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Origin and Affinity of the People of Guam: A Dental Anthropological Assessment

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Abstract—Dental morphology of Guam crania is compared with that of other Micronesians, Polynesians, Australmelanesians, and various Asians to assess relationships and probable origins. Using 25 crown and root traits of several thousand individuals, obtained chiefly by archaeological means, clustering analyses of multivariate between-group Mean Measures of Divergence show a major pattern of Pacific Basin affinities with SE Asia. Guam dentition is most like those of some Polynesians and some SE Asians. There is practically no dental support for a close relationship between Guam and Australmelanesians. These findings suggest that the Guam population originated in southern Island SE Asia, either directly, or indirectly by a Polynesian-derived colonization of Micronesia.

Introduction

Guam is situated at the southern end of the Marianas archipelago, about 13.3 degrees north latitude, 144.5 degrees east longitude. It is about 1500 air miles east by northeast of the Philippines; about 1300 miles north of New Guinea. There are several intervening islands between Guam and the Philippines and between Guam and New Guinea (Voisin & Leverenz 1974). Spanish colonization and relocation of the indigenous population for missionizing purposes began in 1668, more than a century after Magellan's discovery of the Marianas in 1521 (Underwood 1973). Various excavations on Guam, particularly those by Reinman (1967, 1968a, 1968b, 1977) and Ray (1981), revealed the presence of Latte (stone pillar house foundations) and pre-Latte occupation. Ray obtained a radiocarbon date for early Guam occupation at about 1300 B.C. A similar date was obtained by Kurashina & Clayshulte (1983) at Tarague. Although Shutler & Shutler (1975) suggest that Guam ceramics are similar to those found on other Mariana islands, Craib's (1983) review of Micronesian prehistory reveals the need for much more local and comparative inter-island excavation and analysis.

Odontological Study

Previous Micronesian odontological studies begin with Leigh's (1929) pioneering Guamanian investigation, wherein he observed trait occurrences similar to those of Hawaiians studied earlier by Chappel (1927). Subsequent Guam dental research by Gerry *et al.* (1951), Birkby (unpubl.), and Hochstetter (1975), did not change this picture. However, Levy (1981) reported a slightly different dental pattern for Marianas teeth than those of Yapese described by Harris *et al.* (1975). Both studies were based on small samples.

The purpose of this paper is to present and evaluate new findings on Guamanian affinity and probable origin. This is done with a battery of dental crown and root traits, such as incisor shoveling, molar cusp number, and others, that form the basis for a multivariate epigenic population characterization. These dental traits evolve slowly, are relatively free of environmental effects, and are influenced hardly at all by age, sex, activity, and diet (see Scott & Turner 1988, for a recent literature review on these factors). To reduce the changes of European admixture I have, for the most part, limited my dental studies to archaeological and ethnographic samples curated in a number of museums and other institutions. Tables 1 and 2 provide the relevant provenience information. A highly standardized observation and recording procedure produces high quality characterizations of trait frequencies which are used to evaluate similarities between groups by a multivariate statistic called Mean Measure of Divergence. These procedures for human population affinity and origin assessment have proven successful in other parts of the world (Turner 1985, 1987).

Overall, the Guam and other Micronesian dentitions reported on here are not especially well-provenienced, although the more recently excavated remains are quite adequately defined in space and time (Tables 1, 2). I suspect that most crania are Latte or even historic in age, may contain minor amounts of historic non-Micronesian admixture (Underwood 1973, 1976), and possibly even prehistoric Japanese admixture (Shutler & Shutler 1975). But, because the Bishop Museum's Guam series is so large, I doubt that a small fraction of foreign genes could distort the aboriginal dental trait frequencies beyond what might occur by simple sampling error alone. Moreover, no significant differences could be demonstrated between any of the four Guam subseries, poorly or well dated, so all have been pooled. The comparative Asian-Pacific series are also uneven in their temporal, spatial, and population structural qualities, but constitute a majority of known museum-curated remains available for study and analysis. Most of the crania on which this paper is based have also been examined by Howells and Pietrusewsky (both in this volume).

Table 1. Source and provenience of the Guam and other Micronesian dental samples.

Sample & collectors	Number of individuals	Source	References
GUAM			
Guam 1: Talaque, Dano, Epau, Apotguan, Tumon, Agana, Piti (Hornbostel, Thompson, Bailey)	195	Bishop Mus.	Wood-Jones,'31; Levy,'81; Howells,'73; Marshall & Snow,'56; Pietrusewsky,'71
Guam 2: (Reinman)	17	Cal State U. Los Angeles	Reinman,'67, '68a, '68b
Guam 3: (Dumoutier, Marche)	10	Mus.de l'Homme	none known
Guam 4: Tarague (Kurashina)	5	U. Guam	Ray,'81; Kurashina & Clayshulte,'83.
MICRONESIA			
Gilberts (Corney, Wilson, Bird, Reinecke, Gurwen Pinart, Laglaize)	19 1 6	Brit.Mus.NH Duckworth Lab Mus.de l'Homme	Flower catalog,'n.d.
Carolines (Knowles, Jaures, Pinart)	5 8	Brit.Mus.NH Mus.de l'Homme	Knowles catalog,'n.d.
Tinian: Taga, Agingan (Hornbostel)	28	Bishop Mus.	Pietrusewsky,'71
Saipan (Marche, Hornbostel)	5 31	Bishop Mus. Mus.de l'Homme	Pietrusewsky,'71
Marianas (Marche)	3	Mus.de l'Homme	None known

Table 2. Group Composition: Pacific #2 (Fig. 1).

Group & sample size* (trait range)	File names
Easter (4-118)	Easter 2
Mokapu (106-205)	Mokapu
Leang Tjadang (6-118)	Leang Tjadang (early Celebes)
Taiwan** (9-33)	Prehistoric Taiwan
Marquesas (50-155)	Marquesas 1 & 2
New Britain (94-192)	New Britain 1, 2, 3
Guam (52-147)	Guam 1, 2, 3, 4
New Zealand (12-171)	New Zealand, Chatham, New Zealand-Chatham
Early Malay Archipelago (13-50)	Gua Cha (Kelantin), Sampung (Java), Flores, Gua Kepah (Malay Peninsula)
Fiji-Rotuma (11-66)	Fiji 1 & 2, Rotuma
Borneo (14-132)	Niah Cave, Borneo, Sarawak
Java-Sumatra (6-55)	Java, Sumatra
Philippines** (29-171)	Philippines 1, 2, Batak (live), Banton I., Calatagan, Penablanca
East Malay Archipelago** (3-32)	Timor, Celebes, Moluccas, Lesser Sunda
Australia-Tasmania (43-220)	Australia north & south, Australia, Tasmania
East Polynesia (4-108)	Tahiti, Society Is., Raiatea, Gambier, Tuamotu Archipelago
Micronesia (17-72)	Gilbert Is., Carolines, Tinian, Marianas, Saipan
Melanesia (10-114)	New Hebrides, Solomons, New Caldonia, Torres Strait, New Guinea
Melanesia-Polynesia Border (17-66)	Santa Cruz, Loyalty Is.

*Individual count, sexes pooled.
**Descriptions of these series are published elsewhere (Turner, 1987). Only Guam and Micronesia dental descriptions are provided in the present paper. Readers asking for additional information should cite the computer identification name, i.e., Pacific #2.

Previous multivariate studies of Guam crania by Howells (1973) showed a very close relationship with Hawaiians, a much more distant relationship with Far Eastern Asiatic skulls, and a very remote link with Australians. Pietrusewsky's (1974) multivariate Oceanic cranial clustering studies placed male Guamanians with Hawaiians, but females with Chinese. Pietrusewsky's (1984) MMD clustering analyses placed the Marianas with the Moluccas, and not with most Polynesians or Australians. His 1984 cranial measurements linked the Marianas with several Polynesian and Southeast Asian series, and as with his earlier work, linkage with Australians and Melanesians was very remote. Neither Howells nor Pietrusewsky offer support for a Melanesian origin of Micronesians in their published works and in their Micronesian Archaeological Conference presentations, although admixture seems evident in the Carolines (Howells 1973).

The present investigation uses 25 largely independent dental traits (Tables 3, 4), whose dichotomized trait frequencies are transformed into C.A.B. Smith's between-group Mean Measures of Divergence (MMD; Table 5). Sample size correction follows that used by Green & Suchey (1976). MMD significance is calculated according to Sjovold, and presented as a cladogram using Ward's clustering method. Readers unfamiliar with MMD logic will find Sjovold's (1977) explanation enlightening. Now, a few remarks on the dendrogram (Fig. 1).

The acceptability of the dental procedure is evidenced foremost by internal consistency. The Guam series clusters very closely to the other non-Guamanian Micronesians, with whom it has its greatest MMD similarity (0.024) (Table 5). Recall that a small MMD indicates a greater inter-group similarity than does a large value. As in all taxonomy, similarity is assumed to be an estimate of genetic relatedness unless convergence has occurred. Confidence in dental morphology as a means for estimating affinity can also be found in the tight Polynesian clustering of Mokapu, East Polynesia, New Zealand, and the Marquesas samples, and the grouping together of all the Australmelanesian samples—New Britain to Melanesia in Fig. 1. Excepting the Early Malay Archipelago series, which linked up with the Australmelanesians as might be expected since the latter had to have originated in or passed through the Malay region, all the Indonesians form a large cluster that includes Polynesians and Micronesians. Seemingly unreliable is the linking of Easter with the East Malay Archipelago (0.002) and Java-Sumatra (0.025) samples. Rather than

Table 3. Key morphological dental traits of Guam.*

Trait	Expression A	B	C	D	E	F	G	H	I	Number of individuals
Winging UI1	43.1	5.2	51.7							58
Shovel UI1	1.6	33.3	36.5	23.8	4.8					63
Double-shovel UI1	85.3	10.3	1.5	0.0	0.0	1.5	1.5			68
Interrup.groov.UI2	72.4	27.6								76
Tub. dentale UI2	68.3	0.0	1.2	7.3	6.1	1.2	0.0	14.6	1.2	82
Hypocone UM2	7.8	4.7	8.6	18.0	49.2	10.9	0.8			128
Cusp 5 UM1	72.1	11.7	12.6	3.6						111
Carabelli UM1	30.1	28.2	2.9	9.7	1.9	14.6	7.8	4.9		103
Parastyle UM3	98.1	0.0	1.9							52
Enamel ext. UM1	69.9	26.0	2.4	1.6						123
Root no. UP1	46.5	53.5								127
Root no. UM2	0.8	25.4	72.0	1.7						118
Peg/red/abs. UM3	52.5	3.3	1.7	42.5						120
Ling.cusp no. LP2	0.0	16.1	73.1	10.8						93
Groove pattern LM2	35.1	45.0	19.8							111
Cusp no. LM1	0.0	57.6	42.4							99
Cusp no. LM2	17.3	49.1	21.8	11.8						110
Def. wrinkle LM1	36.5	5.8	32.7	25.0						104
Trigonid crest LM1	96.8	3.2								124
Protostylid LM1	71.9	12.5	0.0	9.4	4.2	2.1				96
Cusp 7 LM1	92.3	0.9	1.7	3.4	1.7					117
Tome's root LP1	0.0	35.3	31.8	18.8	11.8	1.2	1.2			85
Root no. LC	100.0									134
Root no. LM1	0.0	98.5	1.5							132
Root no. LM2	15.0	85.0								147

* Scaling and scoring are available from the author. Briefly: WINGING, A = bilateral winging, B-D = other conditions; SHOVEL, A = none, B = threshold, G = marked (UI2, H = barrel-form); DOUBLE-SHOVEL, A = none, G = marked; INTERRUPTION GROOVES, A = none, B = present; TUBERCULUM DENTALE, A = none, J= very large free cusp; MESIAL RIDGE, A = none, D= pronounced; DISTAL ACCESSORY RIDGE, A = none, F = pronounced; UTO-AZTEC UP1, A = none, B = present; METACONE, A = none, G = large cusp; HYPOCONE, A = none, G = very large; CUSP 5, A = none, F = very large; CARABELLI, A = none, H = large free cusp; PARASTYLE, A = none, F = very large free cusp; ENAMEL EXTENSION, A = none or reversed, D = marked; ROOT NUMBER UP1, A = 1, C = 3; ROOT NUMBER UM2, A= 1, D = 4; PEG/REDUCED/CONGENITAL ABSENT UM3, A = normal size, B = reduced, C = peg (< 7 mm in L-B diameter), D = congenital absence; LINGUAL CUSP NUMBER LP2, A= no lingual cusp, D = 3 lingual cusps; ANTERIOR FOVEA LM1, A = none, E = very wide fovea; GROOVE PATTERN LM2, A = +, B = X, C = Y; CUSP NUMBER LM1, A = 4 cusps, C = 6; CUSP NUMBER LM2, A = 4, C = 6, D = >4; DEFLECTING WRINKLE, A = none, D = pronounced; TRIGONID CREST, A = none, B = present; PROTOSTYLID, A = none, H = large free cusp; CUSP 7, A = none, F = large cusp; TOME'S ROOT, A = none, D-E = Tome's, F = 2 roots; ROOT NUMBER LC, A = 1 root, B= 2 roots; ROOT NUMBER LM1, A = 1 root, C = 3 roots; ROOT NUMBER LM2, A = 1 root, C= 3 roots; ODONTOME ULP12, A = absent, B = present.

Table 4. Key morphological dental traits of Micronesia. (see Table 3 notes).

Trait	Expression A	B	C	D	E	F	G	H	I	Number of individuals
Winging UI1	30.0	0.0	70.0							20
Shovel UI1	5.0	5.0	50.0	20.0	20.0					20
Double-shovel UI1	58.8	17.6	11.8	5.9	5.9					17
Interrup.groov.UI2	84.6	15.4								26
Tub. dentale UI2	60.7	0.0	14.3	0.0	0.0	0.0	0.0	14.3	10.7	28
Hypocone UM2	17.2	3.4	24.1	24.1	20.7	10.3				58
Cusp 5 UM1	73.1	1.9	17.3	5.8	1.9					52
Carabelli UM1	40.4	21.1	17.5	5.3	1.8	7.0	1.8	5.3		57
Parastyle UM3	84.4	6.3	6.3	0.0	3.1					32
Enamel ext. UM1	47.1	38.6	4.3	10.0						70
Root no. UP1	40.6	58.0	1.4							69
Root no. UM2	4.5	22.7	72.7							66
Peg/red/abs. UM3	59.4	0.0	0.0	40.6						69
Ling.cusp no. LP2	0.0	19.4	66.7	13.9						36
Groove pattern LM2	26.5	49.0	24.5							49
Cusp no. LM1	0.0	49.0	51.0							49
Cusp no. LM2	27.5	41.2	11.8	19.6						51
Def. wrinkle LM1	57.8	8.9	15.6	17.8						45
Trigonid crest LM1	94.3	5.7								53
Protostylid LM1	75.0	16.7	0.0	6.3	0.0	2.1				48
Cusp 7 LM1	94.8	1.7	0.0	0.0	3.4					58
Tome's root LP1	0.0	47.5	12.5	15.0	15.0	2.5	7.5			40
Root no. LC	96.8	3.2								62
Root no. LM1	0.0	94.4	5.6							72
Root no. LM2	20.3	78.1	1.6							64

attempt to explain away this unexpected linkage by genetic drift, founder's effect, or prehistoric or historic American Indian or European admixture (Turner & Scott 1977), I will simply note that statistically, we can expect misclassification one out of twenty times on the basis of chance alone. The position of Easter is still close to the other Polynesians, and decidedly distant from the Australmelanesians. The Australians and Melanesians form their own very divergent dental branch, which has been previously recognized (Katich & Turner 1975), and attributed to microevolution in isolation (Turner & Swindler 1978). An estimate of the combination of, and relative contributions by, microevolutionary processes (selection, drift, mutation, and admixture) has yet to be determined regionally for the Pacific Basin and Rim, although Brace and associates favor a species-wide differential selection model for general tooth size (Brace 1980, Brace & Hinton 1981, Brace *et al.* 1984, and elsewhere).

Despite the tight clustering of most of the Polynesian samples, there is some significant intra-Polynesian divergence. Given the short separation times involved, the common ancestral gene pool, and the substantial uniformity of the Polynesian environment, this divergence must have been influenced to a large degree by genetic drift (including founder's effect and population structure). If the frequencies of evolutionarily stable polygenic dental traits can shift as much as they did (MMD = $\pm$ 0.03) during this brief period of time, then it is no wonder that evolutionarily volatile monogenic traits like blood groups have not fulfilled their overstated potential for human affinity research, especially for Pacific Basin populations. For example, Simmons (1962) could make very little sense out his Pacific blood group data. More recently, Cavalli-Sforza *et al.* (1988) found on the basis of many single gene traits that Polynesians had diverged more from Micronesians

Table 5. Ranked Mean Measures of Divergence (computer ref: Pacific #2). Nonsignificant MMD values indicated by ns.

EASTER		MOKAPU		LEANG TJADANG	
E Malay Arch	.002ns	E Polynesia	.000ns	Philippines	.059
Java-Sumatra	.025ns	E Malay Arch	.024ns	Taiwan	.068
E Polynesia	.035ns	Java-Sumatra	.028ns	Fiji-Rotuma	.075
Mokapu	.044ns	Borneo	.030	Java-Sumatra	.078
New Zealand	.051ns	Fiji-Rotuma	.036	Mel-Poly Border	.085
Philippines	.058	New Zealand	.037	New Zealand	.087
Leang Tjadang	.091	Marquesas	.039	Easter	.091
Fiji-Rotuma	.096	Easter	.044ns	Mokapu	.099
Marquesas	.099	Philippines	.047	Borneo	.103
Borneo	.113	Micronesia	.059	E Polynesia	.107
Taiwan	.115	Mel-Poly Border	.060	Marquesas	.122
Mel-Poly Border	.125	Guam	.076	Micronesia	.123
Micronesia	.129	Taiwan	.081	E Malay Arch	.123
Melanesia	.132	Ear Malay Arch	.090	Ear Malay Arch	.124
Ear Malay Arch	.144	Melanesia	.094	Austral-Tasmania	.132
Austral-Tasmania	.186	Leang Tjadang	.099	Melanesia	.135
Guam	.187	Austral-Tasmania	.105	Guam	.185
New Britain	.234	New Britain	.140	New Britain	.251

TAIWAN		MARQUESAS		NEW BRITAIN	
Philippines	.016ns	E Polynesia	.014ns	Fiji-Rotuma	.050
Fiji-Rotuma	.049ns	Fiji-Rotuma	.020ns	Marquesas	.055
New Zealand	.053	New Zealand	.036	Ear Malay Arch	.057
Borneo	.064	Mokapu	.039	Austral-Tasmania	.060
Leang Tjadang	.068	Guam	.053	Mel-Poly Border	.068
Mokapu	.081	New Britain	.055	Java-Sumatra	.084
Marquesas	.100	Java-Sumatra	.055	E Polynesia	.085
Mel-Poly Border	.104	Mel-Poly Border	.056	Melanesia	.087
E Malay Arch	.106	Micronesia	.060	Guam	.094
Java-Sumatra	.107	E Malay Arch	.067	Borneo	.117
Easter	.115	Austral-Tasmania	.068	Micronesia	.120
E Polynesia	.118	Borneo	.071	E Malay Arch	.126
Micronesia	.129	Philippines	.079	Mokapu	.140
Guam	.129	Melanesia	.082	New Zealand	.169
Austral-Tasmania	.162	Ear Malay Arch	.083	Philippines	.190
Ear Malay Arch	.168	Easter	.099	Easter	.234
Melanesia	.242	Taiwan	.100	Leang Tjadang	.251
New Britain	.264	Leang Tjadang	.122	Taiwan	.264

than had North American Indians from those of South America, a finding that does not correspond with archaeological evidence. Moreover, these workers directly link Micronesia with Melanesia rather than with Southeast Asia, which is inconsistent with findings based on dental morphology, cranial metrics (Howells, this volume), and cranial nonmetrics (Pietrusewsky, this volume).

Guamanian Origins and Affinities

Figure 1 and Table 5 show clearly that the Guamanian dental characteristics are most like those of other Micronesians, next resemble most other Polynesians, then resemble the teeth of Southeast Asians, and are finally least like the Australmelanesian dental pattern. Said another way, Guamanians, as evidenced by their teeth, are more closely related to

Table 5. (cont'd)

GUAM		NEW ZEALAND		EARLY MALAY ARCHIPELAGO	
Micronesia	.024	E Polynesia	.000ns	Mel-Poly Border	.000ns
E Polynesia	.032ns	Marquesas	.036	Fiji-Rotuma	.000ns
Borneo	.044	Mokapu	.037	Java-Sumatra	.030ns
Fiji-Rotuma	.048	Fiji-Rotuma	.037ns	E Polynesia	.036ns
Marquesas	.053	Mel-Poly Border	.044	E Malay Arch	.051ns
Mokapu	.076	Easter	.051ns	Melanesia	.056
Java-Sumatra	.084	Taiwan	.053	New Britain	.057
Mel-Poly Border	.084	Java-Sumatra	.054	Austral-Tasmania	.064
Austral-Tasmania	.090	E Malay Arch	.063	Borneo	.070
New Britain	.094	Ear Malay Arch	.076	New Zealand	.076
New Zealand	.097	Philippines	.085	Micronesia	.078
Philippines	.101	Leang Tjadang	.087	Marquesas	.083
Ear Malay Arch	.110	Guam	.097	Mokapu	.090
Melanesia	.126	Borneo	.098	Guam	.110
Taiwan	.129	Micronesia	.104	Philippines	.119
E Malay Arch	.130	Austral-Tasmania	.109	Leang Tjadang	.124
Leang Tjadang	.185	Melanesia	.133	Easter	.144
Easter	.187	New Britain	.169	Taiwan	.168

FIJI-ROTUMA		BORNEO		JAVA-SUMATRA	
Mel-Poly Border	.000ns	Micronesia	.004ns	E Malay Arch	.000ns
Ear Malay Arch	.000ns	Philippines	.011ns	Mel-Poly Border	.010ns
E Polynesia	.007ns	Java-Sumatra	.011ns	Borneo	.011ns
Java-Sumatra	.014ns	E Malay Arch	.012ns	Fiji-Rotuma	.014ns
Borneo	.015ns	Fiji-Rotuma	.015ns	E Polynesia	.015ns
Marquesas	.020ns	E Polynesia	.026ns	Easter	.025ns
Austral-Tasmania	.032	Mel-Poly Border	.027ns	Mokapu	.028ns
Mokapu	.036	Mokapu	.030	Ear Malay Arch	.030ns
E Malay Arch	.037ns	Guam	.044	Philippines	.035
New Zealand	.037ns	Taiwan	.064	Austral-Tasmania	.043
Guam	.048	Austral-Tasmania	.068	Melanesia	.052
Taiwan	.049ns	Ear Malay Arch	.070	New Zealand	.054
Micronesia	.049	Marquesas	.071	Marquesas	.055
New Britain	.050	New Zealand	.098	Micronesia	.063
Philippines	.056	Leang Tjadang	.103	Leang Tjadang	.078
Leang Tjadang	.075	Easter	.113	Guam	.084
Melanesia	.085	Melanesia	.113	New Britain	.084
Easter	.096	New Britain	.117	Taiwan	.107

Polynesians and Southeast Asians than they are to Melanesians and Australians. This is not a strikingly novel anthropological finding. Of the dozen or so Micronesian languages, most are classified as members of the East Oceanic group of the East Austronesian subfamily, which also contains the Polynesian languages (Tryon 1985, after Grace; see also Ruhlen 1975). Palau and Chamorro belong to the Western Austronesian or Indonesian division. The majority of Micronesian languages are thought to have originated from the southeastern quarter of Micronesia (Tryon 1985), even though some Indonesian cultural features occur in much of Micronesia (Howell 1973). Melanesians speak languages belonging to other groups of East Austronesian or they speak Papuan languages.

These dental data and analyses provide no support for thinking that Micronesians, Guamanians especially, originated solely or mainly in Melanesia. Spriggs (1985) has argued that eastern Micronesians originated in Melanesia. As most of the dental remains

Table 5. (cont'd)

PHILIPPINES		EAST MALAY ARCHIPELAGO		AUSTRALIA-TASMANIA	
Borneo	.011ns	Java-Sumatra	.000ns	Fiji-Rotuma	.032
Taiwan	.016ns	Easter	.002ns	Mel-Poly Border	.033
E Malay Arch	.017ns	Borneo	.012ns	Java-Sumatra	.043
Java-Sumatra	.035	Philippines	.017ns	E Polynesia	.057
Micronesia	.047	Mel-Poly Border	.022ns	New Britain	.060
Mokapu	.047	Mokapu	.024ns	Ear Malay Arch	.064
Fiji-Rotuma	.056	E Polynesia	.026ns	Marquesas	.068
Easter	.058	Fiji-Rotuma	.037ns	Borneo	.068
Leang Tjadang	.059	Ear Malay Arch	.051ns	E Malay Arch	.090
Mel-Poly Border	.068	New Zealand	.063	Guam	.090
Marquesas	.079	Marquesas	.067	Melanesia	.099
E Polynesia	.081	Melanesia	.069	Micronesia	.102
New Zealand	.085	Micronesia	.078	Mokapu	.105
Guam	.101	Austral-Tasmania	.090	New Zealand	.109
Austral-Tasmania	.118	Taiwan	.106	Philippines	.118
Ear Malay Arch	.119	Leang Tjadang	.123	Leang Tjadang	.132
Melanesia	.130	New Britain	.126	Taiwan	.162
New Britain	.190	Guam	.130	Easter	.186

EASTERN POLYNESIA		MICRONESIA		MELANESIA	
New Zealand	.000ns	Borneo	.004ns	Mel-Poly Border	.039ns
Mokapu	.000ns	Guam	.024	Java-Sumatra	.052
Fiji-Rotuma	.007ns	E Polynesia	.045ns	Ear Malay Arch	.056
Mel-Poly Border	.011ns	Philippines	.047	E Malay Arch	.069
Marquesas	.014ns	Fiji-Rotuma	.049	E Polynesia	.071
Java-Sumatra	.015ns	Mokapu	.059	Marquesas	.082
E Malay Arch	.026ns	Marquesas	.060	Fiji-Rotuma	.085
Borneo	.026ns	Java-Sumatra	.063	New Britain	.087
Guam	.032ns	Mel-Poly Border	.063	Mokapu	.094
Easter	.035ns	Ear Malay Arch	.078	Austral-Tasmania	.099
Ear Malay Arch	.036ns	E Malay Arch	.078	Borneo	.113
Micronesia	.045ns	Austral-Tasmania	.102	Micronesia	.119
Austral-Tasmania	.057	New Zealand	.104	Guam	.126
Melanesia	.071	Melanesia	.119	Philippines	.130
Philippines	.081	New Britain	.120	Easter	.132
New Britain	.085	Leang Tjadang	.123	New Zealand	.133
Leang Tjadang	.107	Taiwan	.129	Leang Tjadang	.135
Taiwan	.118	Easter	.129	Taiwan	.242

originated in western Micronesia, it is not possible to test his view. The Guam and Micronesian/non-Micronesian MMD values are too close to call for any decision about possible Melanesian admixture in the Micronesian gene pool. Direct migration from the Philippines is unlikely as the source of Micronesian dental characteristics, despite the island-hopping possibility towards the southern end of the Philippine Sea. The relatively great Guam/Philippine divergence (0.101) may indicate that the Guam skeletal remains were not those of Chamorro-speaking individuals. However, the island-hopping possibility could easily be extended through the Celebes and Moluccas to Borneo. The Borneo dental sample is, as one would expect, generally most like other Southeast Asians, and only slightly less like the Micronesians and Polynesians. Bellwood (1985) suggested that the Moluccas to Timor might have been the staging area for the post-2500 BC settlement of Oceania by central-eastern Malayo-Polynesians. Recall that Pietrusewsky found Microne-

Table 5. (cont'd)

MELANESIA-POLYNESIA BORDER	
Fiji-Rotuma	.000ns
Ear Malay Arch	.000ns
Java-Sumatra	.010ns
E Polynesia	.011ns
E Malay Arch	.022ns
Borneo	.027ns
Austral-Tasmania	.033
Melanesia	.039ns
New Zealand	.044
Marquesas	.056
Mokapu	.060
Micronesia	.063
New Britain	.068
Philippines	.068
Guam	.084
Leang Tjadang	.085
Taiwan	.104
Easter	.125

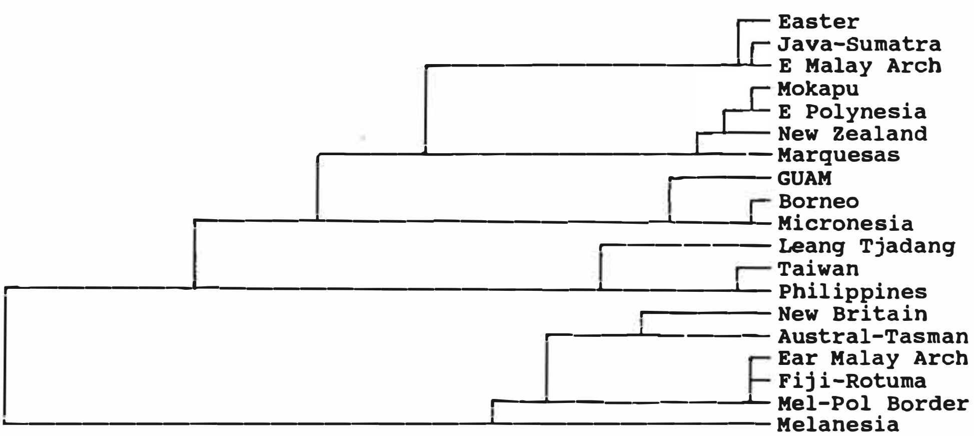

Figure 1. Dental relationships between Guam and other Asian-Pacific areas.

sians to cluster closely with crania from the Moluccas. I find nothing in these data to reject the view that Polynesia could have been settled by way of Micronesia—an older idea brought back to life by Howells (1973), but generally unsupported today according to Bellwood (1975). The MMD values between Borneo and the majority of other samples are so similar as to raise serious problems in objectively deciding between a primary Polynesian or southern Island Southeast Asian origin for Micronesians in general and Guamanians specifically. Indecisiveness notwithstanding, the dental divergence values do not favor the Philippine and Taiwan populations as the most likely sources for the present samples of Micronesians.

Elsewhere (Turner, unpublished analyses), I have experimented with Greenlandic

Eskimo dental data and prehistory to estimate how long human groups must be separated before dentally identifiable distinctions evolve. In Greenland, where entry was limited to the northeast coast from Ellesmere Island, and all migration was seaside due to the interior ice mass, the population system had a thin belt-like quality, unbuckled at the south, with severe isolation favoring maximal divergence by chance (genetic drift and/or founder's effect). Over a period of about 1000 years enough between-district dental difference accumulated to be recognizable by the present procedures.

Extending this finding to the Pacific area, the strong relationship between Micronesia, Polynesia, and Southeast Asia suggests that there has not been enough isolation, not enough time, and too many people involved to permit the degree of differentiation that occurred in the Greenland Eskimo groups. It would appear that the demographic, geographic, dental sampling, and other considerations involved in microevolution are here so combined and weighted as to place both the Micronesians and Polynesians in an approximately equal degree of relationship with Southeast Asians. Had there been fewer founders of Micronesia originating from the Polynesian gene pool, as suggested by affinal but distinct Micronesian language developments, and had there been no subsequent outside contact with Micronesia, the Micronesian and Guamanian teeth should have diverged more, and in so doing exhibit a greater similarity with Polynesian than with Southeast Asian teeth. As things stand, conditions for more rapid microevolution were seemingly not met. It is difficult to tell, on dental grounds alone, whether Micronesians originated directly from a Southeast Asian source or indirectly from Southeast Asian-derived Polynesians. This indecisiveness could be due entirely to the quality and representativeness of the present dental samples. This ever-present statistical problem only can be resolved with additional sampling. Still, sampling may not be faulty since the HLA genetic complex shows a similar pattern of Micronesia, Polynesia, and Southeast Asia (i.e., Philippines) clustering together (Serjeantson 1985), as do the richly detailed Asian-Pacific craniometric analyses carried out by Pietrusewsky (unpubl.).

An experimental use of dental morphology for estimating fissioning time for genetically separated daughter populations is based on an average worldwide rate of dental microevolution of 0.01 MMD/1000 years ± 0.004 (Turner 1986). On this basis, Guam and Micronesia have been separated from Southeast Asia and Polynesia about 4000 to 5000 years. Craib (1983) relates that the earliest Carbon 14 date in Micronesia is about 3500 years old. The correspondence between the dental and carbon dates is reasonably good. Insofar as the dentochronological method can determine, the Guam/Micronesian populations could have had about 2000 years of internal divergence. As this is less than the external fissioning estimate, it supports the dental estimate for when Micronesians branched from their ancestral pre-Micronesian stock. As just discussed, the presently known dental characteristics of Guam and other Micronesians are sufficiently unlike those of Australians and Melanesians to disallow any recently shared common single ancestor. There is little support in these data for viewing "all of Polynesia as just another Melanesian village," as Terrell (1986: 261) suggests would be an unimaginative reading of western Pacific biological variation. Strong Micronesian-Melanesian divergence is also evident for dental crown features of living Yapese, which were found to be several times more similar to Hawaii (MMD=0.164), and Easter teeth (0.170), than to those of eastern New Guinea (0.743) described by Barksdale (Harris *et al.* 1975). As far as these generally robust dental procedures and skeletal samples can tell, Melanesians have not contributed in a major way to the Micronesian gene pool, a finding paralleled by the Micronesian Archaeological Conference contributions of Brace *et al.*, Howells, and Pietrusewsky in this volume. Finally, Micronesians are insufficiently differentiated from Polynesians in their respective dental characteristics to question the taxonomic validity or usefulness of the geographic race distinction between Polynesians and Micronesians proposed by Garn (1971). Dentally, both are only slightly more differentiated than are North and South American Indians (Turner 1985), populations generally agreed upon as members of a single geographic race. W. G. Solheim II suggested at the Micronesian Archaeological Conference that people like those possessing the Southeast Asian boat cultures are good candidates for the pioneer colonists of Micronesia and Polynesia. The dental findings are clearly supportive of his suggestion.

Summary

The dental characteristics of Guam and other Micronesians are more like those of Polynesians and southern Island Southeast Asians, than like Australians and Melanesians. Restrictive microevolutionary conditions and insufficient time are suggested as responsible for a lack of definitive micro-affinity assessment. Micronesian dentitions, as presently known, are about as much like southern Island Southeast Asians as they are like Polynesians. Guamanians, viewed from the overall context of the comparative samples used in this study, along with most Polynesians, must have originated in Island Southeast Asia. Inhabitants of Borneo, or people like those used here from Niah Cave in Sarawak, would seem to be a good candidate population for Micronesian origins. Guam and Micronesia could have been settled 4000 to 5000 years ago based on dentochronology. There is no dental support for a primary Micronesian origin in the Australmelanesian gene pool.

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