Cranial Nonmetric Variation of Circum-Pacific Populations with Special Reference to the Pacific Peoples

Hajime Ishida

Department of Anatomy, Sapporo Medical College

Cranial nonmetric traits of the Pacific and other Asian populations were investigated. The frequency of the supraorbital foramen in the Hawaiian people is as high as in the Asian peoples with the Chamorro people having low incidence. The Hawaiian and Chamorro peoples have the lowest incidences of transverse zygomatic suture vestige of all populations compared, and distance analyses revealed that although not being very near each other, they are both closer to the East Asian and inland Siberians than to the Jomon-Ainu or to other Siberian or Arctic peoples. The analysis of cranial nonmetric variation failed to support a direct affinity for the Jomon to the Pacific peoples.

Keywords: Cranial nonmetric trait, Hawaiian, Chamorro, Migration

INTRODUCTION

People who originated in Asia today inhabit a vast area of Asia and North and South Americas. They were also the first to colonize the islands of the Pacific Ocean, as well as the Americas. Archaeological evidence has clearly shown that people of the Lapita cultural complex must be ancestors of the Polynesians (Bellwood, 1989). However, there are many questions awaiting solution. Many biological anthropologists have devoted themselves to resolving the problems of origin of the Pacific people (Pietrusewsky, 1971, 1984, 1990a, 1990b; Howells, 1973, 1979, 1989, 1990; Brace and Hinton, 1981; Brace *et al.*, 1990; Omoto, 1985; Katayama, 1987, 1988, 1990; Turner, 1989, 1990; Hill *et al.*, 1989; Serjeantson, 1989).

In 1985-1990, Professor Dodo of Sapporo Medical College and author had the opportunity to investigate cranial nonmetric traits and metric characters of the Oceanian peoples at the B.P. Bishop Museum, Honolulu. The result of the cranial nonmetric analysis revealed that the Hawaiian and Chamorro peoples are both closer to the East Asian than to the Jomon-Ainu or to the Arctic peoples (Ishida and Dodo, 1993). In addition, the author had the opportunity to investigate the cranial metric and nonmetric characteristics of the Siberian and other groups in collections in the former Soviet Union in 1988-1989. The differentiation of the Northern populations and relationships between them and the Asian populations

have been argued in some previous papers (Ishida, 1990; Ishida and Dodo, 1990a; Ishida and Kida, 1991; Ishida and Dodo, 1992).

In this study the incidences of cranial nonmetric traits of the Hawaiian and Chamorro people (Mariana Islands) were compared with those of the Asian, Siberian and North American populations to elucidate their anthropological positions.

MATERIALS AND METHODS

The materials examined in Honolulu consisted of two cranial series; one was a sample of 203 male and female Hawaiian skulls from the Mokapu site, Oahu Island, and the other was a sample of 170 Chamorro skulls from the Mariana Islands (Ishida and Dodo, 1993). These skeletal collections are now housed at the B.P. Bishop Museum, Honolulu, Hawaii (Pietrusewsky, 1971) with the Mokapu series having mainly been studied by Snow (1974). Although there are many items in the human skeletal collections of the Pacific series, only almost complete skulls with mandibles were used for analyses. The skeletal remains of the Chamorro were collected by J.C. Thompson and H.G. Hornbostel in 1922-23, and are said to belong to a pre-Spanish or early post-Spanish epoch. As for the Mokapu series, no chronological data has been obtained because of the lack of artifacts at the Mokapu burial site, which had been excavated from 1912. However, the complete lack of European influence in their burial suggests that the Mokapu burial ground was used prior to European contact.

The samples of Asian and North American people used for comparison consisted of the Modern Japanese, Hokkaido Ainu, Mongolian, Alaskan Eskimo, Canadian Eskimo, Aleut (Dodo and Ishida, 1987), Jomon, Aeneolithic Doigahama Yayoi, Protohistoric Kofun (Dodo and Ishida, 1990), and Northern Chinese (Dodo et al., 1992), all the data of which were gathered by Dodo. On the other hand, the samples in Siberia and the Far East used for comparison were composed of the Aleut, Asia Eskimo, Ekven (the Iron age), Buryat, Neolithic Baikal, Mongolian, Tagar (the Iron age, southern Siberia), Kazach, Hokkaido Ainu (Ishida and Dodo, 1992), Amur (Ulch + Nanay + Negidal + Oroch) (Ishida, 1990; Ishida and Kida, 1991) and Sakhalin Ainu (Ishida and Kida, 1991), the data of which were collected by the author. The cranial samples of the Neolithic Baikal consisted of collections from both the East and West coasts of Lake Baikal. The Tagar culture thrived from the 7th to the 3rd century B.C. in southern Siberia and their crania show European characteristics in many respects (Kozintsev, 1977).

Twenty-two cranial traits of the Hawaiian and Chamorro were examined by Dodo for presence or absence following the criteria of Dodo (1974, 1986, 1987). Because we had selected 16 of those traits as having high interobserver consistency (Ishida and Dodo, 1990b, 1992), the 16 traits were employed for comparisons between the Siberian Mongoloids examined by the author, and the others in order to decrease the influence of interobserver errors.

The biological distances between the Hawaiian and Chamorro series and the

other Mongoloid populations were estimated by the mean measure of divergence (MMD) and its standard deviation using the nonmetric incidences per individual (Sjøvold, 1973). Clustering and principal coordinate analyses were applied to the distance matrices of the MMDs (Sneath and Sokal, 1973). The neighbor-joining method was also carried out based on the MMD matrices (Saitou and Nei, 1987).

RESULTS

The incidences of the 22 cranial nonmetric traits in the Hawaiian and Chamorro series are given in Appendix Tables 1 and 2, respectively. The 16 cranial nonmetric incidences per individual in 9 populations from the Pacific, Asia and North America are given in Table 1. In addition, the per-individual incidences of 16 cranial nonmetric traits in 11 populations from Siberia and the Far East are given in Table 2.

The frequency of the supraorbital foramen in the Hawaiian people (0.639) is as high as in the Asian peoples, with the Chamorro people having low incidence (0.335). The Hawaiian have a high incidence in the precondylar tubercle, while both have the lowest incidences of transverse zygomatic suture vestige of all Mongoloid populations compared.

Table 1. Skull-incidencies of cranial nonmetric traits of several population samples from the Pacific and East Asia.

Traits	Hawaiian*		Chamorro*		Northern	Chinese**
	n	p	n	p	n	p
1. Metopism	203	(0.001)	170	0.006	167	0.066
2. Supraorbital nerve groove	196	0.235	159	0.069	159	0.270
3. Supraorbital foramen	202	0.639	164	0.335	167	0.617
4. Ossicle at the lambda	195	0.031	156	0.154	155	0.135
5. Parietal notch bone	202	0.079	154	0.240	159	0.270
6. Condylar canal patent	199	0.839	116	0.931	162	0.864
7. Precondylar tubercle	196	0.270	114	0.149	164	0.122
8. Paracondylar process	194	0.021	97	0.031	153	0.026
9. Hypoglossal canal bridging	201	0.129	113	0.168	166	0.211
10. Foramen ovale incomplete	199	0.035	114	0.088	166	0.030
11. Foramen of Vesalius	195	0.364	117	0.419	167	0.533
12. Pterygo-spinous foramen	202	0.059	120	0.108	168	0.054
13. Medial palatine canal	201	0.055	130	0.023	166	0.054
14. Transverse zygomatic suture	162	0.012	98	0.010	142	0.106
15. Clinoid bridging	182	0.049	83	0.024	164	0.104
16. Mylohyoid bridging	185	0.103	121	0.107	88	0.045

Figures in parentheses were calculated by 1/4N or 1-1/4N (Bartlett's adjustment).
*: Ishida and Dodo (1993), **: Dodo et al., (1992), ***: Dodo and Ishida (1990), ****: Dodo and Ishida (1987)

Table 1. (Continued)

Traits	Doigahama Yayoi***		Kofun***		Modern Japanese****	
	n	p	n	p	n	p
1. Metopism	126	0.0079	199	0.025	180	0.089
2. Supraorbital nerve groove	97	0.165	107	0.206	177	0.311
3. Supraorbital foramen	96	0.531	134	0.560	180	0.550
4. Ossicle at the lambda	128	0.180	164	0.104	174	0.040
5. Parietal notch bone	109	0.349	95	0.189	172	0.360
6. Condylar canal patent	55	0.836	90	0.922	178	0.860
7. Precondylar tubercle	76	0.105	116	0.086	178	0.090
8. Paracondylar process	41	0.024	52	0.019	168	0.054
9. Hypoglossal canal bridging	90	0.144	130	0.169	180	0.144
10. Foramen ovale incomplete	77	0.013	104	0.019	180	0.017
11. Foramen of Vesalius	68	0.338	103	0.476	179	0.469
12. Pterygo-spinous foramen	91	0.022	112	0.027	179	0.028
13. Medial palatine canal	84	0.048	124	0.073	177	0.079
14. Transverse zygomatic suture	58	0.190	35	0.200	167	0.114
15. Clinoid bridging	24	(0.010)	82	0.024	177	0.045
16. Mylohyoid bridging	94	0.096	77	0.065	177	0.062

Table 1. (Continued)

Traits	Jomon***		Alaska Eskimo****		Canada Eskimo****	
	n	p	n	p	n	p
1. Metopism	159	0.151	200	0.005	152	(0.002)
2. Supraorbital nerve groove	117	0.171	198	0.197	140	0.214
3. Supraorbital foramen	124	0.185	200	0.785	151	0.722
4. Ossicle at the lambda	156	0.045	189	0.090	144	0.035
5. Parietal notch bone	88	0.205	198	0.278	149	0.255
6. Condylar canal patent	42	(0.994)	198	0.949	138	0.964
7. Precondylar tubercle	80	0.100	198	0.076	141	0.028
8. Paracondylar process	15	0.133	159	0.019	101	0.010
9. Hypoglossal canal bridging	84	0.333	199	0.256	138	0.348
10. Foramen ovale incomplete	44	0.045	200	0.015	144	0.028
11. Foramen of Vesalius	55	0.564	200	0.330	145	0.255
12. Pterygo-spinous foramen	65	0.046	200	0.060	147	0.197
13. Medial palatine canal	80	0.188	198	0.035	142	0.035
14. Transverse zygomatic suture	68	0.456	170	0.129	99	0.091
15. Clinoid bridging	10	(0.025)	198	0.172	141	0.220
16. Mylohyoid bridging	112	0.205	116	0.155	78	0.141

Table 2. Skull-incidencies of cranial nonmetric traits of several population samples from Siberia and the Far East.

Traits	Aleut*		Asia Eskimo**		Ekven**	
	n	p	n	p	n	p
1. Metopism	177	0.034	133	0.053	111	0.027
2. Supraorbital nerve groove	172	0.314	130	0.231	109	0.138
3. Supraorbital foramen	178	0.735	133	0.602	108	0.648
4. Ossicle at the lambda	171	0.129	132	0.053	109	0.055
5. Parietal notch bone	169	0.172	132	0.227	101	0.317
6. Condylar canal patent	172	0.907	124	0.944	91	0.901
7. Precondylar tubercle	174	0.052	118	0.068	99	(0.003)
8. Paracondylar process	163	0.012	71	0.042	72	0.027
9. Hypoglossal canal bridging	175	0.354	126	0.325	98	0.327
10. Foramen ovale incomplete	175	0.074	121	0.099	101	0.059
11. Foramen of Vesalius	176	0.176	128	0.313	99	0.303
12. Pterygo-spinous foramen	178	0.039	128	0.008	102	0.088
13. Medial palatine canal	171	0.023	119	(0.002)	100	0.030
14. Transverse zygomatic suture	141	0.142	101	0.030	85	0.094
15. Clinoid bridging	160	0.281	131	0.229	84	0.202
16. Mylohyoid bridging	103	0.408	38	0.237	88	0.159

Figures in parentheses were calculated by 1/4N (Bartlett's adjustment)
*: Pooled incidence data of two cranial series (Dodo and Ishida, 1987; Ishida and Dodo, 1992), **: Ishida and Dodo (1992), ***: Ishida and Kida (1991)

Table 2. (Continued)

Traits	Buryat**		Baikal**		Mongolian*		Tagar**	
	n	p	n	p	n	p	n	p
1. Metopism	140	0.043	61	(0.004)	286	0.070	147	0.034
2. Supraorbital nerve groove	138	0.290	49	0.122	284	0.320	143	0.343
3. Supraorbital foramen	139	0.705	58	0.655	285	0.600	146	0.568
4. Ossicle at the lambda	137	0.139	51	0.078	280	0.129	143	0.175
5. Parietal notch bone	128	0.133	45	0.200	278	0.209	130	0.200
6. Condylar canal patent	135	0.852	34	0.971	284	0.789	120	0.800
7. Precondylar tubercle	138	0.174	50	0.100	280	0.162	119	0.042
8. Paracondylar process	129	0.054	25	0.080	263	0.023	111	(0.002)
9. Hypoglossal canal bridging	138	0.217	52	0.308	283	0.170	121	0.322
10. Foramen ovale incomplete	138	0.036	42	0.048	283	0.042	129	0.023
11. Foramen of Vesalius	137	0.474	37	0.324	285	0.526	123	0.577
12. Pterygo-spinous foramen	138	0.029	47	0.021	286	0.042	132	0.053
13. Medial palatine canal	131	0.061	47	0.021	273	0.033	133	0.038
14. Transverse zygomatic suture	120	0.108	40	0.250	226	0.150	104	0.010
15. Clinoid bridging	138	0.116	36	0.056	282	0.089	111	0.207
16. Mylohyoid bridging	117	0.145	40	0.050	68	0.088	81	0.099

Table 2. (Continued)

Traits	Kazach**		Amur***		Sakhalin Ainu***		Hokkaido Ainu**	
	n	p	n	p	n	p	n	p
1. Metopism	120	0.033	132	(0.002)	92	(0.003)	150	0.020
2. Supraorbital nerve groove	120	0.308	127	0.157	79	0.190	144	0.097
3. Supraorbital foramen	120	0.600	131	0.725	92	0.435	145	0.283
4. Ossicle at the lambda	114	0.126	124	0.048	91	0.011	146	(0.002)
5. Parietal notch bone	119	0.168	127	0.118	92	0.348	141	0.220
6. Condylar canal patent	118	0.754	127	0.764	86	0.837	143	0.937
7. Precondylar tubercle	120	0.150	128	0.039	84	0.071	143	0.112
8. Paracondylar process	119	0.008	115	0.043	73	0.041	108	0.093
9. Hypoglossal canal bridging	120	0.308	130	0.215	90	0.322	146	0.377
10. Foramen ovale incomplete	120	0.017	130	0.031	92	0.109	139	0.094
11. Foramen of Vesalius	120	0.517	125	0.280	92	0.413	138	0.428
12. Pterygo-spinous foramen	120	0.050	131	0.046	92	0.022	142	0.063
13. Medial palatine canal	119	0.050	119	0.034	88	0.045	119	0.202
14. Transverse zygomatic suture	112	0.080	107	0.159	66	0.242	97	0.289
15. Clinoid bridging	119	0.109	127	0.039	88	0.114	131	0.092
16. Mylohyoid bridging	117	0.103	92	0.076	71	0.099	95	0.200

MMDs and their standard deviations for the 20 populations from the circum-Pacific and Siberian regions were calculated based on the 16 nonmetric cranial traits in order to include for comparison the Siberian populations. As for the Aleut and Mongolian series, the respective nonmetric data investigated by Dodo and Ishida were pooled to get sufficient sample size (Dodo and Ishida, 1987; Ishida and Dodo, 1992). Table 3 shows the distance matrix of the MMDs. The MMD between the Hawaiian and Chamorro is fairly large (0.0721) and statistically significant. All the MMDs between the Chamorro and Hawaiian and the other 18 population samples are also significant. The closest to the Chamorro are the Doigahama Yayoi and Kofun in Japan, while the Buryat and Kazach are closest to the Hawaiian. The taxonomic relation between the other 18 populations has been discussed in previous papers (Ishida and Kida, 1991; Ishida and Dodo, 1992).

Clustering analysis (group average method) was done based on the MMD matrix in Table 3 with the negative values being replaced by zeroes. The result, shown in Fig. 1, is slightly different from the clustering of the previous report (Ishida and Dodo, 1993, Fig. 1). The Asian and American populations are in a large cluster within which three subgroups are identifiable. The first subcluster consists of the Arctic populations in Asia and North America while the Northern Chinese, the three inland Siberian populations and three Japanese groups join to make a second subcluster. The Neolithic Baikal, Amur and Sakhalin Ainu are in the third subcluster. The Chamorro and Hawaiian are loosely lumped together to make a cluster, then this cluster connects to the large cluster of Asian and American populations, whereas the Jomon and Hokkaido Ainu, clustering together, are isolated from the others as with the previous results.

Table 3. Matrix of the MMDs and their standard deviations based on the 16 nonmetric variants.

	1	2	3	4	5	6
1. Jomon						
2. Doigahama Yayoi	0.1317 (0.017)					
3. Kofun	0.1017 (0.015)	0.0033 (0.0099)				
4. Modern Japanese	0.1318 (0.013)	0.0163 (0.0077)	0.0153 (0.0062)			
5. Alaska Eskimo	0.2168 (0.0129)	0.0644 (0.0076)	0.0424 (0.0062)	0.0673 (0.0039)		
6. Canada Eskimo	0.2472 (0.0136)	0.1274 (0.0084)	0.0909 (0.0070)	0.1111 (0.0048)	0.0138 (0.0047)	
7. Aleut	0.2660 (0.0131)	0.1403 (0.0079)	0.1340 (0.0064)	0.1562 (0.0042)	0.0475 (0.0041)	0.0587 (0.0050)
8. Asia Eskimo	0.2145 (0.0142)	0.1040 (0.0091)	0.0907 (0.0078)	0.0875 (0.0056)	0.0414 (0.0056)	0.0568 (0.0065)
9. Ekven	0.1993 (0.0145)	0.0779 (0.0094)	0.0678 (0.0079)	0.0736 (0.0057)	0.0178 (0.0056)	0.0088 (0.0065)
10. Buryat	0.1720 (0.0135)	0.0439 (0.0083)	0.0218 (0.0068)	0.0389 (0.0047)	0.0332 (0.0046)	0.0868 (0.0054)
11. Neolithic Baikal	0.1192 (0.0189)	0.0341 (0.0141)	0.0045 (0.0127)	0.0545 (0.0105)	0.0174 (0.0104)	0.0536 (0.0113)
12. Mongolian	0.1638 (0.0126)	0.0247 (0.0073)	0.0170 (0.0056)	0.0207 (0.0037)	0.0597 (0.0037)	0.1127 (0.0045)
13. Tagar	0.2626 (0.0138)	0.0992 (0.0086)	0.0746 (0.0071)	0.0746 (0.0049)	0.0714 (0.0049)	0.0892 (0.0057)
14. Kazach	0.1928 (0.0137)	0.0458 (0.0086)	0.0280 (0.0071)	0.0391 (0.0050)	0.0499 (0.0049)	0.0865 (0.0057)
15. Amur	0.2245 (0.0137)	0.0494 (0.0085)	0.0297 (0.0071)	0.0648 (0.0049)	0.0429 (0.0048)	0.0690 (0.0057)
16. Sakhalin Ainu	0.1126 (0.0147)	0.0599 (0.0098)	0.0407 (0.0084)	0.0462 (0.0062)	0.0642 (0.0061)	0.0805 (0.0070)
17. Hokkaido Ainu	0.0307 (0.0136)	0.1262 (0.0084)	0.0887 (0.0070)	0.1120 (0.0062)	0.1390 (0.0047)	0.1409 (0.0055)
18. Hawaiian	0.2720 (0.0129)	0.0972 (0.0076)	0.0623 (0.0061)	0.0816 (0.0038)	0.0829 (0.0038)	0.1140 (0.0046)
19. Chamorro	0.1885 (0.0140)	0.0668 (0.0087)	0.0641 (0.0072)	0.0951 (0.0049)	0.1113 (0.0049)	0.1292 (0.0057)
20. Northern Chinese	0.1574 (0.0132)	0.0221 (0.0080)	0.0093 (0.0065)	0.0108 (0.0043)	0.0405 (0.0043)	0.0830 (0.0051)

NOTE: The figures in parentheses are standard deviations.

Table 3. (Continued)

	7	8	9	10	11	12	13
8. Asia Eskimo	0.0355						
	(0.0059)						
9. Ekven	0.0496	0.0252					
	(0.0059)	(0.0073)					
10. Buryat	0.0749	0.0524	0.0699				
	(0.0048)	(0.0063)	(0.0064)				
11. Neolithic Baikal	0.1014	0.0580	0.0403	0.0373			
	(0.0107)	(0.0120)	(0.0122)	(0.0111)			
12. Mongolian	0.1162	0.0786	0.0829	0.0050	0.0553		
	(0.0039)	(0.0052)	(0.0053)	(0.0043)	(0.0101)		
13. Tagar	0.1103	0.0635	0.0630	0.0429	0.1180	0.0433	
	(0.0051)	(0.0066)	(0.0066)	(0.0056)	(0.0114)	(0.0046)	
14. Kazach	0.0985	0.0684	0.0687	0.0040	0.0632	0.0035	0.0106
	(0.0052)	(0.0066)	(0.0067)	(0.0056)	(0.0115)	(0.0046)	(0.0059)
15. Amur	0.1067	0.0898	0.0485	0.0428	0.0181	0.0556	0.0992
	(0.0051)	(0.0065)	(0.0066)	(0.0056)	(0.0114)	(0.0046)	(0.0058)
16. Sakhalin Ainu	0.1191	0.0652	0.0400	0.0712	0.0233	0.0583	0.1019
	(0.0064)	(0.0078)	(0.0079)	(0.0069)	(0.0127)	(0.0058)	(0.0071)
17. Hokkaido Ainu	0.1844	0.1369	0.1085	0.1301	0.0743	0.1383	0.1982
	(0.0049)	(0.0064)	(0.0064)	(0.0054)	(0.0112)	(0.0044)	(0.0057)
18. Hawaiian	0.1562	0.0991	0.1258	0.0409	0.0832	0.0618	0.0955
	(0.0040)	(0.0055)	(0.0055)	(0.0045)	(0.0103)	(0.0035)	(0.0048)
19. Chamorro	0.1970	0.1007	0.1009	0.0954	0.0772	0.0921	0.1051
	(0.0051)	(0.0065)	(0.0067)	(0.0056)	(0.0115)	(0.0046)	(0.0059)
20. Northern Chinese	0.1222	0.0696	0.0576	0.0091	0.0380	-0.0004	0.0286
	(0.0045)	(0.0060)	(0.0060)	(0.0050)	(0.0108)	(0.0041)	(0.0053)

Table 3. (Continued)

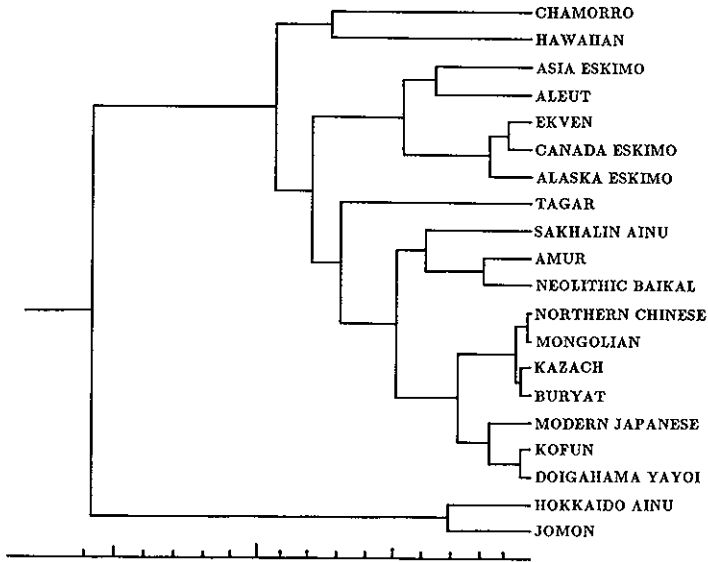|	14	15	16	17	18	19
15. Amur	0.0484					
	(0.0059)					
16. Sakhalin Ainu	0.0608	0.0539				
	(0.0072)	(0.0071)				
17. Hokkaido Ainu	0.1368	0.1335	0.0358			
	(0.0057)	(0.0057)	(0.0069)			
18. Hawaiian	0.0469	0.0558	0.1129	0.1694		
	(0.0048)	(0.0047)	(0.0060)	(0.0046)		
19. Chamorro	0.0883	0.1077	0.0968	0.1293	0.0721	
	(0.0059)	(0.0058)	(0.0071)	(0.0057)	(0.0048)	
20. Northern Chinese	0.0050	0.0561	0.0531	0.1286	0.0669	0.0745
	(0.0053)	(0.0052)	(0.0065)	(0.0051)	(0.0042)	(0.0053)

Fig. 1. Clustering analysis (group average method) based on the MMD matrix of Table 3.

Again principal coordinate analysis was applied to the MMD matrix in Table 3, which are drawn in Fig. 2. The East Asian and inland Siberian (Buryat, Mongolian) form a loose cluster, from which the Hawaiian and Chamorro appear to issue. However, the two Pacific series are at a distance from each other.
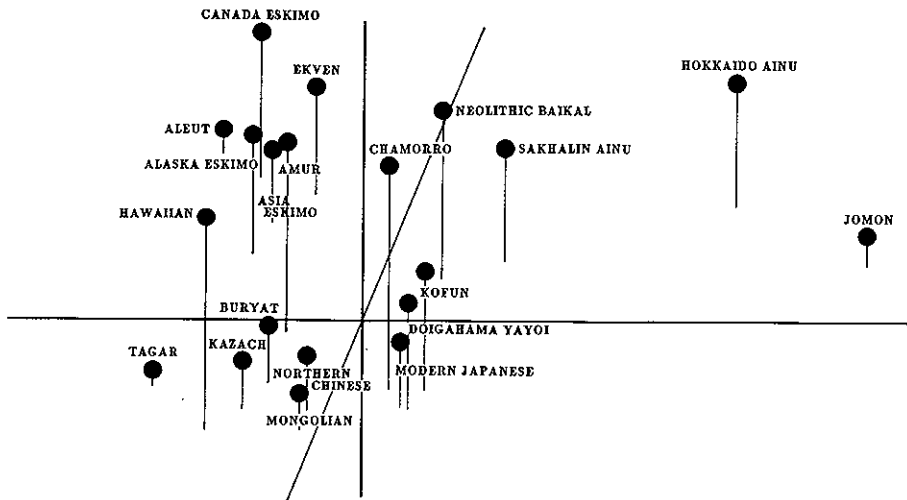

Fig. 2. Three dimensional representation of 20 population samples by principal coordinate analysis applied to the MMD matrix of Table 3.

The neighbor-joining method was also applied to the MMD matrix to establish two dimensional relationships. The result, drawn in Figure 3, is almost the same as that of the clustering analysis. The East Asian groups mass, whereas the Jomon and Hokkaido Ainu loosely lump together and are isolated. The Hawaiian and Chamorro seem to come out of the East Asian cluster and to branch off early. The Northern populations have two branches; one consists of the Amur and Arctic peoples, while the Northern Chinese and inland Siberians make the other. The three Japanese populations of Yayoi, Kofun and Modern are joined to make a small cluster.
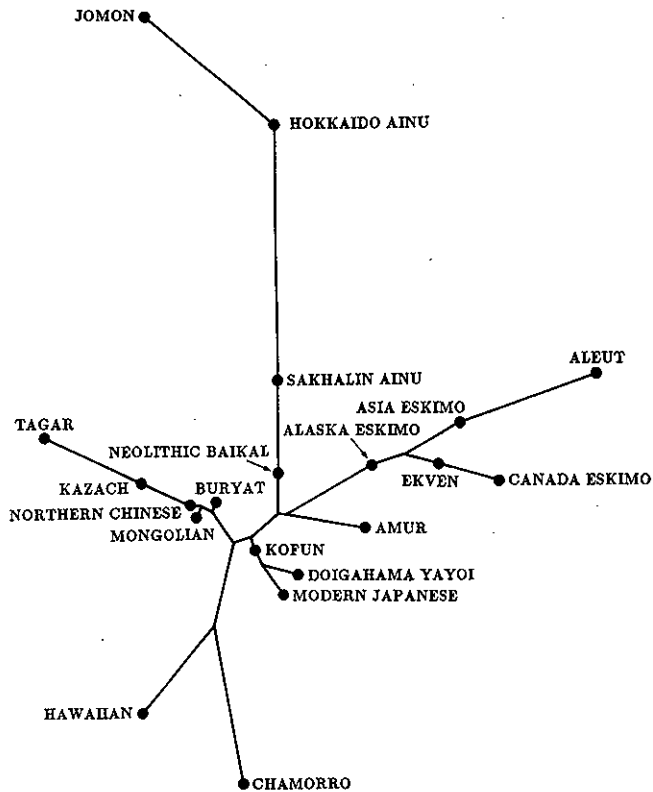
Fig. 3. A phylogenetic tree of 20 population samples by the neighbor-joining method based on the MMD matrix of Table 3.

The result of the distance analysis showed that the Hawaiian and Chamorro people, although not being very near each other, are both closer to the East Asians and inland Siberians than to the Jomon-Ainu or to the Arctic peoples.

DISCUSSION

We reconfirmed the results of Wood-Jones (1931a, 1931b) that the frequency of the supraorbital foramen in the Hawaiian people is as high as in the Asian peoples with the Chamorro people having low incidence (Ishida and Dodo, 1993). In addition, it was proven that the incidences of transverse zygomatic suture vestige of both peoples are the lowest of all populations compared.

Although anthropologists use different traits and different criteria (Pietrusewsky, 1971, 1984; Katayama, 1988), it can be said that the Polynesian peoples have basically the following characteristics in common: high frequencies of the supraorbital foramen and precondylar tubercle, and quite low frequency of the transverse zygomatic suture vestige. In addition, Katayama (1988) noticed a frequency variation of the antegonial notch among Polynesian populations. Unfortunately, however, this trait was not examined in this study.

Frequency differences between the Hawaiian and Chamorro are statistically significant in 8 traits of the 22 examined and the MMD between them is statistically significant (Ishida and Dodo, 1993). However, it was recognized that the two peoples of the Chamorro and Hawaiian are loosely joined together to make a small cluster based on the analyses of clustering and neighbor-joining methods.

It has to be acknowledged that an East-West division within Micronesia has been recognized by craniometric and some genetic analyses (Howells, 1989; Serjeantson, 1989; Pietrusewsky, 1990a). Because the craniometry shows that the Western Micronesians have a closer affinity with Southeast Asian people than with the Polynesians, it may stand to reason that the Chamorro and Hawaiian are not very near each other in our analyses of the nonmetric traits and postcranial bones (Ishida, 1993; Ishida and Dodo, 1993). Pietrusewsky (1990a, 1990b) maintained that the Micronesians, although being somewhat differentiated, are basically of the same stock and based on craniometry they make a cluster with the Polynesians. We agree with his argument because both this and previous analyses of clustering and neighbor-joining methods have indicated that both the Hawaiian and Chamorro seem to come out of East Asian stock and lump together to make a loose cluster (Ishida and Dodo, 1993). It is suggested that the differentiation of the Pacific peoples, such as respective different incidence patterns of cranial nonmetric traits of the Hawaiian and Chamorro, resulted from genetic drift.

We have postulated that the Hawaiian and Chamorro were derived from the stock of an East Asian population, but not from that of the Jomon, because the Jomon and Ainu form a striking contrast to the Hawaiian and Chamorro in incidences of the supraorbital foramen and transverse zygomatic suture vestige and because the distances between the two contrast samples were remarkable (Ishida and Dodo, 1993).

Recently the opinion has been offered by Brace that the Jomon have an ethnic connection with the Pacific peoples (Brace and Hunt, 1990; Brace et al., 1990). He claims that the Jomon people had migrated into the islands of the Pacific, that he calls "the Jomon-Pacific cluster". Katayama (1990) advocates the same conception

that the "Proto-Oceanic" population, represented by the Jomon people, had dispersed into the Pacific region. However, that idea is not acceptable because "the Jomon-Pacific cluster" is contradicted by the results of our analyses.

Turner (1989, 1990) has classified both the Jomon-Ainu and the Pacific peoples as the Sundadont, as he considered that they had originated in the Sundaland, that is continental Southeast Asia. It seems most likely that the Polynesian and Micronesian peoples are derived from the Asian continent, probably, from Southeast Asia, and that they are not closely related to the Melanesian or Australian, because physical anthropology and genetics have offered some significant views on the origins of the Oceanian people (Pietrusewsky, 1984, 1990a, 1990b; Howells, 1989, 1990; Turner, 1989, 1990; Serjeantson, 1989; Hill et al. 1989). We will have to investigate the cranial nonmetric traits of the modern and ancient Southeast Asian peoples in order to elucidate the people who had migrated into the Pacific.

Because no cranial series from Southeast Asian populations were included for comparison in this study, the population history of the Asian peoples as a whole can not be determined undeniable. However, our analyses, based on the cranial nonmetric traits, have revealed populational variations of several ethnic peoples (Dodo and Ishida, 1987, 1990; Ishida, 1990; Ishida and Kida, 1991; Ishida and Dodo, 1992). For example, the populations of East Asia, Siberia and North America were clearly classified and the Jomon and Hokkaido Ainu are isolated from others because of their peculiar characteristics. Ossenberg (1991), examining the skeletal materials from America, mentioned that there is a close relationship between the Aleut and Na-dene Indians. Recently, we also showed that the Aleut and Ontario Iroquois are connected through the analysis of the neighbor-joining method (Dodo, et al., 1992). As for the Siberians, based on the neighbor-joining method, drawn in the Figure 3, the Amur peoples are closer to the Arctic peoples, whereas the inland Siberians are in a different branch within which the Northern Chinese are located. The result of this analysis, including data of the Northern Chinese, confirmed the idea that the inland Siberians came from the China to Central Siberia, during the Iron and middle Ages (Ishida and Dodo, 1992). We must collect more detailed data of the Siberians and Americans, which may help in the elucidation of the origin of the "First American".

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環太平洋地域の人類集団の頭蓋形態小変異：
太平洋民族の起源を求めて

石田　肇

要旨：ハワイ人およびチャモロー人の頭蓋形態小変異を調査し、アジア、アメリカおよびシベリアの人類集団と比較検討した。これら太平洋民族の頭蓋形態小変異については、別の論

文で詳しく述べている（石田・百々、1993）。眼窩上孔についてみると、ハワイ人の頻度は
高く、アジアの集団と同じ程度であるのに対して、チャモロー人はその頻度が低い。横頬骨
縫合残存の頻度は、両集団ともに、極めて低い。頭蓋形態小変異を基に、集団間の距離を計
算して、クラスター分析他の手法を施してみた。その結果、ハワイ人とチャモロー人は互い
には、それほど類似しないが、両者とも、東アジア集団や、中央アジア型のシベリア集団に
近く、縄文人やアイヌ、他のシベリアや北アメリカの集団とは類似しない。このことは、縄
文と太平洋民族との直接の類縁関係を否定するものである。

Appendix Table 1. Bilateral presence (RL), unilateral presence (RO or OL), and bilateral absence (OO) of cranial nonmetric traits in the Hawaiian series.

	Male					Female				
	RL	RO	OL	OO	N	RL	RO	OL	OO	N
1. Metopism*	0	-	-	97	97	0	-	-	106	106
2. Supraorbital nerve groove	8	7	1	80	96	11	6	13	70	100
3. Supraorbital foramen	25	15	15	42	97	37	17	20	31	105
4. Ossicle at lambda*	0	-	-	93	93	6	-	-	96	102
5. Biasterionic suture vestige	6	10	6	75	97	2	3	4	97	106
6. Asterionic ossicle	4	6	7	80	97	2	2	4	97	105
7. Occipitomastoid ossicle	7	16	5	69	97	6	9	13	77	105
8. Parietal notch bone	3	3	3	87	96	2	3	2	99	106
9. Condylar canal patent	34	30	15	17	96	49	21	18	15	103
10. Precondylar tubercle	12	3	10	67	92	15	5	8	76	104
11. Paracondylar process	0	1	1	90	92	0	0	2	100	102
12. Hypoglossal canal bridging	2	6	4	84	96	0	4	10	91	105
13. Tympanic dehiscence	3	5	3	86	97	5	1	2	98	106
14. Foramen ovale incomplete	1	1	0	92	94	0	1	4	100	105
15. Foramen of Vasalius	12	8	15	58	93	15	8	13	66	102
16. Pterygospinous foramen	1	2	6	88	97	0	2	1	102	105
17. Medial paltine canal	0	2	2	93	97	1	5	1	97	104
18. Transverse zygomatic suture vestige	0	0	1	77	78	0	1	0	83	84
19. Clinoid bridging	2	1	1	80	84	2	1	2	93	98
20. Mylohyoid bridging	2	4	3	78	87	1	4	5	88	98
21. Jugular foramen bridging	0	6	3	85	94	1	2	2	100	105
22. Sagittal sinus groove left*	13	-	-	84	97	14	-	-	92	106

*Median trait

Appendix Table 2. Bilateral presence (RL), unilateral presence (RO or OL), and bilateral absence (OO) of cranial nonmetric traits in the Chamorro series.

	Male					Female				
	RL	RO	OL	OO	N	RL	RO	OL	OO	N
1. Metopism*	1	-	-	94	95	0	-	-	75	75
2. Supraorbital nerve groove	0	5	1	83	89	1	0	4	65	70
3. Supraorbital foramen	8	13	10	62	93	10	6	8	47	71
4. Ossicle at lambda*	14	-	-	73	87	10	-	-	59	69
5. Biasterionic suture vestige	6	7	3	70	86	2	4	1	62	69
6. Asterionic ossicle	3	3	6	69	81	1	1	3	60	65
7. Occipitomastoid ossicle	5	1	6	64	76	2	6	6	43	57
8. Parietal notch bone	8	8	5	59	90	3	3	10	48	64
9. Condylar canal patent	39	13	9	4	65	33	9	5	4	51
10. Precondylar tubercle	3	5	3	53	64	4	0	2	44	50
11. Paracondylar process	0	0	2	51	53	0	1	0	43	44
12. Hypoglossal canal bridging	3	2	4	54	63	1	5	4	40	50
13. Tympanic dehiscence	25	4	9	47	85	26	6	6	29	67
14. Foramen ovale incomplete	2	2	3	58	65	1	1	1	46	49
15. Foramen of Vasalius	9	6	11	40	66	6	4	13	28	51
16. Pterygospinous foramen	1	3	4	60	68	1	0	4	47	52
17. Medial paltine canal	0	0	0	76	76	0	2	1	51	54
18. Transverse zygomatic suture vestige	0	1	0	58	59	0	0	0	39	39
19. Clinoid bridging	0	0	0	47	47	0.	1	1	34	36
20. Mylohyoid bridging	0	2	3	61	66	3	1	4	47	55
21. Jugular foramen bridging	0	6	0	55	61	0	0	2	46	48
22. Sagittal sinus groove left*	12	-	-	74	86	10	-	-	58	68

*Median trait