wounds present (Verano 1986:133).

In terms of craniofacial morphology (visual assessment by J.W.V.), the four individuals in Group I appear to fit well with the contemporaneous population of Pacatnamu, and all show cranial deformation of a type commonly found in cemetery populations at the site. The individuals in Groups II and III are more heterogeneous. Three individuals show cranial deformation, while four do not. Moreover, the four undeformed skulls appear morphologically distinctive, showing features which have traditionally been ascribed to prehistoric highland Peruvian populations: specifically, a long skull with a low, "pinched" occiput (Newman 1943; Ericksen 1962).

Possible Source Populations

If some or all of the individuals in the mass burial were war prisoners who were sacrificed at Pacatnamu, there are two nearby candidates for their likely place of origin. The first is the Chicama Valley, located just south of the Jequetepeque River Valley. The Chicama Valley constituted the northern boundary of the powerful Chimú Empire until around A.D. 1200, when the Chimú expanded northward and conquered the Jequetepeque Valley (Rowe 1948; Keatinge and Conrad 1983). It is not unreasonable to assume that there was animosity between the two valley populations before the final conquest of the Jequetepeque Valley in the thirteenth century.

A second possible origin for the mass burial victims, which is suggested by the cranial morphology of some of the individuals in Groups II and III, is the adjacent northern highlands. Cajamarca, located at the headwaters of the Jequetepeque River, was an important center of influence in the northern highlands of Peru at this time (Reichlen and Reichlen 1949; Lumbraeras 1974). While little is known about the political relationship between Cajamarca and

Pacatnamu, ethnohistoric sources indicate that Cajamarca was an ally of the Chimú Empire at the time of the Inca conquest of northern Peru in the fifteenth century (Rowe 1948).

Approaches to the Problem

In attempting to assess the population affinities of the mass burial victims, we tested two different approaches: the first was biometric, the second, paleodietary. Discriminant functions derived from craniofacial measurements were used to compare a sample of male crania from Late Period (A.D. 1100–1400) cemeteries at Pacatnamu with roughly contemporaneous cranial samples from archaeological sites in the Chicama Valley (Malabrigo) and the Cajamarca area (Maquis-Maquis and Rumi Lanchi). The eleven measurable cranial crania from the mass burial were then entered as test cases to be classified by the discriminant functions. It was hypothesized that if the mass burial victims were members of the local populations at Pacatnamu, they would be classified with that sample and not with those from Chicama or Cajamarca. Alternatively, if they were not locals, they might be expected to be classified into the Chicama or Cajamarca groups and not that from Pacatnamu.

The paleodietary approach consisted of isotopic analysis of bone collagen to compare the diets of mass burial victims with the diets of contemporary individuals from Pacatnamu. Archaeological evidence indicates that marine resources were a significant component of the diet at Pacatnamu (Gummerman 1988). Fish bones and marine shell are common in domestic refuse, and fishing paraphernalia are frequently found associated with male burials at the site. Bones of either llama or alpaca are also common in domestic refuse and as burial offerings, indicating that domesticated camels provided another source of animal protein in the diet. Plant remains in refuse deposits at Pacatnamu indicate that both C₄ (maize) and C₃ plants (beans, squash, chili peppers, and various fruits) were consumed.

If the mass burial victims were not native to Pacatnamu, but were individuals who had grown up at an inland site (particularly in an area such as the northern highlands), it is possible that they consumed a diet containing substantially less marine protein than that of the inhabitants of Pacatnamu. Pózorski's studies of domestic refuse deposits at north coast Peruvian sites roughly contemporaneous with Pacatnamu revealed that sites located near the coast showed evidence of heavy reliance on marine protein, while inland sites generally showed little evidence of marine resource consumption. She
concluded that domestic camelids provided the principal source of animal protein for these inland populations (Pozorski 1976, 1979).

**Marine vs. Terrestrial Food Sources**

A number of recent studies have demonstrated that $^{13}C/^{12}C$ and $^{15}N/^{14}N$ isotopic ratios of bone collagen can be used to estimate the relative proportions of marine versus terrestrial food sources in the diet (Taubin 1971; DeNiro and Epstein 1981; Chisholm et al. 1982; Schoeninger et al. 1983; Hobson and Collier 1984; Schoeninger and DeNiro 1984; Sealy and van der Merwe 1985; Walker and DeNiro 1986; see also reviews in Schrader and Schoeninger 1991; Katzenberg 1992; Ambrose this volume, Chapter 2). Combined analyses of both carbon and nitrogen isotopes have proven particularly useful in cases where $C_4$ plants such as maize were a significant component of the diet, because carbon isotopic ratios alone would not provide terrestrial/marine discrimination (Schoeninger et al. 1983; Schoeninger and DeNiro 1984; Walker and DeNiro 1986; DeNiro 1987).

Based on analyses of bone collagen from a sample of animals representing diverse environments and feeding strategies, Schoeninger and DeNiro (1984) have developed a set of expectations for carbon and nitrogen isotopic ratios of animals following different dietary regimes (see also DeNiro 1987). These expected values are diagrammed in Figure 3, with $^{13}C/^{12}C$ ratios are shown on the horizontal axis, $^{15}N/^{14}N$ ratios on the vertical axis. The dot at the center of each box represents the mean isotopic ratio for the sample; the outer limits of each box represent two standard deviations from the mean. It can be seen that $^{15}N/^{14}N$ isotopic ratios effectively distinguish marine from terrestrial feeders. $^{13}C/^{12}C$ ratios can also be used to distinguish marine from terrestrial feeders, provided that $C_4$ plants do not constitute a substantial portion of the terrestrial animal’s diet. Thus, the terrestrial herbivore box illustrated in Figure 3 reflects a sample of exclusively $C_3$ plant eaters, as substantial consumption of $C_4$ plants would shift the $^{13}C$ value further to the right, toward less negative values.

**METHODS AND MATERIALS**

**Discriminant Function Analysis**

Table 1 lists sources for the Pacatnamu and comparative cranial series. Sixteen craniofacial measurements selected for their freedom from effects of simple fronto-occipital deformation (Verano 1987) were used to generate the discriminant functions. These measurements are listed in Table 2. Separate discriminant functions were generated between the Pacatnamu Late Period sample and the two comparative samples, using the SAS-PC procedure DISCRIMINANT (Sas Institute Inc. 1985). The eleven measurable crania from the mass burial were then entered as test cases for classification by the functions.
Table 1. Pacatnamu Late Period and comparative cranial samples.

<table>
<thead>
<tr>
<th>Site</th>
<th>N</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacatnamu Late Period</td>
<td>37</td>
<td>Verano 1987</td>
</tr>
<tr>
<td>Malabrigo</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Maquis-Maquis and Rumi-Lanchi</td>
<td>14</td>
<td>Eriksen 1962</td>
</tr>
</tbody>
</table>

Table 2. Craniofacial measurements used in the discriminant analyses.

1. Basion-nasion length
2. Basion-prosthion length
3. Nasion-prosthion height
4. Nasal height
5. Nasal breadth
6. Orbit height
7. Orbit breadth
8. Bi-orbital breadth
9. Interorbital breadth
10. Bijugal breadth
11. Bimaxillary breadth
12. Palate breadth
13. Malar length, inferior
14. Malar length, maximum
15. Minimum Cheek height
16. Nasion-bregma chord

Measurements are taken from Howells (1973) and follow his definitions of landmarks and measurement technique. Measurements were taken with a sliding caliper and rounded off to the nearest millimeter. All crania were measured by JWV.

LOCALS OR FOREIGNERS?

Isotopic Analysis of Bone Collagen

Samples of femoral cortical bone were collected from each of the mass burial victims. Bone samples were also collected from 9 Early Period (A.D. 600–900) and 10 Late Period (A.D. 1100–1400) human burials, as well as samples from 13 camelids, 3 marine fish, and 1 marine mammal from refuse deposits at Pacatnamu. All samples were collected from well-defined stratigraphic and cultural contexts.

Collagen extracted from the ground bone samples was combusted, CO$_2$ and N$_2$ extracted, and isotopic composition of the carbon and nitrogen determined by mass spectrometer using procedures described in DeNiro and Epstein (1981) and Schoeninger and DeNiro (1984). Following recommendations suggested by DeNiro (1985) and DeNiro and Weiner (1988), bone samples that showed atomic C/N ratios or percent collagen by weight values outside the ranges characteristic of fresh or well-preserved prehistoric bone were judged to have suffered diagenetic change, and were excluded from further consideration.

RESULTS AND DISCUSSION

Biometric Analysis

Results of the discriminant analyses are presented in Table 3. The discriminant function is relatively successful at distinguishing Pacatnamu crania from the Chicama Valley sample, correctly classifying more than 80% into their correct group (Wilk's $\lambda = 0.521; p = .007$). The Mahalanobis generalized distance between the two samples is relatively small, however ($D^2 = 1.91$). When the mass burial crania are entered as test cases, they are classified about half and half into one group or the other.

Cajamarca crania appear more distinctive from Pacatnamu, showing a larger generalized distance ($D^2 = 3.11$) and better classification results. The discriminant function derived from the 16 facial measurements correctly classifies 100% of the Pacatnamu crania and 100% of the Cajamarca crania. When the mass burial skulls are entered as test cases, all are classified into Pacatnamu.

The results of the discriminant analyses do not lend support to the hypothesis that the Cajamarca area was a possible source for the mass burial victims. The Pacatnamu-Chicama Valley results are more difficult to interpret. Given the fact that about equal numbers of individuals were classified into Pacatna-
Table 3. Results of discriminant function analysis of Pacatnamu Late Period crania vs. Chicama Valley and Cajamarca crania.

I. PACATNAMU LATE PERIOD-CHICAMA VALLEY

Wilk's Lambda = 0.521  (p = 0.007)
Mahalanobis D² = 1.91

30/37 (81.1%) of Pacatnamu crania correctly classified
23/27 (85.2%) of Chicama Valley crania correctly classified

TEST CLASSIFICATION OF MASS BURIAL CRANIA:
6/11 (54.5%) Classified into Pacatnamu
5/11 (45.5%) Classified into Chicama Valley

II. PACATNAMU LATE PERIOD-CAJAMARCA

Wilk's Lambda = 0.349  (p = 0.002)
Mahalanobis D² = 3.11

37/37 (100%) of Pacatnamu crania correctly classified
12/12 (100%) of Cajamarca crania correctly classified

TEST CLASSIFICATION OF MASS BURIAL CRANIA:
11/11 (100%) Classified into Pacatnamu

Figure 4. Plot of $^{13}$C/$^{12}$C and $^{15}$N/$^{14}$N ratios of bone collagen of Pacatnamu Early and Late Period human samples, superimposed on the data in Figure 3.

Isotopic Analysis of Bone Collagen

Data on carbon and nitrogen isotopic composition of bone collagen from the sample of Early and Late Period Pacatnamu burials are listed in Table 4 and plotted in Figure 4. Following the format of Figure 3, the black dot at the center of each box represents the mean isotopic ratio for the sample, while the outer limits of the box indicate two standard deviations from the mean. Isotopic values are consistent with our dietary expectations for the prehistoric Pacatnamu population: a mixed diet of C₃ and C₄ plants with substantial consumption of marine protein.

Carbon and nitrogen isotopic ratios for the faunal sample from Pacatnamu are given in Table 4 and plotted individually in Figure 5. Empty circles represent Early Period camels; empty triangles indicate Late Period camels. The single dark triangle indicates the only marine mammal sample available,
Table 4. Isotopic ratios, carbon/nitrogen ratios, and % collagen by weight for individual samples.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>% Collagen/wt.</th>
<th>C/N Ratio</th>
<th>$\delta^{13}$C</th>
<th>$\delta^{15}$N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Samples: Early Period (A.D. 600-900) N=6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2-4</td>
<td>11.3</td>
<td>3.2</td>
<td>-11.7</td>
<td>+10.6</td>
</tr>
<tr>
<td>S2-2</td>
<td>15.1</td>
<td>3.2</td>
<td>-12.6</td>
<td>+9.2</td>
</tr>
<tr>
<td>S2-3</td>
<td>15.2</td>
<td>3.1</td>
<td>-11.4</td>
<td>+11.0</td>
</tr>
<tr>
<td>S2-1</td>
<td>10.4</td>
<td>3.2</td>
<td>-11.8</td>
<td>+11.7</td>
</tr>
<tr>
<td>S2-5</td>
<td>8.4</td>
<td>3.2</td>
<td>-11.2</td>
<td>+7.3</td>
</tr>
<tr>
<td>S2-6*</td>
<td>0.7</td>
<td>4.4</td>
<td>-14.4</td>
<td>+13.0</td>
</tr>
<tr>
<td>H2B1</td>
<td>19.4</td>
<td>3.3</td>
<td>-11.0</td>
<td>+10.8</td>
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<tr>
<td>H20B1</td>
<td>21.7</td>
<td>3.2</td>
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<td>+10.7</td>
</tr>
<tr>
<td>H31B1</td>
<td>22.6</td>
<td>3.3</td>
<td>-12.4</td>
<td>+11.0</td>
</tr>
</tbody>
</table>

| Human Samples: Late Period (A.D. 1100-1400) N=10 | | | | |
| S8-1 | 10.7 | 3.1 | -10.5 | +14.2 |
| S8-2 | 19.4 | 3.2 | -13.5 | +11.6 |
| S8-3 | 22.5 | 3.2 | -11.5 | +10.7 |
| S1-1 | 8.8 | 3.2 | -10.5 | +12.1 |
| S1-2 | 15.0 | 3.1 | -9.3 | +12.1 |
| S1-3 | 18.2 | 3.1 | -9.7 | +14.2 |
| H31B1 | 27.8 | 3.3 | -12.4 | +11.0 |
| H31B12 | 24.3 | 3.3 | -10.4 | +11.7 |
| C1B1 | 23.3 | 3.2 | -13.0 | +11.5 |
| H1M1B2 | 24.6 | 3.3 | -11.0 | +8.2 |

Figure 5. Plot of $\delta^{13}$C/$^{12}$C and $\delta^{15}$N/$^{14}$N ratios of bone collagen for individual camelid and marine mammal samples from Pacatnamu, superimposed over the data presented in Figure 4. Empty circles are Early Period camelids, empty triangles are Late Period camelids; the single dark triangle is a marine mammal.

a sea lion. The three fish bone samples all had suffered diagenetic alteration and are not plotted. Carbon and nitrogen isotopic ratios for camelids fall into the expected range for terrestrial herbivores, although the $\delta^{13}$C/$^{12}$C ratios suggest substantial consumption of $\text{C}_4$ plants. The marine mammal sample falls within the expected range for an exclusively marine protein consumer.
Table 4. (continued)

<table>
<thead>
<tr>
<th>Specimen</th>
<th>% Collagen/wt.</th>
<th>C/N Ratio</th>
<th>δ¹⁰C</th>
<th>δ¹⁵N</th>
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<td>Camelids: Early Period (A.D. 600-900) N = 8</td>
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<tr>
<td>H45CM1B60</td>
<td>1.7</td>
<td>3.4</td>
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<tr>
<td>H31B11</td>
<td>18.4</td>
<td>3.2</td>
<td>-11.9</td>
<td>+7.8</td>
</tr>
<tr>
<td>S24T10</td>
<td>9.2</td>
<td>3.2</td>
<td>-12.5</td>
<td>+6.1</td>
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<tr>
<td>S24T5</td>
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<td>3.2</td>
<td>-16.2</td>
<td>+5.7</td>
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<tr>
<td>HIR6</td>
<td>0.8</td>
<td>48.2</td>
<td>-18.1</td>
<td>---</td>
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<tr>
<td>H45CM1B54</td>
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<td>47.4</td>
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<td></td>
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<tr>
<td>H1F40</td>
<td>19.5</td>
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<td>LPNP1</td>
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<td>3.3</td>
<td>-15.6</td>
<td>+4.5</td>
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<table>
<thead>
<tr>
<th>Specimen</th>
<th>% Collagen/wt.</th>
<th>C/N Ratio</th>
<th>δ¹⁰C</th>
<th>δ¹⁵N</th>
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<tr>
<td>Mass Burial: Group I</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>TIC3B1</td>
<td>22.9</td>
<td>3.2</td>
<td>-12.3</td>
<td>+10.8</td>
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<td>TIC3B2</td>
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<td>3.2</td>
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<td>TIC3B12</td>
<td>18.7</td>
<td>3.2</td>
<td>-12.9</td>
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<tr>
<td>Group II/III</td>
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<td>17.0</td>
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</tr>
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<td>TIC3B5</td>
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<td>3.2</td>
<td>-14.3</td>
<td>+12.8</td>
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<td>3.2</td>
<td>-13.0</td>
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<td>TIC3B15</td>
<td>23.7</td>
<td>3.2</td>
<td>-13.2</td>
<td>+8.2</td>
</tr>
</tbody>
</table>
Table 4. (continued)

<table>
<thead>
<tr>
<th>Specimen</th>
<th>% Collagen/wt.</th>
<th>C/N Ratio</th>
<th>δ¹⁵N</th>
<th>δ³⁴S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fist</td>
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<tr>
<td>H2C4LA</td>
<td>2.0</td>
<td>2.7</td>
<td>-12.8</td>
<td>+10.8</td>
</tr>
<tr>
<td>H2C4L6</td>
<td>2.2</td>
<td>3.4</td>
<td>-11.9</td>
<td>-</td>
</tr>
<tr>
<td>H2C2L11</td>
<td>1.5</td>
<td>3.7</td>
<td>-18.3</td>
<td>+6.2</td>
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<tr>
<td>Sea Mammal</td>
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<td></td>
</tr>
<tr>
<td>H23AR1C2</td>
<td>14.5</td>
<td>3.2</td>
<td>-11.3</td>
<td>+15.8</td>
</tr>
</tbody>
</table>

* evidence of postmortem alteration

**MASS BURIAL INDIVIDUALS**

Carbon and nitrogen isotopic ratios for individuals from the mass burial are given in Table 4 and plotted in Figure 6, where individuals from Group I are plotted as black triangles and individuals from Groups II and III are plotted as empty triangles. One individual (T1C3B6) showed anomalous values for the C/N ratio and % collagen by weight, indicating postmortem alteration, and was not plotted. It can be seen that the four individuals in Group I fall within the range of Pacatnamu carbon and nitrogen isotopic ratios. Three of the individuals in Groups II and III also fall within two standard deviations of the Pacatnamu mean values (including a borderline case). Six individuals in Groups II and III (T1C3B4, T1C3B5, T1C3B7, T1C3B9, T1C3B10, T1C3B14), however, fall outside the Pacatnamu range for ¹⁵N/¹⁴N ratios. Nitrogen values (δ¹⁵N) for these six individuals are quite low, ranging from +5.1 to +7.5‰ (parts per mil). Although the comparative sample from Pacatnamu is small, these individuals appear to constitute outliers, falling into the range of terrestrial resource consumers, and away from expected values for mixed terrestrial/marine consumers.

**Figure 6.** Plot of ¹³C/¹²C and ¹⁵N/¹⁴N ratios of bone collagen for individuals from the mass burial. Individuals in Group I are plotted as dark triangles, individuals from Groups II and III as empty triangles.

Summary statistics by group (Table 5) reveal a low mean δ¹⁵N for Groups II and III, 2.2‰ below that of the Pacatnamu Early sample, and 3.7‰ lower than that of the Late Period sample. A t-test was used to compare δ¹⁵N means between the Late Period sample and individuals from Groups II and III, but the difference was not statistically significant at the .05 level (t = 1.30, df = 17). High variability in δ¹⁵N values in the mass burial sample (s.d. = 2.6) seem to be largely responsible for the lack of significance in this case. Look-
Table 5. Pacatnamu isotope data: summary statistics.

<table>
<thead>
<tr>
<th>Sample</th>
<th>$\bar{x}$</th>
<th>s.d.</th>
<th>Min.</th>
<th>Max.</th>
<th>$\bar{x}$</th>
<th>s.d.</th>
<th>Min.</th>
<th>Max.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$\delta^{13}$C</td>
<td></td>
<td></td>
<td></td>
<td>$\delta^{15}$N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humans</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Pacatnamu Early</td>
<td>-11.9</td>
<td>0.7</td>
<td>-13.0</td>
<td>-11.0</td>
<td>+10.2</td>
<td>1.3</td>
<td>+7.3</td>
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<td>(N = 8)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pacatnamu Late</td>
<td>-11.2</td>
<td>1.3</td>
<td>-13.5</td>
<td>-9.3</td>
<td>+11.7</td>
<td>1.6</td>
<td>+8.2</td>
<td>+14.2</td>
</tr>
<tr>
<td>(N = 10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass Burial</td>
<td>-12.2</td>
<td>1.8</td>
<td>-13.8</td>
<td>-9.6</td>
<td>+11.7</td>
<td>2.0</td>
<td>+9.2</td>
<td>+13.4</td>
</tr>
<tr>
<td>Group I</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(N = 4)</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Mass Burial</td>
<td>-12.8</td>
<td>1.1</td>
<td>-14.3</td>
<td>-11.0</td>
<td>+8.0</td>
<td>2.6</td>
<td>+5.1</td>
<td>+12.8</td>
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<td>Group II-III</td>
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<td></td>
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<tr>
<td>Camelids</td>
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<tr>
<td>Early Period</td>
<td>-12.8</td>
<td>2.5</td>
<td>-16.2</td>
<td>-10.3</td>
<td>+7.7</td>
<td>2.5</td>
<td>+5.7</td>
<td>+11.1</td>
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<td>(N = 4)</td>
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<td></td>
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</tr>
<tr>
<td>Late Period</td>
<td>-13.0</td>
<td>2.9</td>
<td>-15.6</td>
<td>-9.1</td>
<td>+7.3</td>
<td>1.8</td>
<td>+4.5</td>
<td>+9.1</td>
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<tr>
<td>(N = 10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Results of the isotopic analyses of bone collagen indicate that the four individuals in Group I of the mass burial fall well within the range of carbon and nitrogen values for the Pacatnamu sample, suggesting that they consumed a similar mixed diet of marine and terrestrial resources. In contrast, nitrogen isotopic ratios for six individuals in Groups II and III of the mass burial suggest consumption of a primarily terrestrial diet, different from that of the Pacatnamu population. Although as a pooled sample, individuals in Groups II and III cannot be shown to be drawn from a population with a significantly different mean $\delta^{15}$N value from that of the Pacatnamu Late Period sample (using a t-test), $\delta^{15}$N values for six individuals fall more than two standard deviations from the Late Period mean.

CONCLUSIONS

Results of the isotopic analyses of bone collagen indicate that the four individuals in Group I of the mass burial fall well within the range of carbon and nitrogen values for the Pacatnamu sample, suggesting that they consumed a similar mixed diet of marine and terrestrial resources. In contrast, nitrogen isotopic ratios for six individuals in Groups II and III of the mass burial suggest consumption of a primarily terrestrial diet, different from that of the Pacatnamu population. Although as a pooled sample, individuals in Groups II and III cannot be shown to be drawn from a population with a significantly different mean $\delta^{15}$N value from that of the Pacatnamu Late Period sample (using a t-test), $\delta^{15}$N values for six individuals fall more than two standard deviations from the Late Period mean.

Results of biometric comparisons between the mass burial individuals and possible source populations do not suggest a northern highlands origin for any individuals, if it can be assumed that the Cajamarca samples are representative of contemporaneous northern highland populations. The discriminant function generated between the Pacatnamu and the Chicama Valley samples, in contrast, classifies about half of the mass burial individuals into each group. It is difficult to interpret the meaning of these results given the lack of other comparative samples from the Jaquetepeque and Chicama valleys. Unfortunately, the discriminant function can only classify at least one of the defined reference samples. "Neither" or "none of the above" are not possible classification options. Additional comparative samples from the Jaquetepeque and Chicama valleys might help resolve the issue, but at present none are available.

Further studies of carbon and nitrogen isotopic ratios in prehistoric north coast Peruvian populations are needed to document the degree of between-and-within-population variability in bone collagen isotopic composition and the relative distinctiveness of coastal and inland populations. Until such research is done, the results of the present study must be considered only preliminary and suggestive. Nevertheless, these preliminary results demonstrate the potential application of carbon and nitrogen isotopic analysis of bone collagen not only to traditional issues of paleodietary reconstruction, but also to the question of population affinity in unknown skeletal remains.
Acknowledgments:

We are grateful to the Peruvian National Institute of Culture for permission to export the bone samples, and to Henry Ajie and Carol Goldberg at the University of California, Los Angeles, for determining the stable isotope data. Isotopic analysis was supported by NSF Grant BNS 84-18280. Principal funding for the Pacatnamu Project was provided by the National Geographic Society and the National Endowment for the Humanities, with additional support from the Ahmanson Foundation and the Ethnic Arts Council of Los Angeles. J WV was supported by fellowships from the Organization of American States and the UCLA Friends of Archaeology, and by a Smithsonian Institution postdoctoral fellowship.

NOTES

1. The isotopically adjusted date (δ¹³C = -12.5‰) on bone collagen from a combined sample from two individuals was 880 ± 110 B.P. (Beta Analytic Beta - 10740). The calibrated date based on tables in Klein et al. (1982) is A.D. 1100, with a 95% confidence interval of A.D. 915–1280.

2. Occipital flattening is present in between 40–80% of male and female skulls sampled from seven Early and Late Period cemeteries at Pacatnamu (Verano 1987). This form of cranial deformation is characteristic of prehistoric populations of northern coastal Peru, and appears to be the result of infant cradleboarding rather than intentional head shaping (Stewart 1943; Weiss 1972). Of the eleven measurable skulls from the Mass Burial, seven show occipital flattening, four do not.

3. Isotope ratios are given with reference to international standards. Differences in the ratios between a sample and the standard are expressed in parts per thousand, or per mil (%). δ¹³C values are expressed relative to the PDB standard, which was derived from the carbonate of a fossil belemnite from the Pecka formation. δ¹⁵N values are expressed relative to the AIR standard, which is atmospheric nitrogen.

Carbon isotope ratios are expressed as δ¹³C values, where

$$\delta^{13}C = \left( \frac{^{13}C/^{12}C}_{\text{SAMPLE}} - 1 \right) \times 1000 \%$$

Nitrogen isotope ratios are expressed as δ¹⁵N values, where

$$\delta^{15}N = \left( \frac{^{15}N/^{14}N}_{\text{SAMPLE}} - 1 \right) \times 1000 \%$$

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