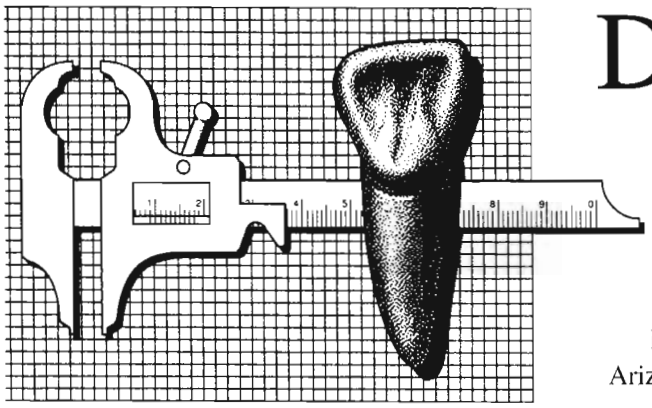

Dental Anthropology

A PUBLICATION OF
THE DENTAL ANTHROPOLOGY ASSOCIATION

Laboratory of Dental Anthropology Department of Anthropology
Arizona State University Box 872402 Tempe, AZ 85287-2402, U.S.A.

Volume 12, Number 1 **1997**

A Strategy for Comparing Odontometrics Among Groups

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Several anthropologists and human biologists have written of their disenchantment with tooth dimensions as discriminators among human groups. While the dentition consists of numerous logical variables, such as mesiodistal and buccolingual crown diameters of the 32 permanent teeth providing a measurement battery of 64 variables, all of the variables tend to behave much the same analytically because of the strong positive collinearity among them (Moorrees and Reed, 1964; Henderson, 1975; Yuen et al., 1996).

Teeth comprise meristic series, as do phalanges of the hand and foot and vertebrae of the spinal column (Huxley and de Beer, 1934). Elements within a series have a common origin embryologically, and, although they display clinal variation in size, shape, and variability, they are developmentally and functionally integrated so that, statistically, there are far fewer orthogonal vectors of variation than suggested by the many dental or bony elements. This is quite different than when an equal-size battery of craniometrics, anthropometrics, or osteometrics are analyzed because there are more statistically independent constellations of variables in these latter situations. This probably is why Falk and Corruccini (1982) found craniometrics to be more powerful discriminators than an equal number of tooth dimensions.

On a worldwide basis, tooth size of contemporary humans is distributed unimodally, but it is positively skewed because of megadont Australians (Fig. 1). In contrast, there evidently are no "microdont" peoples. A logical question is: Given the continuum in tooth size across the species, with no apparent racial divisions, what can be done analytically to distinguish among human groups? Size per se is uninformative. Put a different way, researchers have, at least since the ground-breaking efforts of Muhlreiter (1874), expended great effort collecting and publishing tooth size data, but to what end?

This paper outlines an analytical approach that removes much of the influence of size from tooth dimensions and also accounts for the considerable statistical redundancy of tooth size within and among morphogenetic fields. This approach first was first discussed at the Physical Anthropology Meetings (Harris and Rathbun, 1988; Harris, 1989), and we used it to contrast tooth size patterns of American blacks and whites (Harris and Rathbun, 1989). It also was applied to a worldwide collation of samples to show that relative tooth size differs among geographic races (Harris and Rathbun, 1991). I tended to skirt the methodological issues in these papers because they seemed straightforward (cf. Sneath and Sokal, 1973). Recent inquiries suggest that it would be useful to focus more narrowly on the method.

MULTIPLE COLLINEARITY

Correlation coefficients are positive and fairly large between crown dimensions of all 32 permanent teeth (Moorrees and Reed, 1964; Garn et al., 1965). Statistically, this means the informational content is diminished relative to uncorrelated traits because more or less of the variation among tooth

dimensions is redundant. Correlations tend to be higher within morphogenetic fields (Harris and Bailit, 1988), but all combinations of teeth exhibit significant variable redundancy.

Principal components analysis (PCA) is a multivariate statistical method of extracting a few compound variables that retain most of the shared variation. PCA is a special case of factor analysis (e.g., Harmon, 1967; Gorsuch, 1983), the technical constraint being that the communalities in the correlation matrix are set to one so the resulting vectors are statistically independent (orthogonal) of one another. On the other hand, there is a great conceptual difference between PCA and factor analysis. PCA makes no assumption about any latent model of causation; it is foremost a data reduction procedure. Factor analysis assumes that the covariance structure among the measured variables results from underlying factors that exert causal influence on these observed variables.

There has been confusion about the correlation matrix submitted to PCA. The conventional method used in numerical taxonomy is to submit the ontogenetic, inter-individual matrix measured on a sample of a biological population. PCA result of this kind are available in Potter et al. (1968), Henderson (1975), Townsend (1976), and Harris and Bailit (1988), among others. Within limits of sampling fluctuation and minor differences in method, these PCA from diverse human samples are

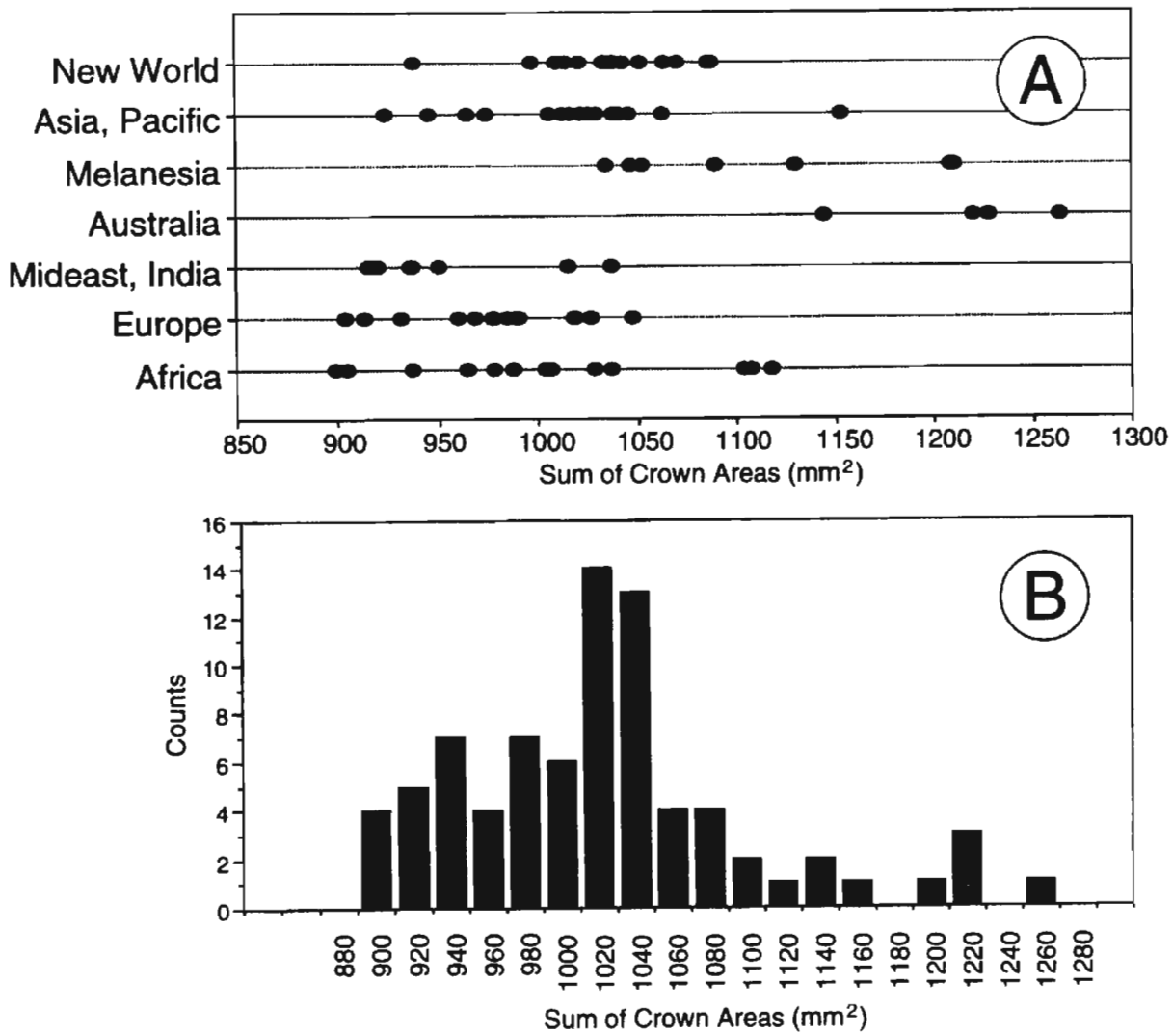

Fig. 1. Two displays of the worldwide distribution of summed crown areas for contemporary human groups (k = 79 groups). Summed area omits third molars, since data are unreported for many groups. Note the positive skewness of the histogram.

remarkably similar. Critics have claimed that the reference sample biases the result, but there is no quantitative data that the number or nature of the components differs among contemporary groups. It seems of more importance to minimize sampling fluctuation by using a large sample, such as that described by Harris and Bailit (1988).

There is, importantly, a quite different correlation matrix that can be submitted to PCA, namely a matrix generated among groups, which I term a microphylogenetic matrix. For example, a matrix of pairwise comparisons could be generated from the 78 samples used by Harris and Rathbun (1991), where the worldwide samples rather than the individuals within a sample are the observational units. There is no reason *de facto* to prefer the ontogenetic or the phyogenetic matrix, but they certainly are not the same and they have quite different interpretations. Consequently, ordination on the two matrices yields quite distinct outcomes. This makes it imperative to understand the differences. I have addressed this briefly (Harris, 1996), and a fuller interpretation is forthcoming (Harris, n.d.).

The reason to condense the raw odontometric data to principal components is three-fold. Foremost, PCA combines strongly intercorrelated variables into fewer compound variables, so there is data reduction—most of the shared variance can be redefined along the axes of major information in the data structure. Secondly, the principal components disclose the statistical and—presumably—the developmental fields controlling tooth size. This greatly aids interpretation. Teeth do not develop independently; their size and shape are determined by their position in the arches, so it makes little biological sense to analyze data univariately (Harzer, 1987). Thirdly, the principal components are statistically independent of one another, which also simplifies interpretation as well as subsequent statistical testing.

In passing, there are several schools of thought about the number of principal components to extract. If no criterion is used, there are as many components as variables in the data, but the first few almost invariably account for most of the shared variance. It has been popular to retain those components with eigenvalues of at least one. This stems from Guttman (1954) and Kaiser's work (1960). Since the variables are normalized to a mean of zero and unit variance, each contributes one unit of variance to the total variance in the data set. When a component has an eigenvalue above 1.0, it is accounting for more variance than in one variable. Since a goal of PCA is to reduce the measurement battery to a small number of components, components containing less information than one variable are trivial and discarded. This eigenvalue-one criterion is, however, inflexible and can lead to mistakes. It is not truly a mathematical criterion, but an approximate gauge.

A flexible and practical approach is the scree test (Cattell, 1966), which is a plot of the eigenvalues in the decreasing order they are extracted. A scree plot generally is an option on mainframe programs, and the visual technique is to look for a break, an inflection point, between big and small

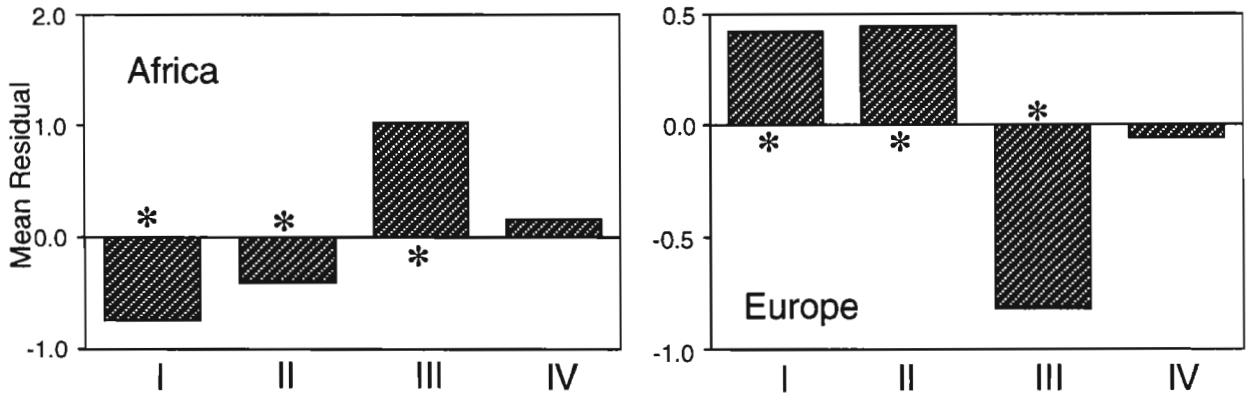

Fig. 2. Plots of the mean residual scores for four principal components averaged for 13 sub-Saharan African samples and 15 European and derived groups. Asterisks flag those residuals significantly different from zero. Africans and Europeans have mirror patterns of tooth size apportionment.

eigenvalues. Components before the break are assumed to be meaningful and are retained; the small ones are discarded, producing a truncated solution. The scree plot works best in conjunction with the eigenvalue-one criterion as an empirical gauge of the number of components to retain.

Unrotated principal components can be difficult to interpret, so the factor loadings typically are rotated to a simpler final solution. Computer programs afford several rotation options, but varimax rotation (Kaiser, 1958) is used most commonly with PCA. It is an orthogonal rotation, so components remain uncorrelated. Varimax rotation maximizes variance within a component, which means that variables' loadings are "pushed" towards 0 or 1, thereby reducing the number of variables with hard-to-interpret intermediate loadings. Rotation to a simpler solution occurs with no loss of information. Indeed, rotation is optional depending on interpretability of the initial solution.

COMPONENT SCORES

PCA does not eliminate the effects of size. Once PCA has been performed and it is decided how many components will be retained, the final solution can be used to generate principal component scores (confusingly termed factor scores) for each group. This is accomplished as an output option in most statistical packages. In brief, each variable is standardized across all samples using the conventional z-transformation. Then, for each component, the products of the variable weighting coefficient for the component and the group's z score are summed. This calculation also distinguishes PCA from factor analysis, because factor scores are summed column-wise down the weightings for a component, whereas factor analysis assumes that observed variables are linear combinations of underlying factors, so scores are summed row-wise across components (Gorsuch, 1983). Since standardization is performed across groups, those with large tooth dimensions will have large z scores and, in turn, large factor scores, and vice versa for groups with small teeth. This means that size effects are carried along to the factor scores.

REGRESSION ON SIZE

One wants to eliminate size effects, especially in dental metrics because size effects are large and they obscure shape differences. Analysis of odontometrics traditionally has been unproductive because the overwhelming effect of size produces an uninformative, one-dimensional result. There are several ways to reduce size effects (e.g., Corruccini, 1987; Darroch and Mosimann, 1985). One strategy that cannot be advocated is to discard the first principal component. It has been argued that PC 1 generally is "overall size" in biological contexts, because all the correlations of the variables on PC 1 are positive and subequal in strength. The first component generally is controlled by size, but much shape information may also reside there as well.

An alternative is to remove the effects of size using multiple linear regression (e.g., Draper and Smith, 1966; Kleinbaum and Kupper, 1978). The least squares best-fit equation is calculated for each PC score across all of the groups under analysis, and the residuals (observed-minus-expected values) are computed and saved for further analysis. Calculation and use of residuals is fundamental to regression analysis; Freund and Littell (1991) offer a useful text in this regard.

The question is what variable is a practical measure of overall size. There are several choices, but, empirically, Brace's (1980) summary measure of occlusal area, termed TS, accounts for considerable variance in the dependent PC scores. TS is the sum across the 14 tooth types of the sample's ΣMDxBL crown diameters (third molars are excluded simply because they seldom are reported in the literature). Actually, I advocate using three predictors of overall tooth size in a multiple linear equation, namely, TS, which is Σ(MDxBL), and ΣMD, and ΣBL. These three collectively are more effective than TS alone because some principal components are more aligned with length or width than area.

ANALYSIS OF RESIDUALS

A residual is the amount a group's PC score is above or below the amount predicted from size of the dentition. If underestimated, so the residual is negative, the group has a disproportionately small

score; tooth dimensions heavily weighted on that component are not as large as expected given the group's overall tooth size. Consequently, less tooth substance has been "apportioned" to dimensions reflected by that component. Inspection of residuals for the group's other components may (but need not necessarily) show where greater than predicted amounts of tooth substance have been apportioned. I originally purloined the word apportionment from Lewontin (1972) who used it in quite a different context, but its uptake by other dental researchers suggests it carries the appropriate connotation.

Figure 2 is a brief example taken from a larger, unpublished analysis. Residuals averaged for 13 samples of sub-Saharan African blacks and for 15 European and derived white groups are graphed. Other geographic groupings are omitted here. The four principal components are (1) mesiodistal widths of the anterior teeth (I1, I2, C) in the two arches, (2) an MD versus BL contrast that extends throughout the dentition, (3) MD and BL size of the premolars, and (4) MD and BL size of the molars. Fig. 2 shows that Africans—relative to their overall tooth size have disproportionately small anterior MD widths; their BL dimensions (PC 2) are smaller than expected; and their premolars (PC 3) are significantly larger than predicted. Of the several geographic groups compared, it is interesting that the European samples possess tooth size apportionments just about opposite those of Africans: Europeans are characterized by relatively large anterior teeth, large buccolingual crown diameters, and small premolars. Africans and Europeans have experienced opposite approaches to the apportionment of tooth size across the morphogenetic fields. In passing, neither group departed from expectation for molar size (PC 4). It seems that Amerindians are the only geographic group to do so; they have disproportionately large molars (Harris, n.d.).

OTHER APPLICATIONS

This method has been used to assess broad differences among human groups at the level Garn (1965) termed geographic races (Harris and Rathbun, 1991; Harris, n.d.). Others (Hemphill, 1991; Lukacs and Hemphill, 1993) have applied the method within a culture area. It also should be insightful to apply the method to temporally sequenced samples (e.g., Hinton et al., 1980), since it is unlikely that change in size of the dentition would be isometric across all morphogenetic fields.

The nature of sexual dimorphism also can be explored with this method. Sexual dimorphism has been defined as a difference in size (e.g., (M-F)/F) on a tooth-by-tooth basis (e.g., Garn et al., 1967b), but the apportionment of tooth size provides a different perspective. First, the method combines individual dimensions based on their statistical and, presumably, genetic relationships, so one is dealing with compound variables incorporating metric information across several teeth. This should be more truly reflective of the underlying control mechanisms governing tooth size than repeated univariate comparisons (Potter, 1972). Secondly, dimorphism would be defined as a difference in the apportionment of size across teeth, so there is a multivariable comparison of relative size (shape) between the sexes. This would complement research that found univariate sex differences in crown shape (Garn et al., 1967a; Rosenzweig, 1970).There is no restriction to using this method with humans; it should prove as insightful when applied to other species.

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RESEARCH WORLD:
FOREIGN CORRESPONDENT OCCASIONAL REPORTS 1: Russia

CHRISTY G. TURNER II
Member, DENTAL ANTHROPOLOGY Editorial Board

Whereas research in dental anthropology is, as in any science, ideally unaffected by sociopolitical boundaries, in fact, economic, political, and social conditions can have marked effects on what can and cannot be done within a specific national, state, tribal, or institutional context. Two timely examples in the U.S. are the numerous ways that the NAGPRA and Smithsonian laws have affected research on Native American and Hawaiian skeletal remains.

These conditions can affect research in obvious as well as subtle ways, including the degree to which international or tribal cooperation is permitted. As a way of aiding those members of the Dental Anthropology Association who might want to carry out an overseas, foreign, or tribal research endeavor, this section of our journal is being started for the occasional reporting of regional research conditions as seen from an internal or autochthonous point of view. Not only do such reports help alert the researcher to local conditions that might have an effect on the project at any time from funding to finish, they do so without being affected by cross-cultural interpretations.

Hence, the editor and editorial board would much appreciate knowing (a) about articles such as the one that follows, so that a report might be published in a timely fashion, and (b) whether the readership finds this section worthwhile. We also wholeheartedly encourage any of our membership to submit reports of their own on research conditions they may have encountered anywhere in the world where dental anthropology is on-going.

SCIENCE CAN SAVE HUMANITY

The Last Interview of a Distinguished Scholar: Academician V. Koptyug

Published in *ARGUMENT AND FACT* 1997(4):3
Translated by Olga Pavlova, Novosibirsk, Russia, clarifications in brackets [ ] by Christy G. Turner II

Our associate Natalia Zheluorova talked with the President of the Siberian Department [Branch] of the Russian Academy of Sciences, Valentine Koptyug, in late December in Novosibirsk. It happened to be the last interview of this outstanding scientist. On January 10 of the present year he died at the age of 65.

Valentine Afanasievich [Koptyug], tell us please, how do Siberian scientists survive? What is your [and their] condition at the present time?

The condition of science in Russia is bad. This is connected first of all with economical reasons. Financing the Siberian Branch is less than fourteen times [its former level]. [To date] the population of the Branch has been reduced from 55,000 to 37,000 people. And this [reduction] continues because each day people hear that the most important occupation now is business and the financial system. Some people go where they can earn something; others go into local administration or go abroad.

To work in administration is not bad. If scientists participate in this kind of work, maybe they will be able to make correct decisions.

But the problem is that there are too many different official structures that do not want to take responsibility for decision [making]. If scientists were able to bring [to administration] their systematic approaches, then it will have some sense. Going abroad by scientists is rather essential but it is not dangerous for us. These are mostly young scientists engaged in fields that are today most profitable for industry (for example, biotechnology). If specialists go for a few months, it is all to the good since [such travel leads to] information Exchange. If they leave permanently, this is also not a disaster because to date only 200 people have left the [Siberian Branch].

Two hundred people. Are you not sorry [for this loss]?

Not very much because we have a very powerful system of training scientists. The basic education is two to three years at some Institute. Then young people prepare their diploma research, not formally but as contributions to particular problems [worked on] by particular groups of specialists at the institutes. This preparation presents the possibility for obtaining a full and sound basis of

knowledge so that a young specialist can continue to learn throughout life. If the specialist was educated in the Siberian Branch, he can easily change even his specialization. If people go abroad to work under contract for a year or two or three, they come back and say: 'Of course, everything is good there from the materialist point of view, but it is of no interest to work there: specialists are very dependent professionally. They are not accustomed to go outside their scientific fields.' And ours, on the contrary, try to work on multidisciplinary grounds. Some of the scientists try to come back home in order that their children might have the possibility of being educated at home.

As the world moves to the year 2000, it is suggested to be full of different kinds of disasters and troubles, even to the complete extinction of humankind. What do scientists think of this? Does this worry them?

Yes, we are worried by the global problems of mankind. An example is ozone holes. We still do not know how they originate. There have been many proposals on how to combat them — some even funny — but it is impossible to undertake [a solution] until we fully understand a phenomenon. Each problem requires much knowledge before making decisions [about solutions]. Another problem is poor people. If the standard of living for the poorest part of the earth's population is raised even a little bit, we will immediately feel a lack of resources. In this case, the consumption of resources in the advanced countries should be decreased as much as 30 times. You see how it is all complicated. Saving mankind requires a maximum application of science.

A massive intrusion of computers in our lives has made human relationships more dynamic. Any form of information is now accessible to everyone who wants it. Does it mean that this is a great advantage for scientists in their attempts to solve the main problems of mankind?

But have you not noticed that due to computers we observe movement from a society to an individual? In the West they are aware of the danger of individualization. One tries not to share his information with another. They are very afraid of the competition and are not accustomed to work in a heap.' Earlier we had communication [in the form of personal contacts] and now we have computers. There is no need to go to the library [or] to attend conferences. Computerization makes life's speed very fast. But contacts between scientists are very important, and we insist on communications between our specialists. A person writes a paper, and he proposes it for discussion at a seminar. He must answer all questions and correct his paper (if needed) by taking into account all the comments and criticisms. This is our form of communication.

I know that scientists are specific [exceptional?] people — not of this world,' and their interest in their work is more important for them than payment for it. Maybe, you do not feel that you are deprived of something?

No, no, that is not true. Of course we sense everything. The problem is that even creating a genius project we are unable to introduce it into practice. Now scientists try to earn [income for] themselves... We started to develop the applied directions in order to realize the achievements made earlier in commercial activities. But, only very few of [these projects] succeed. For example at the Dobretsov Institute (the Institute of Geology), there are two joint ventures with foreign firms. One of them is the production of synthetic diamonds and semiprecious stones. This is really very high technology and very expensive products. Another enterprise product is on a lesser scale — supersensitive chromatography, which makes possible the locating of plastic land mines as much as one half meter below ground. Custom houses and detective agencies are interested in such technology. But, you can see that they are very complex approaches. Simple ones do not provide any profit [because] everything goes for taxes and transportation.

This is so pleasant to hear that science nevertheless 'rolls' and survives.

Yes, we succeeded with the aid of joint ventures, and Soros grants, and Russian funds for basic research. Some Institutes, for example that of Nuclear Physics, earns by itself three quarters of its [annual] budget. This is a powerful Institute. It produces industrial type technologies, including accelerators. They sell their products all over the world. In spite of the reduction in the government budget we could maintain the Siberian Branch as a system [of scientific institutes]. We have 100 institutes and we must survive together. Our strong point is in our maneuverability. We have to

rebuild some of the institutes [in order to] make them structurally fit the realities of the present day. Not all of them will survive. In this case, it is better to invest money in those institutes that can adapt to modern conditions.

The Soros fund is always an object of argument. Some people say that it helps us, others say that it robs us.

The Soros fund behaves rather correctly, although we have had a few very bitter lesions while making contracts with foreign partners. With respect to the Soros fellowship we do not have any pretensions. I can say more. If he is able to earn a lot of money in the financial markets and is engaged [also?] in non-profitable activity, then he is an ingenious man. Recently he was asked to participate in a TV program, and in answer to a question about the present situation in Russia he remarked: 'I cannot understand many of your reform decisions. You have established some control organs that look for coins, for trifles, and at the same time, so many good things are wasted.' I share his point of view. I too do not understand why we first receive money (from the state budgets and they take taxes. Why not take first what they want to take and then give us what remains?

What are, in your opinion, three main troubles of society?

The global problem is our social disparity. For the last 30 years the disparity in the world doubled — twenty percent of the richest people dropping into twenty percent of the poorest layers of the population. In the U.S.S.R. thirty years ago, it was [the ratio of rich to poor] 1:6, and now in Russia it is 1:30. In Moscow they do not appreciate how people of distant regions live. And they live terribly. All that they earn goes for food. People cannot afford anything else.

Our society has crashed morally. Let us take the Novosibirsk region [for example]. People are so exhausted that all they want is strong power and order. If Boris Nikolaevich [Yeltsin] had possessed a real sense of things he would have behaved in a different way.

Is it so difficult to learn the real sense of things?

Here we have a psychological moment. A real situation scares and [we] do not know how to learn anything [adapt?]. Even Chernomyrdin does not know the actual situation, although he stands nearer to industry, to the nation. Two other troubles are very definite. These are corruption and criminality.

By the way, why are Russians so easily deceived?

Chekhov wrote that 'it is very difficult to understand a Russian intellectual. Either he wants democracy or sturgeon with horseradish...' Unfortunately, a lot of bad things were done by the hands of the Russian intelligentsia. Our Novosibirsk scientists tried to call a spade a spade, and to forecast events not for two years ahead but for many years. The transition to the condition of copying the West and the attempt to introduce the free market is great nonsense and it can only end in catastrophe.

Recently I went to China, to the central region that I visited more than five years ago. I was greatly impressed by the changes. [There has been a] reasonable introduction of market reforms, and a rise in labor productivity. Control mechanisms have led to the desired results. As for us, we did not take into account that the majority of goods [produced] in Russia would be more expensive than in other countries, even with the same [level of] labor productivity.

Why does it happen?

First of all, [there is] climate. It is warm in the U.S.A. And here we have a different pattern. Expenditures for fuel and transportation make goods (and foodstuffs) more expensive. We do not have favorable conditions (for example broad rivers that do not freeze in winter and which could be used for delivering communities). And if we do not have them, we should not compete. Our task is to fight for high technologies.

Did our local administrations achieve anything [in dealing with] these conditions?

Maybe now they have more definite ideas concerning local conditions. But there is as yet no systematization (in managing local industry), most probably because it is lacking at the governmental level. I spoke recently to a businessman from South Korea about the possibility of organizing joint ventures. He said: 'Your economics are unstable. We are frightened by this fact. We would be better to move into communistic China. What do we call democracy? When you (as we do) confront a

couple of your Prime Ministers so that they have to account for all they had done, then I will tell you, yes, you have democracy.'

Does foreign capital support you?

The authority [reputation?] of the Siberian Branch is very high. Our foreign partners support us in creating here international scientific centers. We have one [complete] such center and one unfinished one. We have built a system of survival.

Valentine Afanasievich [Koptyug], what are your proposals for science to our President?

Without education and science, Russia, as with any other country, does not have any future. Now, our scientists are formulating a common-civilized conception of a stable development that is in its essence, socialistic. I have remarked already that Russia was prepared for this concept much better than any other country in the world. We have great resources. We have great industrial and agricultural potentials. [Our] society's mental outlook facilitates the acceptance of the socialistic concept. It should be taken into account that we have advanced much along this socialistic [path], although not without plenty of errors. We must become world leaders of the new way. The main idea of this [new] way is in [producing] a balance [between] economic and social development, and the preservation of the environment.

What are your predictions as a scientist? In the socio-political aspect...

I believe in the re-creation of Russia. And this re-creation will be possible only through the introduction of normal governmental regulation [balanced] with some reasonable elements of the [free] market. But, many elements of the present economical conditions must be reversed. If earlier, the Church was separated from the State, now Science is separated from the State. If earlier, we did not like the way of helping our agricultural state farms, now we do it ourselves (we grow potatoes and cabbages), and spend for this not the two days [as in the past], but much more time.

DENTAL ANALYSIS AND DETERMINATION OF OCCUPATIONAL ACTIVITIES IN A PERUVIAN FORMATIVE POPULATION

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ABSTRACT Dental analysis of the individuals excavated from the Roca Verde Site in southern Peru demonstrated a relationship between dental pathology and sex-related occupational activities in a Formative Period population. Instances of dental attrition, abrasion, and premortem and postmortem fractures were the majority of the dental pathology. The pathological conditions were categorized according to sex. Macroscopic and microscopic investigations of the dentition provided evidence for a sex-related occupational dichotomy.

INTRODUCTION

Sex-related occupational dichotomy in the form of demal usage of the dentition during textile processing can be determined through examination of dental attrition and abrasion and analysis of dental calculus (Nelson, 1997). Samples of male and female teeth, representing the Roca Verde population, were analyzed macroscopically and microscopically to determine a pattern between dental wear, phytolith content of dental calculus, and occupation. The significant differences between male and female attrition and calculus content demonstrate that female dental pathology was mainly caused by textile processing (Figs. 1 and 2).

Roca Verde is a coastal site located in the Atacama Desert of southern Peru. Based upon archaeological evidence, the Formative Period (ca. 1000 BC) is the approximate date for the site (Burger, 1988; Moseley, 1992). Excavation of the Roca Verde site produced roughly 130 features[1] of human skeletal remains that could be used for analyzing the frequency of skeletal pathology. Most of the features were adults aged 20-30 years, although the remains also included infants, juveniles, and older adults.

The skeletal and dental examinations revealed frequent dental attrition and abrasion, postcranial osteoarthritis, and some instances of skeletal fractures. This report focuses only upon the frequency and severity of dental attrition and abrasion within the Roca Verde population.

MATERIALS AND METHODS

For the macroscopic analysis, a total of 418 teeth from the Roca Verde collection were analyzed on location in Peru. Tooth sockets for missing teeth were also examined to determine whether the tooth had been lost premortem, postmortem, or due to an abscess. Many of the features from the site contained fragmentary remains that could not be sexed or aged. A sub-sample of 14 features became the primary focus of the analysis.

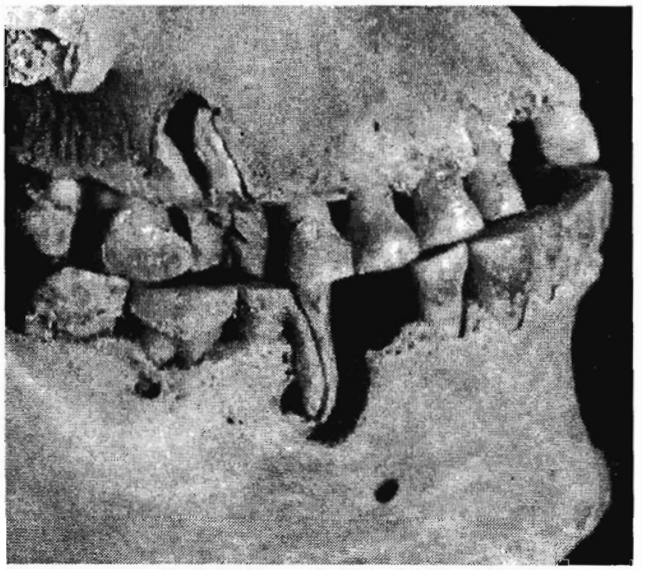

Fig. 1. Feature E 23, right side. The mandibular first molar demonstrates a premortem fracture running longitudinally from the occlusal surface of the crown to the apex of the roots.

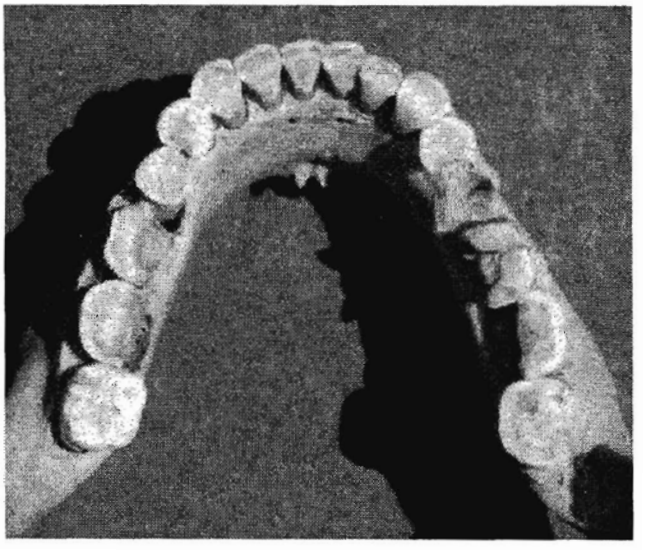

Fig. 2. Feature E 23, occlusal view of the mandibular dentition. The right first molar has polishing of the exposed dentin, indicating that the tooth was continually used until death.

The 14 features were chosen based upon the completeness of both the skeletal remains and the dentition. Seven female features and seven male features were included in the study. The mean age for the female features was 27.0 years old and the mean age for the male features was 27.2 years old. Sex determination was based upon characteristics of the innominate, clavicle, mandible, and the robusticity of the long bones. Age determination was based upon the methods of Brooks and Suchey (1990) for aging the pubic symphysis and Szilvassy (Steele and Bramblett, 1988) for aging the clavicle.

Nelson and Dr. Karl J. Reinhard, University of Nebraska-Lincoln, developed a scoring method applicable to the attrition and abrasion in the dentition found in the Roca Verde features. For each type of tooth, scores were recorded for no wear, mild wear, moderate wear, severe wear, dental abscess, premortem loss, and postmortem loss.

The dental attrition and abrasion of the sample was scored with the following methodology. For the incisors and canines: no wear = no wear; mild wear = polishing (smooth and bright surface due to rubbing) of the enamel to polishing of the enamel with a thin line or one small exposure of dentin; moderate wear = wide line or large area of dentin exposed; severe wear = only a rim or partial rim of enamel around dentin. For the premolars: no wear = no wear; mild wear = polishing of the enamel to polishing of the enamel with an exposure of one point of dentin; moderate wear = exposed dentin; severe wear = no enamel on occlusal surface and a rim or a partial rim of enamel exhibited on the margin of the tooth. For the molars: no wear = no wear; mild wear = polishing of the enamel to polishing of the enamel with exposure of one to four points of

dentin; moderate wear = most occlusal enamel worn away with large areas of dentin exposed; severe wear = all occlusal enamel worn away except for a rim or partial rim of enamel surrounding dentin.

For the statistical investigation, the chi-square analysis was used. The purpose was to show the presence of significant differences between the frequencies of the variables.

The microscopic analysis was done using the Scanning Electron Microscope (SEM) on a different sample of teeth from the Roca Verde population after the macroscopic analysis was completed. The intention of the analysis was to determine any significant difference between male and female microscopic dental features, and whether the difference corresponded with the results of the macroscopic analysis. Since the teeth have been shown to be important in processing solid vegetal material (Nelson, 1997), the occlusal surface should reflect the activity.

A number of loose teeth from the laboratory at Centro Mallqui in Peru were analyzed at the University of Nebraska. In total, 23 teeth from the Roca Verde Site collection were used for SEM analysis. Three female features (fourteen total teeth), one male feature (four total teeth), and two unidentified features (five total teeth) represented the sample.

Parallel striations were apparent on the occlusal surface of all the teeth used in the SEM analysis. To determine if there was a difference between the number of striations on the female and male teeth, SEM micrographs were taken of every tooth. The first micrograph was taken at a magnification between 1000X and 1500X. The second micrograph was taken in approximately the same region as the first micrograph, but at a magnification between 4000X and 5000X. The most precise working distance, 10mm, was consistent for each micrograph.

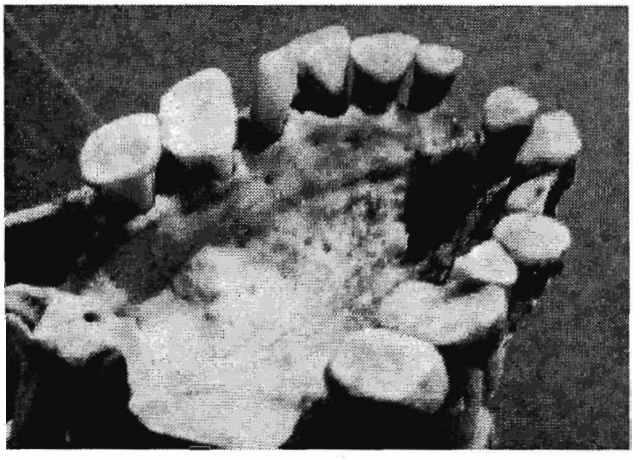

Fig. 3. Feature E 21-1, occlusal view of the maxillary dentition. The dental attrition and abrasion is typical for the females in the population. The severity of the dental attrition is the result of textile processing.

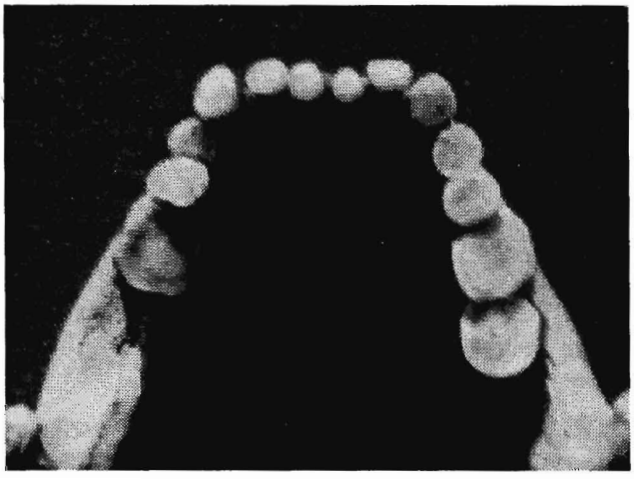

Fig. Fig. 4. Feature E21-1, occlusal view of the mandibular dentition.

Incisors, canines, and premolars were evaluated with SEM techniques. Micrographs were taken on the labial mesial surface of the incisal edge. The occlusal surfaces of canines and premolars were first scanned for the presence of striations. Then the micrographs were taken at the location of the recognizable striations. Molars were not included in the sample for microanalysis, due to the severity of wear and the exposure of dentin.

Dental calculus was removed from the teeth of five of the features. A sample of totora[2] matting made from species in the genus *Scirpus* (Reinhard, 1997) was taken for the extraction of phytoliths. The samples were dissolved and the macroscopic components were examined by light microscopy and SEM. A detailed description of this analysis will be included in a future publication by Reinhard and Nelson.

RESULTS

According to the macroscopic analysis, a large difference existed between female and male attrition and abrasion. Female features, in general, showed a greater frequency and severity of dental attrition and abrasion than did

the male features (Figs. 3 to 6). The variations between males and females in overall dental pathology, mainly attrition and abrasion, were statistically different (χ^2=53.12, p<0.001). A meaningful difference between males and females was seen in the first and second premolars (χ^2=9.82, 0.005>p>0.001) and in the lateral and central incisors (χ^2=6.53, 0.025>p>0.01). The statistical difference was also significant in the first and second molars (χ^2=9.29, 0.005>p>0.001). The chi square values for the canine teeth (χ^2=2.85, 0.10>p>0.05) were not significant.

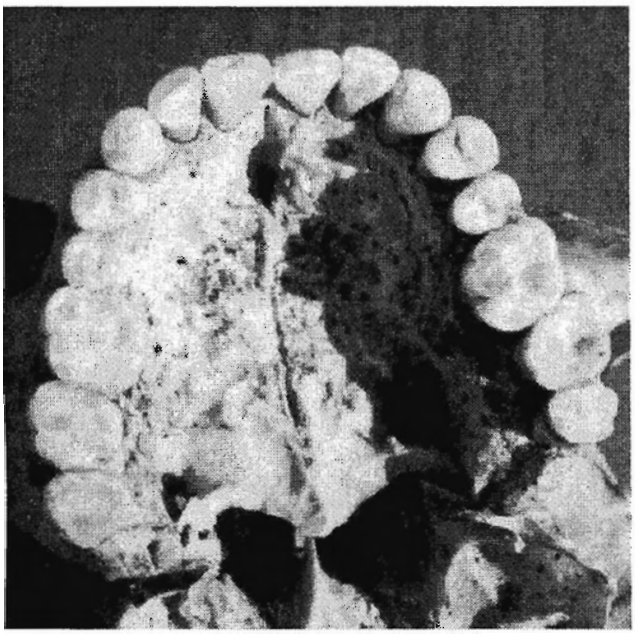

Fig. 5. Feature E 21-2, occlusal view of the maxillary dentition. The typical case of male frequency of dental attrition and abrasion is demonstrated by E 21-2, a male in his early to mid-twenties. Although some small areas of dentin may be exposed through the enamel, the frequency and severity of dental attrition and abrasion are much less than those in the females in the population. Features E 21-1 and E 21-2 were associated in the same burial.

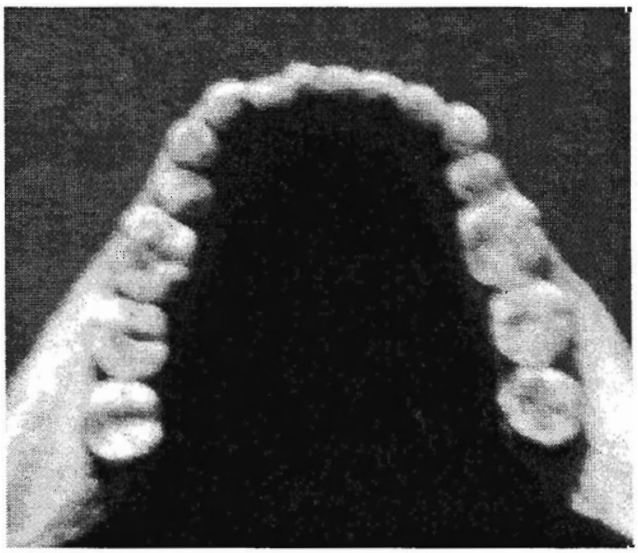

Fig. 6. Feature E 21-2. Occlusal view of the mandibular dentition.

Microscopic results were less significant than the macroscopic results in demonstrating a dichotomy between male and female dental pathology. Microscopic analysis revealed a number of attrition-based striations visible on the surface of most teeth. Quantitative differences of striations were not significant between male and female features.

Examination of the dental calculus from all of the females revealed fibers and phytoliths consistent with the types present in the textiles. Fragmented cotton fibers dominated in three female samples, indicating the use of teeth to prepare cotton, probably for weaving. Silica phytoliths consistent with totora, squash, and beans were also found. Manioc and maize starch grains were both present in male and female dental calculus. A variety of phytolith shapes, which could not be identified taxonomically, were also found.

DISCUSSION

The macroscopic analysis demonstrated significant differences between male and female dental attrition and abrasion. The variations between male and female overall dental pathology were statistically significant for the incisors, premolars, first molars, and second molars. The canines were the only teeth that failed to demonstrate a statistical difference for cases of male and female dental attrition and abrasion. Also, every female mandibular tooth in the analysis exhibited dental pathology.

Microscopic analysis (SEM) indicated striations on almost every tooth in the sample regardless of sex. Due to severe attrition and exposure of dentin, striations may have naturally eroded away on some teeth, especially the severely worn female teeth, leading to an inaccurate determination of the number of

striations present. Further testing of the actual surface of the tooth may reveal the chemical components still present on the tooth at the time of death, which possibly could have led to the surface reduction of the tooth.

The presence of phytoliths and fibers in the dental calculus, which are consistent with those in the textiles, suggest that dental wear was caused by textile processing. However, the dental calculus analysis showed that totora was not the only phytolith source of dental abrasives. Along with vegetal fibers from wood and cane, the calculus also contained grit and maize, bean, and squash phytoliths.

The frequency of female dental attrition and abrasion was most likely the result of basket and textile processing. The female wear appears to be too severe to have been caused strictly by diet. Moreover, analysis of the dental calculus exhibited dietary phytoliths on both male and female teeth. However, cotton fibers, cane, and totora phytoliths were demonstrated mainly on female teeth. The macroscopic, microscopic, and phytolith evidence suggests that the excessive attrition and abrasion of the female teeth in comparison with these conditions in the male teeth was likely caused by the processing of vegetal remains related to textile production.

CONCLUSION

The differences in dental attrition and abrasion between male and female features can be attributed to sex-related occupational dichotomy. Analysis of dental calculus from samples of Roca Verde teeth revealed phytoliths from totora, cotton fibers, and other vegetal material. Maize, Cucurbit, and bean phytoliths were also discovered in the dental calculus. Most likely, the totora and vegetal fibers from wood and cane used to make baskets and textiles (True, 1980) caused the severe attrition and abrasion of the female teeth. The severe dental pathology, along with the collaborating evidence of the presence of textile phytoliths in the dental calculus supports the hypothesis that textile processing was a major task for the females of the Roca Verde population.

[1]A feature is one skeleton.
[2]Totora is a phytolith-rich plant from a species in the genus *Scirpus*.

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ACKNOWLEDGMENTS

I would like to thank Dra. Sonia Guillen and Drs. Karl J. Reinhard, Matthias I. Okoye, Doug Scott, and Dan Tylka for their scientific support and guidance. I would also like to thank Lisa A. Fitzpatrick and Kate Blue for their editorial comments. The University of Nebraska and Karl J. Reinhard funded my research. Dra. Sonia Guillen, Dr. Jane Buikstra, Dr. Roxie Walker, and other workers involved with the Centro Mallqui kindly permitted my access to the laboratory and to the Roca Verde population.

DENTAL ANTHROPOLOGY ASSOCIATION SECTION

NEWS OF THE DENTAL ANTHROPOLOGY ASSOCIATION AND ITS MEMBERS

Dahlberg Scholarship Established at the University of Toronto

JOHN T. MAYHALL
Faculty of Dentistry, University of Toronto, 124 Edward Street, Toronto, Ontario, M5G 1G6, Canada

The Faculty of Dentistry, University of Toronto, has established a new entrance scholarship for the D.D.S. Program. The Albert Dahlberg Admission Scholarship will be awarded for the first time in 1998 to an entering dental student, who has received a Master's or Ph.D. degree before entering into the program. The award will be based on academic achievement and demonstrated need. The award is to honor the memory of Albert A. Dahlberg, one of the founders of modern dental anthropology. He has a profound effect on the study of dental morphology, a major part of a dental student's early education.

Note from the Secretary/Treasurer

STEPHEN C. REICHARDT
Department of Anthropology, Arizona State University, Box 872402, Tempe, Arizona 85287-2402, U.S.A.

Hello! First and foremost, I would like to officially welcome all our new members. Also, I would like to take this opportunity to announce that since the release of our last issue, our Association has maintained an average of seven new memberships a month. I am pleased with our growth and hope to see this positive trend maintained in the coming months.

December 31 is still off in the distance but, just in case there are any questions, this is the date when the 1998 fees are due. Unfortunately, we still have some members who are not current for 1997. Past due notices have been sent to all of the non-current members and hopefully we can count on everyone for their support. If you have any questions about your membership status, you can call me at (602) 965-0156 or e-mail me at srsrs@imap2.asu.edu. I can also be reached by mail at the Department of Anthropology, Arizona State University, Box 872402, Tempe, Arizona, 85287-2402.

Thanks to everyone for their help and support. This year promises to be a good one for our association.

Corrections in the Membership List

The following is a correction of an address in *DENTAL ANTHROPOLOGY NEWSLETTER* (11:2).

Chiu, Alison L.S., 16A Alfred Street, Woolwich, Sydney, NSW, 2110, Australia, Telephone (+612) 9351 4319, Fax (+612) 9351 2813, achiu@anatomy.su.oz.au (dental anthropology).

Guidelines for Contributors to *Dental Anthropology*

A.M. HAEUSSLER
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1. Articles have short abstracts. Text format, citation, and abbreviation styles follow those used by *American Journal of Physical Anthropology*. Names of journals that are not familiar to readers are spelled out. The feature, *Recent Publications*, contains unabbreviated citations.
2. Illustrations and photographs enhance articles and are encouraged. They will be returned, if the authors so request. Graphs should be accompanied by a table containing the data, even if the table is not to be published. In that way, the editor can construct a new graph if the one submitted presents problems in formatting.
3. Two copies of each manuscript should be submitted. The second copies of illustrations can be photocopies. Contributors are also asked to send a copy of the manuscript on diskette, if possible The newsletter uses IBM© format and *Word Perfect* 6.1©.
4. Deadlines for manuscripts and membership lists for the next issues are November 15, 1997; March 15, 1998; and August 15, 1998. Manuscripts and membership lists received after these dates will be considered for future issues.

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Volume 12, Number 1, 1997

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Volume 12, Number 1, 1997
Published three times yearly

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