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MORPHOLOGICAL VARIATION OF THE PERMANENT DENTITION IN PREHISTORIC OHIO

ABSTRACT. — Forty morphological characteristics of the permanent dentition in samples ranging from the Late Archaic (ca. 1500 BC.) to Middle Mississippian (ca. AD 1200) time periods are scored for 97 expressions. The expressions of the characteristics are examined for temporal and spatial variation using correspondence analysis. Approximately 25 % of the characteristics exhibit stability of expression through time and with respect to geographical location.

The results obtained for the prehistoric Ohio Amerindians are compared to other Amerindian groups in eastern North America and to other world populations. A number of character expressions are found to be associated with various population groupings.

KEY WORDS: Dental morphology — Geographical variation — Chronological variation — Prehistoric Ohio.

INTRODUCTION

Morphological variation of the dentition in prehistoric eastern native Americans falls within a range of trait expressions referred to as the Mongoloid Dental Complex (Hanihara 1967, 1969). This complex includes moderate to high frequencies of traits such as shovel shaped incisors, five cusped lower, first and second molars, protostylid, lower first molar cusp 6 or tuberculum sextum and metaconule. Although the Mongoloid Dental Complex serves to unite taxonomically east Asian and east Asian derived populations Turner's investigations (1979a, b, 1981) showed variation within this complex. Turner described two major subpatterns within the Mongoloid Dental Complex. The first subpattern, termed SINODONTY, generally is expressed as a complicated dental morphological phenotype, i.e., the characteristics of the Mongoloid Dental Complex are present at high frequencies and with an intensive expression. The Sinodont subpattern is found almost exclusively in northern east Asian populations and in native Americans. The second subpattern of the Mongoloid Dental Complex is referred to as SUNDADONTY. The Sundadont subpattern, in contrast to Sinodonty, generally shows lower frequencies and a less intensive expression of Mongoloid Dental Complex traits. The distribution of Sundadonty is in populations of southern east Asia and the Pacific islands. In Turner's opinion (1979a) subsistence base and technological level of populations contributed to the divergence of these subpatterns. Sundadonty may have been a response to the early development of domestication in the Late Pleistocene of Southeast Asia since a less complex dental morphology generally resists caries formation (Kerr and Ash 1978). The phenotypically more complex Sinodont pattern is hypothesized as a response to masticatory stress in Arctic and Sub-arctic hunting and gathering populations wherein greater surface area would prolong the life of the tooth and, by extension, the life of the individual.

Within this theoretical framework the purpose of the present study is to examine dental morphological variation in a series of prehistoric eastern North American populations from the Ohio Valley and lower Great Lakes region in order to investigate their relative placement in the Mongoloid Dental Complex and to determine which dental characteristics contribute to their placement. These populations should provide information on dental morphological microevolution since they span approximately 2,500 years and they represent both hunting and gathering populations and full time horticulturalists.

MATERIAL AND METHODS

The prehistoric American native populations which we analyzed in this study are presented in *Table 1.* Temporally, the earliest populations we sampled are from the Late Archaic Glacial Kame and Western Basin complexes. The Glacial Kame complex is represented by four populations from northwestern and central Ohio with a sample of 61 individuals. The Late Archaic Western Basin is represented by the Williams Cemetery site with a sample of 38 individuals. Populations in these complexes were pre-pottery and pre-agriculture and subsisted primarily as hunter-fisher-gatherers with the inclusion of some native cultigens (Sciulli 1979). The populations sampled from the Glacial Kame and Western Basin Late Archaic fall with the time span of 1000—500 BC. In time, the next sampled groups are the Early Woodland Adena represented by three populations in central Ohio with a sample size of 59 individuals and the Middle Woodland Hopewell also in central Ohio and represented by three populations with 47 individuals. The populations sampled for this study from the Adena and Hopewell groups were extant from about 300 BC to AD 300, possessed and utilized pottery and, even though there was an intensification of the use of some native cultigens especially among Hopewell populations, the basic subsistence remained hunting-fishing-gathering. The temporally most recent groups we sampled are the Fort Ancient and Sandusky Bay Traditions. The Fort Ancient Tradition is represented by 29 individuals from the Anderson Village site in southwestern Ohio which dates to between AD1200—1300. The Sandusky Bay Tradition is represented by 41 individuals from the northern Ohio Pearson Village Middle cemetery site which dates to approximately AD 1500. The populations at Anderson and Pearson Villages practiced full time horticulture using the major tropical domesticates of maize, beans and squash. The inferences concerning subsistence base for these groups are supported also by two indirect sources. First the frequency of dental caries in these and other groups spanning the time range 2500 BC—AD 1610 shows a marked increase at about AD 900—1000 rising from a frequency of less than 5 percent to between 15 and 20 percent (Sciulli, et al. 1982; Sciulli and Schneider nd.). A similar pattern of increase is seen in the amount of carbon 13 from skeletal remains in this area (Bender et al., 1981). These sources as well the recovery of the actual food remains indicate the shift to full time horticulture in this area did not occur until about AD 900. In *Table 1* the Glacial Kame, Adena and Hopewell populations are pooled and are represented as the Ohio Woodland. The rationale for this grouping will be presented below.

TABLE 1. *DENTAL TRAIT FREQUENCIES. I^1 shovel (3—7/0—7), I^2 lingual groove (1—5/0—5), I^2 tuberculum dentale (1—5/0—5), M^1 Carabelli (1—7/0—7), M^2 hypocone (2—5/0—5), $P_{ant.}$ lingual cusps (1—9/A—1), M_1 C6 (1—5/0—5), M_1 C7 (1—4/0—4), M_1 Protostylid (1—6/0—5), M_2 four cusped (4/4—7)*

	I^1 Shovel Shape	I^2 Linqual Groove	I^2 Tuberculum Dentale	M^1 Carabelli Complex	M^2 Hypocone	$P_{ant.}$ Linqual Cusps	M_1 C6	M_2 C7	M_1 Protostylid	M_2 4-Cusped
Eskimo	.78	.78	.67	.14	.83	.47	.44	.15	.19	.04
Aleut	.72	.61	.20	.06	.58	.37	.45	.09	.25	.11
Na-Dene	.83	.61	.40	.24	.86	.46	.50	.07	.35	.04
Indian	.92	.50	.37	.36	.89	.43	.56	.10	.40	.08
Jomon	.30	.66	.63	.11	.83	.16	.58	.02	.34	.31
Easter Island	.28	.07	.37	.26	.78	.43	.20	.23	.40	.53
Ainu	.29	.43	.35	.31	.73	.21	.26	.04	.23	.58
New Britian	.06	.04	.35	.46	.79	.60	.32	.11	.18	.61
Ohio Woodland	1.00	.52	.23	.58	.81	.19	.51	.06	.25	.06
Anderson	.95	.44	.20	.41	.81	.05	.38	.06	.50	.50
Pearson	1.00	.43	.14	.22	.74	.19	.18	.03	.40	.56
Williams	1.00	.45	.07	.30	.93	.14	.43	.05	.59	.11
Modern British	0.15	.09	.13	.49	.67	.03	.01	.01	.82	.87

Data sources: *Eskimo-Indian (Turner, 1981); Jomon (Turner, 1979); Easter Island (Turner and Scott, 1977); Ainu (Turner and Hanihara, 1979); New Britian (Turner and Swindler, 1978); Ohio Woodland (Sciulli, 1979 and present study); Anderson—Williams (present study); Modern British (Mayhall, et al. 1982 and Berry, 1978).*

The initial phase of the analysis consisted of collecting, where possible, 97 expressions of 40 dental morphological variables for each individual. The forty variables and their expressions are listed in Sciulli (1979). Scoring of the expressions for this study follow Turner (1979b) and Turner and Scott (1973) (see top of *Table 1*). We made comparisons between major cultural groups, *eg.,* Glacial Kame, *vs.* Adena, Western Basin *vs.* Hopewell *etc.,* using the X^2 or Fisher's exact test. Groups exhibiting a number of significant differences less than or equal to that expected by chance were pooled and the pooled group used in the second phase of the analysis.

In the second phase of the analysis we compared the prehistoric native Americans with various other populations exhibiting the Mongoloid Dental Complex, both the Sinodont and Sundadont subpatterns. We included a sample of modern British as a contrast to the Mongoloid Dental Complex. These populations are also listed in *table 1.* In the second phase we chose 10 dental morphological traits based on the following criteria: 1. a trait should exhibit variation among the samples. 2. the scoring of a trait should be consistent across samples and 3. each trait should be scored for each sample. The resulting 10 traits are listed across the top of *table 1.*

The second phase of the analysis, based on the data in *table 1,* employed a multivariate technique referred to as correspondence analysis (Greenacre, 1982). This is basically a technique for displaying the rows and columns of an *n* x *m* table as points in low dimensional vector spaces. The spaces (one for rows and one for columns) may be superimposed to obtain a joint display (Greenacre, 1982). Correspondence analysis also may be thought of as a double discriminant analysis where the dependence of two partitions of the same data matrix is investigated. In the present case the rows of *table 1* are the sampled populations and the columns are the dental morphological traits. The analysis of rows (populations) will discriminate among populations while the analysis of columns will discriminate the traits. The joint display of the analysis will show which dental morphological traits contribute to the discrimination of the populations.

The initial step of the correspondence analysis was to divide each element of the matrix by the matrix sum yielding a matrix we can call XS (Greenacre and Degos 1974). Next, row and column sums were converted to diagonal matrices Dr and Dc. The matrix from which the eigenvalues and eigenvectors are extracted is: $A = Dr^{-1} . XS . D_c^{-1} . XS^t$. The space of this matrix is thus structured by a generalized Euclidian metric referred to as the chi-squared metric (Greenacre and Degos 1974). The use of this metric means that large distances in relative frequencies of common traits between populations are reduced while small differences between less common traits are increased. This tends to equalize the contribution of all traits to the metric structure of the space. As in principal components analysis the principal axes solution of the problem is contained in an eigen-equation where the eigenvalues are the amount of variation explained and the respective eigenvectors are the principle axes of the variation. The axes are orthonomal and form a new basis in the space of the rows or populations. The points representing the populations can be displayed and interpreted in the subspace of the first few principles axes. The quality of the display is judged by the amount of variation explained. This is expressed as the magnitude of the i^{th} eigenvalue divided by the sum of all eigenvalues. Once each population is plotted on the first few principal axes the coordinates of the traits on these same axes can be found. If vector V_1 contains the coordinates of the population along the first principal axis which has eigenvalue λ, and if t_1 is the vector of the frequencies of a trait across populations divided by the corresponding column total, then the coordinates of the trait on the first principal axis is given by $t^T v_1 \sqrt[\star]{\lambda_i}$. This can then be repeated for the second and succeeding principal axes. Thus, the positions of all the populations collectively determine the positions of the traits and vice versa. The matrix operations employed in correspondence analysis were carried out using Speakeasy III computational methods (Cohen and Pieper, 1979).

RESULTS AND DISCUSSION

The results of the initial phase of data analysis in which we compared the prehistoric American natives led to the pooling of the Glacial Kame, Adena and Hopewell groups listed collectively as the Ohio Woodland. In these comparisons only a small number of morphological differences reached significance: an interrupted protocristid of the lower anterior premolar and the presence of the maxillary third molar hypocone reached high frequencies in Glacial Kame and maxillary second and third molar buccal pits were frequently found in Adena. The remaining trait differences as well as the overall differences among these groups could be attributed to chance. The corrected x^2 values for the overall differences between Glacial Kame and Adena and Glacial Kame and Hopewell are 0 and the corrected X^2 for the Adena and Hopewell groups is 0.18; each comparison has one degree of freedom. Comparison between the three Ohio Woodland groups and the other prehistoric American Indian groups showed a more marked differentiation. For example, the Late Archaic Western Basin Williams Cemetery differs from the Ohio Woodland group in the frequencies of maxillary lateral incisor and canine and tuberculum dentale, maxillary first and second molar Carabelli complex presence, maxillary second molar hypocone presence, mandibular anterior premolar lingual groove frequency and the frequency of the protostylid complex for all mandibular molars. Similar numbers of differences occur with the comparison of Anderson and Pearson Villages. These results indicate that of the 40 traits considered 11 or about 25 % of the traits remained stable in frequency of expression in the prehistoric groups throughout the time span considered here. These traits include shoveling of the upper and lower incisors and canines, maxillary incisor lingual grooves, cusp number of the lower posterior premolar, maxillary molar hypocone presence and mandibular M1 cusp number. Because these traits are stable over time and in very different groups they will likely make poor candidates for any investigation of dental variation in eastern North American natives.

rally similar way to the second axis with Asian derived populations higher on the axis and Asian populations lower. The modern British population is far removed from all of the populations exhibiting the Mongoloid dental complex.

Principle coordinates analysis of the populations although based on only 10 dental morphological traits has produced a discrimination among them which is in accord generally with interpretations based on allele frequencies, linguistic analysis, ske-

FIGURE 1. *Plot of the first three principal axes of the correspondence analysis. Populations: Eskimo (Esk), Aleut (Ale), Na-Dene (Den), Indian (Ind), Jomon (Jom), Easter Island (Eas), Ainu (Ain), New Britian (Nbr), Ohio Woodland (Ohw) Anderson (And), Pearson (Pea), Williams (Will), Modern British (Eng). Traits: Shovel shape (SS), Lingual groove (LG), Tuberculum dentale (TUD), Carabelli Complex (CAR), Hypocone (M2H), Lingual cusps (PLC), C6 = C6, C7 = C7, Protostylid (PRS) Four cusped M2 (M24).*

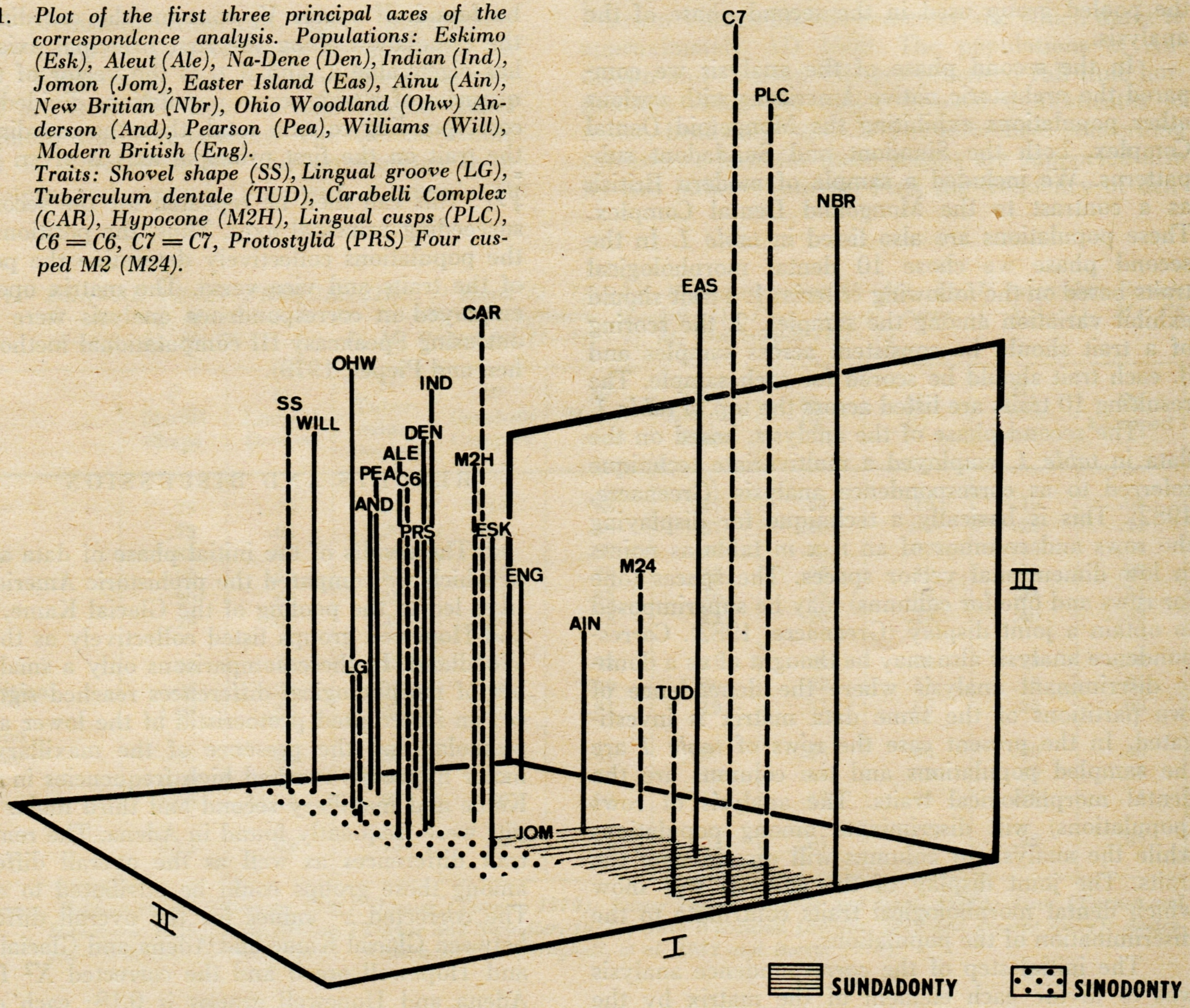

Figure 1 presents the first three principal axes of the correspondence analysis preformed on the data from *table 1.* The first axis accounts for 50.6 percent of the variation in table 1 and we interpret it here as a general measure of complexity. Populations towards the right, the Pacific Populations and the Modern British, generally exhibit a less complex dental morphological phenotype while those to the left with the Sinodont pattern a more complex phenotype. In this analysis the second axis which accounts for 25.5 % of the variation appears to separate Asian derived population, American natives to the left and Pacific populations to the right, from Asian populations in the center. The third axis accouting for 10.5 % of the variation acts in a gene-

letal morphology and prehistory (Turner, 1979; Laughlin and Harper 1979). Because the placement of each population along the axis depends collectively on the placement of the traits (which will be discussed below) the addition of more traits from the subpatterns of the Mongoloid Dental Complex should provide an even better discrimination.

Figure 1 also represent the plot of the 10 dental morphological traits. In correspondence analysis each trait will tend towards the direction of the population(*s*) in which it is most prominent. For example, the populations in the Sinodont subpattern are associated most strongly with three traits: shovel-shaped incisors, lingual grooves of the maxillary lateral incisor and C_6 of the lower first molar. Associated with the Sundadont subpattern are tuberculum dentale of maxillary lateral incisor, lower anterior premolar cusp number and lower first molar C_7. The modern British population shows low frequencies of these six traits and is thus placed far from the Mongoloid Dental complex. The traits most affecting the placement of the British population are the four cusped mandibular second molar and protostylid.

The placement of the prehistoric American natives analyzed in this study is, as expected, generally within the Sinodont subpattern. The Ohio Woodland (Glacial Kame, Adena and Hopewell) and the Late Archaic Wiliams Cemetery groups fall within the range of American native groups on the first axis. However, the higher frequency of shovel shaped incisors tends to move these group away from the other American natives (to the left on axis II). The horticultural Anderson and Pearson village groups appear to have undergone a secondary simplification of dental morphology which is reflected in their placement to the right of the other American natives on the first axis. Contributing most to this placement is the high frequency of reduced, four cusped mandibular second molars. We do not find this result unexpected since there is much evidence for dental reduction associated with plant and animal domestication (Wolpoff 1971). It is interesting to note that the "reduction" in complexity in these two groups does not affect all traits. Maxillary incisor shoveling remains at a high frequency keeping these populations far to the left on axis II. In this case the reduction of a presumably ancestral Sinodont pattern in the Anderson and Pearson samples does not lead to a Sundadont pattern. Characters such as incisor shoveling may be virtually fixed in some groups with thus little chance for rapid or even moderate change.

In summary, the present analysis has shown that a number of dental morphological traits remained stable in their frequency of expression in the prehistoric American natives examined. These traits noted above will provide little information on population variability *among these groups.* However, some of these traits when included in comparative analysis of world populations are useful in discriminating among related groups. The technique of correspondence analysis appears to be a useful method both for investigating and displaying population affinities and the traits or pattern of traits which contribute to the affinities.

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