28. Population History of Japan: A Cranial Nonmetric Approach

YUKIO DODO, HAJIME ISHIDA AND NARUYA SAITOU

The incidence data of 22 cranial nonmetric traits were analyzed in 16 cranial series, of which ten are from Japan and six from overseas. It was demonstrated that the incidence pattern of cranial nonmetric traits reflected the Japanese genetic constitution of historic times when no significant gene flow from abroad was evident in Japan. Concerning the population history of Japan, distance analyses based on trait incidences indicated that (1) the Jomon and Ainu are closely related to each other; (2) there existed population discontinuity between the Jomon and the Yayoi; and (3) the genetic constitution of continental immigrants such as the Yayoi of northern Kyushu had predominated over that of the natives in various parts of western Japan by around the middle of the Yayoi period, and this resulted in the appearance of the direct ancestral population of the modern Japanese.

Introduction

Laughlin and Jørgensen (1956) first estimated biological distances between populations based on multivariate statistical analysis of the incidence data of cranial nonmetric traits. Since then, a great number of population studies using these variant traits have been carried out (Brothwell 1959; Yamaguchi 1967; Berry and Berry 1967, 1972; Ossenberg 1969; Pietrusewsky 1971; Czarnetzki 1972; Dodo 1974; Cybulski 1975; Suchey 1975; and many others). Many of these studies are reviewed in the painstaking and comprehensive atlas of Hauser and De Stefano (1989).

It was not until quite recently that attempts were made to reconstruct the population history of Japan in terms of cranial nonmetric variation. Nevertheless, a close resemblance between the Jomon and Ainu has been demonstrated by the evidence of cranial nonmetric traits (Ossenberg 1986; Dodo 1986a, 1987; Mouri 1986, 1988; Kozintsev 1990; Dodo and Ishida 1990). Moreover, it has been indicated from the data of cranial nonmetric traits that the Yayoi and the protohistoric Kofun are much closer to the modern Japanese than to the Jomon (Yamaguchi 1985; Mouri 1986; Dodo 1987; Dodo and Ishida 1988, 1990; Kozintsev 1990).

On the origin of the modern Japanese, two major hypotheses have been presented: the transformation theory and the immigration theory. The former hypothesis asserts that the Jomon evolved without admixture into the protohistoric Kofun and finally the modern Japanese of the greater part of Japan (Suzuki 1956, 1969, 1981), whereas the latter postulates that immigrants from the Asian continent during the Yayoi and Kofun periods made a considerable contribution to the formation of the modern Japanese (Kanaseki 1956, 1966).

The objective of the present study is to reconstruct methodically the population history of

Japan by cranial nonmetric analyses of 16 population samples from Japan and overseas.

Materials

Ten cranial series from Japan, ranging in age from around 4000 BP to the present time, and six cranial series from the Asian continent and North America were investigated for the presence or absence of 22 cranial nonmetric traits. The sample sizes and provenances of these materials are given in Table 28.1. For the provenances of the Japanese and Chinese materials, see Figure 28.1. All the cranial series consist of more than 100 adult individuals.

The crania of the Doigahama Yayoi are from Yamaguchi Prefecture, the westernmost part of Honshu, and those of the Kanenokuma Yayoi are from northern Kyushu. These two Yayoi series are generally believed to represent immigrants from the Asian continent and their offspring. The crania of the Modern East and Southwest Japanese are from dissecting room subjects of Tohoku University, Chiba University and Kyushu University. The cranial series of the Jomon and the protohistoric and historic Japanese are derived from the Kanto and Tohoku districts in Honshu. The crania of the Ainu are those excavated at various sites in Hokkaido.

The cranial materials examined in this study are housed in Sapporo Medical College; Tohoku University School of Medicine; School of Medicine, Chiba University; Tokyo Dental College; University Museum, University of Tokyo; National Science Museum, Tokyo; Faculty of Science, Kyoto University; Faculty of Medicine, Kyushu University; National Museum of Natural History, Smithsonian Institution; St. George Campus and Erindale College, University of Toronto; Archaeological Survey of Canada, National Museum of Man.

Table 28.1 Cranial series examined.

Cranial series	Number of skulls	Provenances
Jomon	171	Kanto/Tohoku
Yayoi(Doigahama)	153	Yamaguchi Prefecture
Yayoi(Kanenokuma)	191	Northern Kyushu
Protohistoric Kofun	276	Kanto/Tohoku
Early Medieval Kamakura	220	Kanto
Late Medieval Muromachi	124	Kanto
Early Modern Edo	194	Kanto
Modern Jpn.(East)	180	Kanto/Tohoku
Modern Jpn.(Southwest)	151	Kyushu/Shikoku/Chugoku
Ainu	187	Hokkaido
Northern Chinese	171	Liaoning(Manchuria)
Mongolian	178	Ulan Bator
Aleut	117	Umnak/Shiprock/Kagamil
Alaskan Eskimo	200	Lower Yukon/Golovin Bay etc.
Canadian Eskimo	152	Franklin/Mackenzie/Keewatin
Ontario Iroquois	255	Southern Ontario

Fig. 28.1 Map of Japan and the neighboring continent.

Methods

The following 22 cranial nonmetric traits were scored as present or absent for each cranium according to the criteria of Dodo (1974, 1975, 1986b).

1. Metopism
2. Supraorbital nerve groove
3. Supraorbital foramen
4. Ossicle at the lambda
5. Biasterionic suture vestige
6. Asterionic ossicle
7. Occipitomastoid ossicle
8. Parietal notch bone
9. Condylar canal patent
10. Precondylar tubercle
11. Paracondylar process
12. Hypoglossal canal bridging

13. Tympanic dehiscence
14. Foramen ovale incomplete
15. Foramen of Vesalius
16. Pterygospinous foramen
17. Medial palatine canal
18. Transverse zygomatic suture vestige
19. Clinoid bridging
20. Mylohyoid bridging
21. Jugular foramen bridging
22. Sagittal sinus groove left

All the data of presence or absence of cranial nonmetric traits were gathered by the senior author (Y. Dodo). For both bilateral and median traits, incidence was determined based on skull and pooled-sex sample.

Differences in frequency of each trait between samples were tested by chi-square statistics. Biological distances between samples were assessed by C.A.B. Smith's Mean Measure of Divergence (MMD), and their standard deviations are also given (Sjøvold 1973). In order to graphically represent mutual relationships of cranial samples, clustering and principal coordinate analyses (Sneath and Sokal 1973), and the neighbor-joining method (Saitou and Nei 1987) were done for MMD matrices.

Incidence Data and Comparison

Incidence data of the 22 cranial nonmetric traits such as bilateral presence, unilateral presence or bilateral absence were given in Dodo and Ishida (1987) for the Ainu, Modern East Japanese, Mongolian, Alaskan Eskimo, Canadian Eskimo, Aleut and Ontario Iroquois series; in Dodo and Ishida (1988) for the Doigahama Yayoi series; and in Dodo and Ishida (1990) for the Jomon, Kofun, Kamakura and Muromachi series. Those for the Kanenokuma Yayoi, Edo, Modern Southwest Japanese and Northern Chinese series will be described on another occasion.

Incidences of each trait were compared between the cranial series of Early Medieval Kamakura, Late Medieval Muromachi, Early Modern Edo and Modern East Japanese. The significance of frequency differences of each trait was tested by chi-square. The results are shown in Table 28.2. The differences are significant at the 5% level for only two traits — the supraorbital nerve groove and parietal notch bone. For the remaining 20 traits, frequency differences between the four historic Japanese series never reach the significance level of 5%.

Distance Analysis

Smith's Mean Measure of Divergence (MMD) and its standard deviation were computed from the incidence data of 22 traits for each pair of samples from the 16 cranial series studied. Figure 28.2 is a schematic representation of MMDs between 11 cranial series from East Asia. The dotted square denotes an MMD significant at the 5% level and the blank square an insignificant one. The smaller distances are observed in pairs of temporally or geographically closer population samples. For example, the MMDs between the Kanenokuma Yayoi - Kofun,

Table 28.2 Comparison of trait incidences between the four Japanese cranial series of historic times.

Trait	Kamakura		Muromachi		Edo		Modern East		x^2	P
	Incidence	(%)	Incidence	(%)	Incidence	(%)	Incidence	(%)	(df=3)	
1. Metopism	9/204	(4.4)	8/124	(6.5)	10/194	(5.2)	16/180	(8.9)	3.773	0.287
2. Supraorbital nerve groove	24/175	(13.7)	19/102	(18.6)	48/177	(27.1)	55/177	(31.1)	17.750	0.001**
3. Supraorbital foramen	99/185	(53.5)	63/116	(54.3)	101/184	(54.9)	99/180	(55.0)	0.103	0.992
4. Ossicle at the lambda	16/188	(8.5)	9/121	(7.4)	19/188	(10.1)	7/174	(4.0)	5.078	0.166
5. Biasterionic suture vestige	21/185	(11.4)	12/121	(9.9)	30/192	(15.6)	28/176	(15.9)	3.678	0.298
6. Asterionic ossicle	29/169	(17.2)	15/104	(14.4)	18/146	(12.3)	20/172	(11.6)	2.571	0.463
7. Occipitomastoid ossicle	25/127	(19.7)	19/81	(23.5)	22/146	(15.1)	31/179	(17.3)	2.747	0.432
8. Parietal notch bone	37/164	(22.6)	24/99	(24.2)	38/160	(23.8)	62/172	(36.0)	10.006	0.019*
9. Condylar canal patent	83/91	(91.2)	64/77	(83.1)	119/148	(80.4)	153/178	(86.0)	5.476	0.140
10. Precondylar tubercle	5/111	(4.5)	3/85	(3.5)	10/154	(6.5)	16/178	(9.0)	3.805	0.283
11. Paracondylar process	1/41	(2.4)	1/65	(1.5)	4/114	(3.5)	9/168	(5.4)	2.216	0.529
12. Hypoglossal canal bridging	19/128	(14.8)	13/88	(14.8)	26/155	(16.8)	26/180	(14.4)	0.401	0.940
13. Tympanic dehiscence	65/191	(34.0)	46/102	(45.1)	56/166	(33.7)	64/179	(35.8)	4.337	0.227
14. Foramen ovale incomplete	6/130	(4.6)	1/87	(1.1)	2/151	(1.3)	3/180	(1.7)	4.769	0.190
15. Foramen of Vesalius	52/114	(45.6)	44/82	(53.7)	68/150	(45.3)	84/179	(46.9)	1.702	0.637
16. Pterygospinous foramen	2/158	(1.3)	2/91	(2.2)	9/151	(6.0)	5/179	(2.8)	6.168	0.104
17. Medial palatine canal	9/149	(6.0)	2/83	(2.4)	9/129	(7.0)	14/177	(7.9)	3.013	0.390
18. Tranv. zygomatic suture vestige	8/90	(8.9)	5/57	(8.8)	13/95	(13.7)	19/167	(11.4)	1.422	0.700
19. Clinoid bridging	2/51	(3.9)	4/59	(6.8)	7/131	(5.3)	8/177	(4.5)	0.633	0.889
20. Mylohyoid bridging	2/51	(3.9)	4/40	(10.0)	3/131	(2.3)	11/177	(6.2)	4.794	0.188
21. Jugular foramen bridging	8/83	(9.6)	12/75	(16.0)	21/188	(11.2)	27/222	(12.2)	1.706	0.636
22. Sagittal sinus groove left	24/159	(15.1)	21/113	(18.6)	23/175	(13.1)	26/153	(17.0)	1.815	0.612

Kofun - Kamakura, Kamakura - Muromachi, Muromachi - Edo, and Edo - Modern are insignificant, and the MMDs between the Modern Japanese - Northern Chinese and Northern Chinese - Mongolian are also insignificant. The Jomon, Ainu and Doigahama Yayoi are consistently distant from the eight other samples.

Clustering analysis by the group average method was done for the MMD matrix of 12 cranial series from East Asia. The result is illustrated as a dendrogram in Figure 28.3. In this dendrogram, two distinct clusters are discernible: one comprises the Jomon and Ainu series, and the other the post-Jomon Japanese, Northern Chinese and Mongolian series. Within the latter cluster, the Kanenokuma Yayoi, Modern Southwest Japanese, Kofun, Kamakura, Muromachi, Edo, Northern Chinese and Modern East Japanese are joined tightly with each other, while the Mongolian connect at some distance with these Japanese and Chinese series, and the Doigahama Yayoi join them at a still lower level of affinity.

Figure 28.4 is a three-dimensional display of the result of principal coordinate analysis done for the MMD matrix of the 12 cranial series from East Asia. The contributions of the first, second and third axes are 60.7%, 15.3% and 11.7%, respectively. Also in this figure, two distinct clusters are discernible: the Jomon-Ainu group and a group consisting of the remaining 10 Japanese and continental series. In the latter group, the positions of the Doigahama Yayoi and Mongolian slightly deviate from those of the other Japanese and Chinese series which are lumped within a limited space.

Figure 28.5 shows a neighbor-joining tree of the 16 cranial series examined in this study. This method of tree construction from distance matrices was developed by Saitou and Nei (1987). In this figure, three clusters are distinguished: the Jomon-Ainu, the East Asian

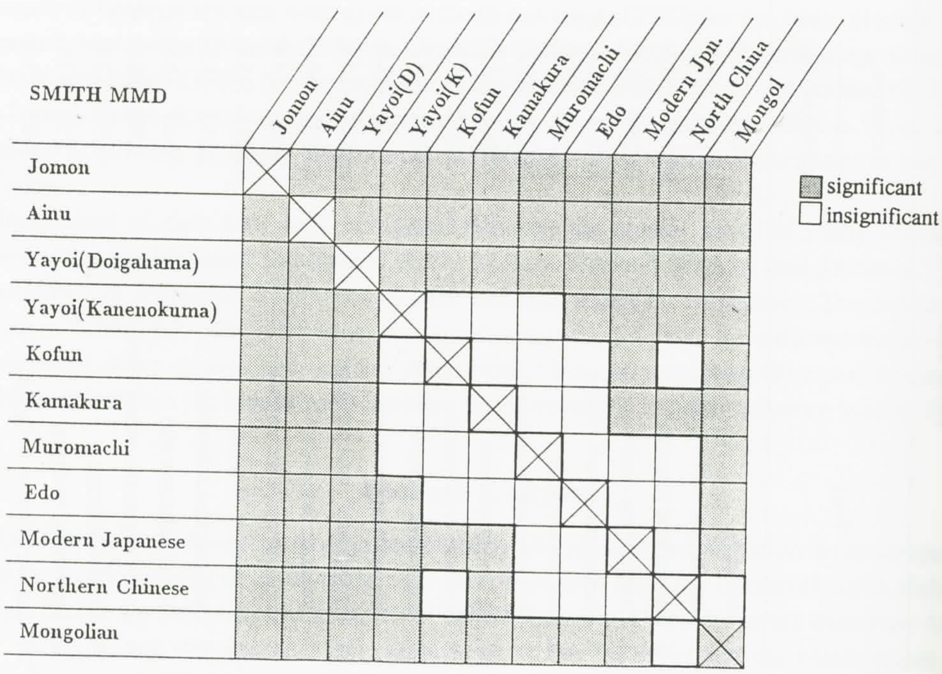

Fig. 28.2 Significance of MMD in each pair of samples between 11 cranial series from East Asia. MMD is significant or insignificant at the 5% level.

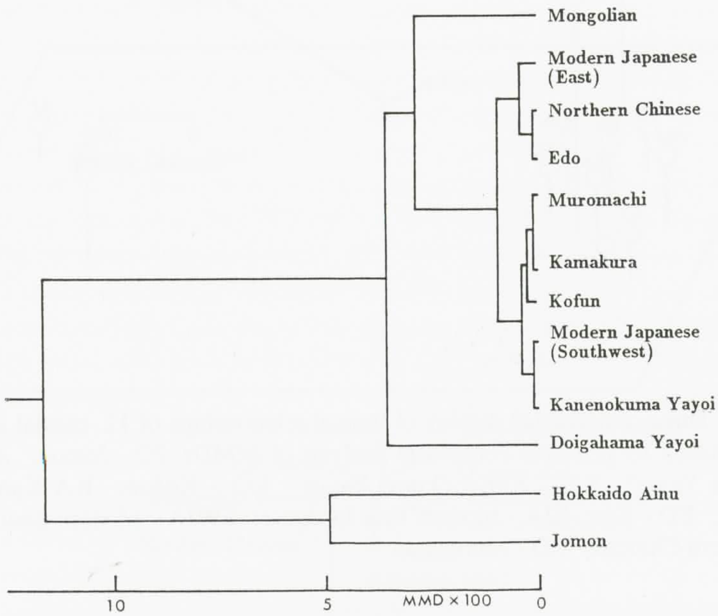

Fig. 28.3 Dendrogram of 12 cranial series from East Asia constructed by clustering analysis of MMDs.

Mongoloid, and the North American groups. In the East Asian group, the Northern Chinese as well as such Japanese samples as the Kanenokuma Yayoi, Kofun, Kamakura, Muromachi, Edo and Modern are closely related to each other, while the Doigahama Yayoi and Mongolian form slightly loose connections with these Japanese and Chinese series.

Discussion

Usefulness of Cranial Nonmetric Traits for Population Study

Secular changes of cranial measurements can be seen even during the last 600 years from the early medieval to the present time when no significant gene flow from abroad is evident in Japan (Suzuki et al 1962, 1969, 1981). Compared to those cranial measurements, however, most of the cranial nonmetric traits dealt with here showed a remarkable homogeneity in frequency within the same time span during historic times in Japan (Table 28.2). Supposedly this constancy of incidence of traits is a reflection of the unchanged genetic constitution of the Japanese population during the last 600 years.

On the other hand, the population variability of trait occurrence was shown to be conspicuous even in the East Asian and North American Mongoloid populations probably having the same lineage (Dodo and Ishida 1990). Such properties of the occurrence of cranial nonmetric traits as "within population homogeneity and between population variability" can be thought to provide good evidence for the usefulness of cranial nonmetric traits in discriminating between skeletal populations bearing rather close relationships to each other.

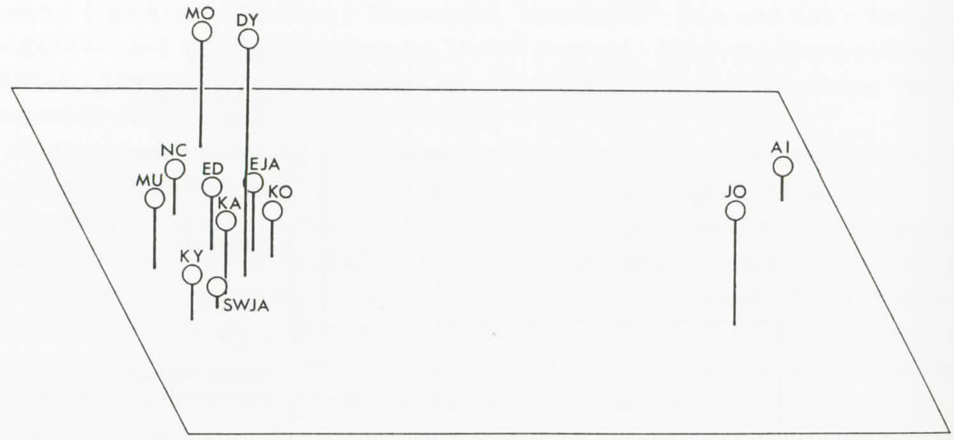

Fig. 28.4 Three-dimensional display of mutual relationships of 12 cranial series from East Asia constructed by principal coordinate analysis of MMDs. JO - Jomon; AI - Ainu; DY - Doigahama Yayoi; KY - Kanenokuma Yayoi; KO - Kofun; KA-Kamakura; MU - Muromachi; ED - Edo; EJA - Modern East Japanese; SWJA - Modern Southwest Japanese; NC - Northern Chinese; MO - Mongolian.

Doigahama Yayoi versus Kanenokuma Yayoi

In the region of Kyushu and Yamaguchi Prefecture, two types of Yayoi skeletal remains are recognized. The first, discovered in the northwestern and southernmost parts of Kyushu, resembles the Jomon in osteological characteristics. It is believed to represent the native inhabitants of Kyushu in the Yayoi period. The other type of Yayoi, which is discussed here, is more or less similar to the East Asian Mongoloids and thus is regarded as comprising continental immigrants and their descendants. It is distributed in northern Kyushu and on the west coast of Yamaguchi Prefecture.

Figure 28.6 shows the locations of the archaeological sites where the Yayoi crania under consideration were discovered. The Doigahama site is a cemetery of the Early Yayoi period and yields the majority of the Yayoi crania of Yamaguchi Prefecture. Therefore, in this study the Yayoi cranial series from Yamaguchi Prefecture is designated Doigahama Yayoi for descriptive convenience. On the other hand, since about one third of the Yayoi crania of northern Kyushu are derived from the Kanenokuma site of the Middle Yayoi period, the cranial series of northern Kyushu Yayoi is referred to here as Kanenokuma Yayoi for the same reason.

Both of the Yayoi series, Doigahama and Kanenokuma, have so far been accepted as belonging to the same population consisting of continental immigrants and their offspring. However, it has been noted archaeologically that there exists a great difference in burial style between the Doigahama and Kanenokuma sites. Burial of individuals within large pottery jars (*kamekan*) is common at Kanenokuma, but such burials are not found at Doigahama (Aikens and Higuchi 1982:205-206). As shown in Figures 28.2-28.5, the results of our cranial nonmetric analyses indicate that the Kanenokuma Yayoi have greater affinity to the protohistoric and historic Japanese than the Doigahama Yayoi. In this connection, it is

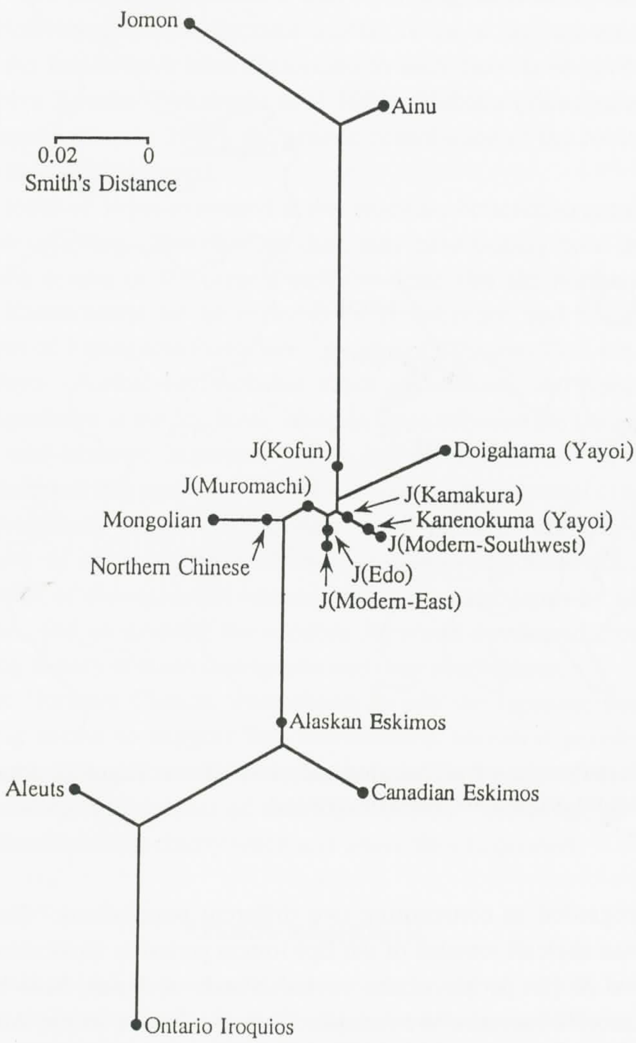

Fig. 28.5 Neighbor-joining tree of 16 cranial series from East Asia and North America based on MMD matrix. For this method of tree construction, see Saitou and Nei (1987).

noteworthy that the craniometric traits of the Jomon appear slightly stronger in the Doigahama Yayoi than in the Kanenokuma Yayoi (Nakahashi and Nagai 1989).

Population History of Japan

The close affinity between the Jomon and Ainu has been repeatedly postulated through craniometric studies (Howells 1966; Yamaguchi 1967, 1982; Hanihara 1985), dental morphology (Turner 1976, 1986, 1989; Brace and Nagai 1982), and cranial nonmetric studies (Ossenberg 1986; Dodo 1986a, 1987; Mouri 1986, 1988; Kozintsev 1990; Dodo and Ishida 1990). Though the same was reconfirmed in this study, the MMD between the Jomon and Ainu was statistically significant at the 1% level. Therefore, in spite of their close affinity,

Fig. 28.6 Distribution of archaeological sites where Yayoi skeletal remains having a probable continental origin have been discovered.

they must be regarded as constituting two different populations. However, the recently discovered human skeletal remains of the Epi-Jomon period in Hokkaido, the contemporaries of the Yayoi and Kofun people of the central islands of Japan, have been disclosed to be transitional in morphological characteristics from the Jomon to the Ainu (Oba et al 1978; Dodo 1983, 1990). Consequently, it is most likely that the Jomon, especially those living in the northeastern part of Japan, have progressed via the Epi-Jomon phase to the modern Ainu through either a microevolutional process or an admixture with their neighbors.

As to the post-Jomon cranial series from Japan, their close affinities to each other are apparent from Figures 28.2 to 28.5. The MMDs between the Kanenokuma Yayoi - Kofun, Kofun - Kamakura, Kamakura - Muromachi, Muromachi - Edo, and Edo - Modern are insignificant at the 5% level. Thus these Yayoi, protohistoric and historic samples are considered to belong to a single population. On the other hand, since all of the MMDs between the Jomon and the post-Jomon Japanese series are significant at the level of 1% or less, it is reasonable to regard them as derived from two different populations. In view of such properties of cranial nonmetric traits as "within population homogeneity and between population variability," as described before, it can be postulated that the dichotomy between the Jomon on the one hand and the Yayoi, Kofun and historic Japanese on the other is due to population discontinuity, probably caused by migration from the Asian continent during the

Yayoi period. This view is roughly consistent with the immigration theory on the origin of the modern Japanese. However, since a respectable number of Yayoi skeletal remains that are very similar to those of the Jomon have been discovered in such districts as northwestern Kyushu (Naito 1971), southern Kyushu (Nakahashi et al 1989), Shikoku (Yamaguchi 1979), and the Kanto district in Honshu (Suzuki 1969), the genetic contribution of the Jomon to the modern Japanese cannot be thoroughly ignored.

The two cranial series of Yayoi examined in this study are believed to consist of continental immigrants and their offspring. Therefore, to date, they have usually been treated as a single series. However, the results of the present study indicate that the northern Kyushu Yayoi represented by the Kanenokuma are far closer to the protohistoric and historic Japanese than the Doigahama Yayoi of Yamaguchi Prefecture. As shown in Figure 28.2, the MMDs between the Kanenokuma Yayoi - Kofun, Kanenokuma Yayoi - Kamakura, and Kanenokuma Yayoi - Muromachi are insignificant at the 5% level, whereas those between the Doigahama Yayoi and the protohistoric and historic Japanese series are all significant at the same level. Consequently, it is inferred that northern Kyushu was one of the dispersal centers of the Yayoi people who have progressed via the Kofun phase to the modern Japanese. Presumably the genetic constitution of such continental immigrants as the Kanenokuma Yayoi had predominated over that of the natives in various parts of western Japan by around the middle of the Yayoi period, and as a result the modern Japanese developed from this incipient population consisting mainly of these immigrants and their descendants.

In this study, the Northern Chinese were shown to join the Japanese samples of historic times. This finding seems to suggest that the common ancestral people of the modern Japanese and northern Chinese once lived somewhere in East Asia. They may possibly be related to the continental immigrants of the Yayoi period. However, as yet, our cranial nonmetric data are insufficient to clarify when and where they flourished.

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