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The Incidence of Minor Non-metric Cranial Variants in the Protohistoric Human Remains from Eastern Japan

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Abstract The frequencies of 27 minor non-metric variants in 119 skulls of the Protohistoric times from the Kantō and Tōhoku districts were recorded. The incidence pattern was compared, for limited number of traits, with those in the skulls of the recent Japanese, Koreans, Northern Chinese, early modern Japanese, and prehistoric Jōmon people. The Jōmon series was found to be the most divergent from others, and, within the cluster of the five remaining series, the closest to the Protohistoric series was that of the recent Koreans. Implication of these findings in disclosing the process of population history in the early post-Jōmon periods was discussed.

The positive value of non-metric minor skeletal variants, otherwise known as discrete traits, for studying differentiation between closely related skeletal populations has repeatedly been demonstrated in the last two or three dacades (*e.g.* LAUGHLIN and JØRGENSEN, 1956; BROTHWELL, 1959; YAMAGUCHI, 1967; ANDERSON, 1968; BERRY, 1968; PIETRUSEWSKY, 1971; CYBULSKI, 1975; OSSENBERG, 1977; BERRY, 1979; RÖSING, 1982; OSSENBERG, 1985).

The investigations of such variants by DODO (1974, 1975, 1985) on the recent, early modern, and prehistoric cranial series from the Kantō and Tōhoku districts showed that the incidence patterns of the cranial variants in the recent Japanese and the early modern Japanese of the Edo period were very much alike to each other and considerably different from that in the prehistoric series of the Jōmon period.

The present research on the cranial variants in the Protohistoric materials has been undertaken to fill a diachronic gap in data and to assess the relationship of the population in the Protohistoric times with those in the Jōmon period on the one hand and modern times on the other by comparing respective trait incidence patterns.

Materials

From the anthropological collections in the National Science Museum, Tokyo and the University Museum, the University of Tokyo, 119 adult skulls excavated from Protohistoric burials of mound type (*kofun*) or of cave type (*yokoana* or *ōketsubo*) in the Kantō district and the southern part of the Tōhoku district were examined for occurrence of twenty-seven minor variants.

The burials range in date from the Kofun period (the 4th to the 7th centuries A.D.)

to the Nara period (the 8th century). The majority of the materials came from Tokyo, Kanagawa, and Chiba prefectures in the southern part of the Kantō district, and about a half of the materials were excavated from numerous cave-type family tombs, of the 7th or 8th century, distributed along the Tama River in Tokyo.

Owing to the property of soil in this region that is generally unfavorable for the preservation of bone tissues, many materials are incomplete and some of them are even fragmentary. Therefore, the sex determination based on morphological assessment was often difficult, and in some cases it was simply impossible. Thus, out of the 119 skulls examined, only 65 and 38 could be assigned respectively to male and female.

Methods

The following twenty-seven traits were scored either as present or absent.

1. Ossicle at lambda
2. Os incae
3. Vestige of sutura mendosa (10 mm or more)
4. Superior sagittal sinus groove, turning to the left
5. Condylar canal, patent
6. Hypoglossal canal, completely divided
7. Jugular foramen, completely divided
8. Precondylar tubercle
9. The third occipital condyle
10. Asterionic ossicle
11. Occipitomastoid ossicle (excl. asterionic ossicle)
12. Occiptiomastoid ossicle (incl. asterionic ossicle)
13. Pterygospinous foramen
14. Foramen of Vesalius (0.5 mm or more in minor diameter)
15. Aural exostosis (excl. trace type)
16. Tympanic dehiscence (1 mm or more in minor diameter)
17. Parietal notch bone (5 mm or more in major diameter)
18. Epipteric ossicle
19. Frontotemporal articulation
20. Metopism
21. Supra-orbital nerve groove
22. Supra-orbital foramen (incl. frontal foramen)
23. Medial palatine canal
24. Posterior vestige of transverse zygomatic suture (5 mm or more)
25. Multiple mental foramina
26. Mandibular torus (incl. trace)
27. Mylohyoid canal

For paired traits, such as the vestige of the sutura mendosa, incidences were counted not only by the skull but also by the right side and left side separately. In comparative analyses, however, the incidences of the paired traits scored only on the left side and those of the unpaired traits were subjected to distance calculations.

Distances between different cranial series were assessed by C. A. B. SMITH's mean measure of divergence and its variance that are written as

$$\mathrm{MMD}=\frac{1}{n}\sum^{n}(\theta_1-\theta_2)^2-\frac{1}{n}\sum^{n}\left(\frac{1}{N_1}+\frac{1}{N_2}\right)$$

$$\mathrm{var\ MMD}=\frac{2}{n^2}\sum\left(\frac{1}{N_1}+\frac{1}{N_2}\right)^2$$

where n is the number of variants; θ_1 and θ_2 are angular transformations in radians of the trait frequencies p_1 and p_2 of each variant in the two series, obtained by the formula $\theta=\arcsin(1-2p)$; and N_1 and N_2 are the numbers of observations in the two series (SJØVOLD, 1973). When p is 0, it is replaced by $1/4N$ (BARTLETT's adjustment).

Incidence Data

Incidences of the twenty-seven variants (22 paired and 5 unpaired) in the adult Protohistoric skulls from eastern Japan are given in Table 1.

One of the six cases of the os incae was, to be more precise, a case of the os apicis. The only case scored as the third occipital condyle was not of facet type but was an ossified apical ligament.

Comparison

Seventeen traits out of 27 variants examined here are available for comparison of incidences with those recorded by DODO (1974, 1985) for cranial series of the recent Japanese and the prehistoric Jōmon population from the Kantō and Tōhoku districts, since practically the same criteria as the present author's were employed by DODO for scoring the 17 traits.

Table 2 gives the midline or left side incidences of the 17 traits in the Protohistoric series by the side of those of the Jōmon and the recent Japanese series. The left side incidences of the paired traits in the recent Japanese series were calculated by the present author from the data published by DODO (1974). Those in the Jōmon series were calculated from an unpublished table of original record (DODO, personal communication).

As compared with the Jōmon series, the Protohistoric series is characterized by lower frequencies of the divided hypoglossal canal, aural exostosis, metopism, and medial palatine canal and higher frequency of the supra-orbital foramen. The recent Japanese series shares all these tendencies with the Protohistoric series. Although the Protohistoric series has some peculiarities all its own, such as a very high incidence of the occipitomastoid ossicle and a low incidence of the mandibular torus, it is distinctly closer, in its overall pattern of the trait incidences, to the recent series than to the Jōmon series.

Table 1. The incidence of twenty-seven minor non-metric variants in the adult skulls of the Protohistoric periods from eastern Japan.

Variants		Incidences by the skull					Incidences by the side	
		N	RL	RO	OL	T (P)	Right (P)	Left (P)
1. Ossicle at lambda	m	39				4		
	f	26				0		
	?	8				1		
	t	73				5 (0.068)		
2. Os incae	m	48				3		
	f	28				2		
	?	8				1		
	t	84				6 (0.071)		
3. Vestige of sutura mendosa (10 mm or more)	m	30	6	3	1	10	12/39	8/36
	f	19	1	0	0	1	3/24	2/22
	?	6	2	0	0	2	3/ 7	2/ 9
	t	55	9	3	1	13 (0.236)	18/70 (0.257)	12/67 (0.179)
4. Superior sagittal sinus groove, turning to the left	m	40				2		
	f	28				2		
	?	9				1		
	t	77				5 (0.065)		
5. Condylar canal, patent	m	20	12	4	1	17	24/30	16/24
	f	19	15	1	2	18	19/22	18/20
	?	2	0	2	0	2	2/ 2	0/ 2
	t	41	27	7	3	37 (0.902)	45/54 (0.833)	34/46 (0.739)
6. Hypoglossal canal, completely divided	m	29	1	2	2	5	4/36	3/32
	f	23	0	3	2	5	3/25	2/24
	?	3	0	1	0	1	1/ 4	0/ 3
	t	55	1	6	4	11 (0.200)	8/65 (0.123)	5/59 (0.085)
7. Jugular foramen, completely divided	m	16	1	0	0	1	2/25	1/20
	f	21	0	1	1	2	1/24	2/22
	?	2	0	0	0	0	0/ 2	0/ 2
	t	39	1	1	1	3 (0.077)	3/51 (0.059)	3/44 (0.068)
8. Precondylar tubercle	m	26	0	0	0	0	0/28	0/27
	f	20	0	0	0	0	0/21	0/21
	?	2	0	0	0	0	0/ 3	0/ 2
	t	48	0	0	0	0 (0.000)	0/52 (0.000)	0/50 (0.000)
9. The third occipital condyle	m	29				0		
	f	24				1		
	?	3				0		
	t	56				1 (0.018)		
10. Asterionic ossicle	m	22	1	3	4	8	4/34	5/31
	f	18	2	0	3	5	2/23	5/20
	?	5	1	1	0	2	2/ 6	1/ 8
	t	45	4	4	7	15 (0.333)	8/63 (0.127)	11/59 (0.186)

Table 1. (*Continued*)

Variants		Incidences by the skull					Incidences by the side	
		N	RL	RO	OL	T (P)	Right (P)	Left (P)
11. Occipitomastoid ossicle (excl. asterionic ossicle)	m	19	3	1	5	9	7/30	9/28
	f	17	0	3	3	6	4/24	3/19
	?	4	0	0	0	0	0/ 6	0/ 5
	t	40	3	4	8	15 (0.375)	11/60 (0.183)	12/52 (0.231)
12. Occiptiomastoid ossicle (incl. asterionic ossicle)	m	20	6	1	4	11	10/30	12/29
	f	17	3	2	4	9	5/22	7/19
	?	5	1	1	0	2	2/ 6	1/ 6
	t	42	10	4	8	22 (0.524)	17/58 (0.293)	20/54 (0.370)
13. Pterygospinous foramen	m	23	0	1	0	1	1/31	0/33
	f	22	0	0	0	0	0/25	0/28
	?	1	0	0	0	0	0/ 3	0/ 5
	t	46	0	1	0	1 (0.022)	1/59 (0.017)	0/66 (0.000)
14. Foramen of Vesalius (0.5 mm or more in minor diameter)	m	22	6	3	2	11	11/26	10/31
	f	20	2	4	1	7	8/25	6/24
	?	0	0	0	0	0	0/ 2	2/ 5
	t	42	8	7	3	18 (0.429)	19/53 (0.358)	18/60 (0.300)
15. Aural exostosis (excl. trace type)	m	36	0	0	0	0	1/46	0/46
	f	26	0	1	1	2	2/29	2/31
	?	5	0	0	0	0	0/ 6	0/11
	t	67	0	1	1	2 (0.030)	3/81 (0.037)	2/88 (0.023)
16. Tympanic dehiscence (1 mm or more in minor diameter)	m	32	4	0	2	6	8/46	8/43
	f	29	1	2	4	7	3/30	5/34
	?	4	1	0	1	2	1/ 6	3/10
	t	65	6	2	7	15 (0.231)	12/82 (0.146)	16/87 (0.184)
17. Parietal notch bone (5 mm or more in major diameter)	m	21	1	2	2	5	8/37	7/31
	f	13	1	0	0	1	2/21	3/20
	?	2	0	0	0	0	0/ 3	1/ 5
	t	36	2	2	2	6 (0.167)	10/61 (0.164)	11/56 (0.196)
18. Epipteric ossicle	m	7	1	1	0	2	3/15	2/15
	f	7	2	0	1	3	5/14	7/16
	?	0	0	0	0	0	0/ 1	1/ 1
	t	14	3	1	1	5 (0.357)	8/30 (0.267)	10/32 (0.313)
19. Frontotemporal articulation	m	7	0	0	0	0	1/15	0/15
	f	7	1	0	0	1	1/14	2/16
	?	0	0	0	0	0	0/ 1	0/ 1
	t	14	1	0	0	1 (0.071)	2/30 (0.067)	2/32 (0.063)
20. Metopism	m	54				0		
	f	34				0		
	?	11				0		
	t	99				0 (0.000)		

Table 1. (*Continued*)

Variants		Incidences by the skull					Incidences by the side	
		N	RL	RO	OL	T (P)	Right (P)	Left (P)
21. Supra-orbital nerve groove	m	32	4	0	2	6	5/36	7/41
	f	16	2	2	3	7	5/20	7/22
	?	5	0	0	0	0	0/ 7	0/ 6
	t	53	6	2	5	13 (0.245)	10/63 (0.159)	14/69 (0.203)
22. Supra-orbital foramen (incl. frontal foramen)	m	33	8	4	5	17	12/38	16/40
	f	19	5	3	2	10	9/20	12/25
	?	5	2	0	0	2	3/ 6	3/ 7
	t	57	15	7	7	29 (0.509)	24/64 (0.375)	31/72 (0.431)
23. Medial palatine canal	m	29	0	1	1	2	1/34	1/31
	f	22	0	1	1	2	1/23	1/25
	?	0	0	0	0	0	0/ 1	0/ 3
	t	51	0	2	2	4 (0.078)	2/58 (0.034)	2/59 (0.034)
24. Vestige of transverse zygomatic suture (5 mm or more)	m	6	3	0	1	4	6/17	4/10
	f	2	0	0	0	0	0/ 5	0/ 7
	?	0	0	0	0	0	0/ 0	0/ 0
	t	8	3	0	1	4 (0.500)	6/22 (0.273)	4/17 (0.235)
25. Multiple mental foramina	m	22	0	1	2	3	1/25	2/22
	f	19	0	3	1	4	3/19	0/22
	?	3	0	0	0	0	0/ 3	0/ 4
	t	44	0	4	3	7 (0.159)	4/47 (0.085)	2/48 (0.042)
26. Mandibular torus (incl. trace)	m	24	3	1	1	5	4/26	3/24
	f	21	1	1	0	2	2/21	1/22
	?	3	0	1	0	1	1/ 3	0/ 4
	t	48	4	3	1	8 (0.167)	7/50 (0.140)	4/50 (0.080)
27. Mylohyoid canal	m	10	0	0	0	0	0/19	0/14
	f	9	0	0	2	2	1/17	2/10
	?	2	0	0	0	0	0/ 2	0/ 3
	t	21	0	0	2	2 (0.095)	1/38 (0.026)	2/27 (0.074)

NOTE: RL=bilaterally present; RO (OL)=unilaterally present on the right (left) side and absent on the other side; T=incidence of unpaired trait, or total of RL, RO, and OL of paired trait; P=proportion; m=male; f=female; ?=sex undetermined; t=total of m, f, and ?.

The three MMDs given in Table 3 that were calculated by the incidences of the 17 traits clearly reveal the mutual relationship among the three cranial series. The Protohistoric series is obviously closer to the recent series and these two are almost equally distant from the Jōmon series.

Several other cranial series from Japan and adjacent regions have been investigated for non-metric traits by various authors (AKABORI, 1933; DODO, 1975; MOURI, 1976; ONISHI, 1941; OSSENBERG, 1985). But numbers of the traits scored with the same criteria as those employed in the present study are rather limited. Thus, it is only for

Table 2. Comparison of the incidences of seventeen variants in three cranial series of different times from eastern Japan. Only the incidences on the left side are given for paired traits.

Variants	Jōmon[1)]		Protohistoric		Recent[2)]	
	(N)	P	(N)	P	(N)	P
1. Ossicle at lambda	(84)	0.060	(73)	0.068	(174)	0.040
3. Vestige of sutura mendosa	(78)	0.205	(67)	0.179	(176)	0.085
5. Condylar canal, patent	(37)	0.811	(46)	0.739	(178)	0.669
6. Hypoglossal canal, divided	(57)	0.228	(59)	0.085	(180)	0.106
12. Occipitomastoid ossicle (incl. ast. oss.)	(49)	0.143	(54)	0.370	(173)	0.127
13. Pterygospinous foramen	(50)	0.005*	(66)	0.004*	(179)	0.017
14. Foramen of Vesalius	(46)	0.370	(60)	0.300	(179)	0.313
15. Aural exostosis	(80)	0.138	(88)	0.023	(176)	0.006
16. Tympanic dehiscence	(77)	0.130	(87)	0.184	(179)	0.285
17. Parietal notch bone	(60)	0.150	(56)	0.196	(172)	0.203
20. Metopism	(84)	0.131	(99)	0.003*	(180)	0.089
21. Supra-orbital nerve groove	(67)	0.104	(69)	0.203	(177)	0.243
22. Supra-orbital foramen	(76)	0.118	(72)	0.431	(180)	0.372
23. Medial palatine canal	(54)	0.111	(59)	0.034	(177)	0.040
24. Vestige of transverse zygomatic suture	(51)	0.373	(17)	0.235	(167)	0.090
26. Mandibular torus	(70)	0.343	(50)	0.080	(177)	0.215
27. Mylohyoid canal	(69)	0.174	(27)	0.074	(177)	0.045

1) Dodo (1985). Left incidences of paired traits were personally communicated.
2) Dodo (1974).
* Zero proportion replaced by 1/4N (Bartlett's adjustment).

Table 3. Smith's mean measure of divergence bassed on the incidence data given in table 2.

	MMD	S.D.
Jōmon to Protohistoric	0.1112	*0.0131*
Jōmon to Recent	0.1125	*0.0077*
Protohistoric to Recent	0.0431	*0.0095*

a set of ten traits that the cranial series of early modern Japanese from Edo (Dodo, 1975) and those of the recent Koreans and the Northern Chinese (Onishi, 1941) can be compared directly with the present series.

Table 4 gives the midline or left side incidences of the ten traits in six cranial series including the three newly added ones. The asterionic ossicle and the occipitomastoid ossicle are scored separately in this table, whereas they have been handled as a single trait under the term of occipitomastoid ossicle in Table 2. The unpublished frequency data of these two variants in the recent Japanese and Jōmon series were again kindly offered by the author (Dodo, personal communication).

MMD was calculated for each couple of the six cranial series on the basis of the incidences of the ten traits. Results are shown in Table 5 with respective standard

Table 4. Comparison of the incidences of ten variants in six cranial series. Only the incidences on the left side are given for paired traits.

Variants	Eastern Japan								Korea		North China	
	Jōmon[1)]		Proto-historic		Early modern (Edo period)[2)]		Recent[3)]		Recent[4)]		Recent[4)]	
	(N)	P	(N)	P	(N)	P	(N)	P	(N)	P	(N)	P
1. OL	(84)	0.060	(73)	0.068	(188)	0.074	(174)	0.040	(318)	0.047	(101)	0.050
5. CC	(37)	0.811	(46)	0.739	(148)	0.588	(178)	0.669	(238)	0.726	(99)	0.758
6. HC	(57)	0.228	(59)	0.085	(155)	0.110	(180)	0.106	(330)	0.115	(98)	0.163
10. AO	(66)	0.015	(59)	0.186	(146)	0.103	(172)	0.076	(329)	0.082	(101)	0.069
11. OO	(54)	0.111	(52)	0.231	(146)	0.055	(179)	0.078	(330)	0.200	(101)	0.109
16. TD	(77)	0.130	(87)	0.184	(166)	0.253	(179)	0.285	(325)	0.182	(100)	0.140
17. PNB	(60)	0.150	(56)	0.196	(160)	0.138	(172)	0.203	(323)	0.226	(97)	0.196
20. MTP	(84)	0.131	(99)	0.003*	(194)	0.052	(180)	0.089	(316)	0.054	(101)	0.069
22. SF	(76)	0.118	(72)	0.431	(184)	0.413	(180)	0.372	(315)	0.457	(101)	0.446
23. MPC	(54)	0.111	(59)	0.034	(129)	0.054	(177)	0.040	(312)	0.032	(96)	0.073

1) DODO (1985). Left incidences of paired traits were personally communicated.
2) DODO (1975). 3) DODO (1974) and personal communication. 4) ONISHI (1941).
* Zero proportion replaced by 1/4N.

Table 5. SMITH's mean measure of divergence based on the incidence data given in table 4.

	Jōmon	Proto-historic	Early modern	Recent	Koreans	Northern Chinese
Jōmon	0					
Protohistoric	0.1459	0				
	(0.0148)					
Early modern	0.1039	0.0412	0			
	(0.0103)	*(0.0101)*				
Recent	0.0754	0.0450	0.0017	0		
	(0.0100)	*(0.0098)*	*(0.0053)*			
Koreans	0.0963	0.0068	0.0317	0.0173	0	
	(0.0090)	*(0.0087)*	*(0.0043)*	*(0.0040)*		
Northern Chinese	0.0520	0.0269	0.0181	0.0103	0.0017	0
	(0.0120)	*(0.0117)*	*(0.0073)*	*(0.0070)*	*(0.0059)*	

NOTE: The figures in parentheses are standard deviations.

deviations.

The MMDs between the Jōmon series and five other series are highly significant, being much greater than twice respective standard deviations. But the mutual MMDs among the five series other than the Jōmon are generally small. Especially those for the following four couples do not reach the 5 percent level of significance, being far less than twice standard deviations:

Protohistoric Japanese and Koreans
Early modern Japanese and recent Japanese

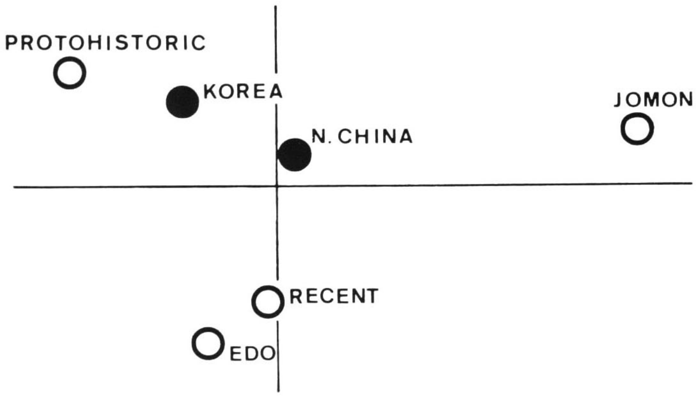

Fig. 1. Principal coordinates analysis of the MMDs given in Table 5. Marked by open circles are cranial series of different dates from eastern Japan.

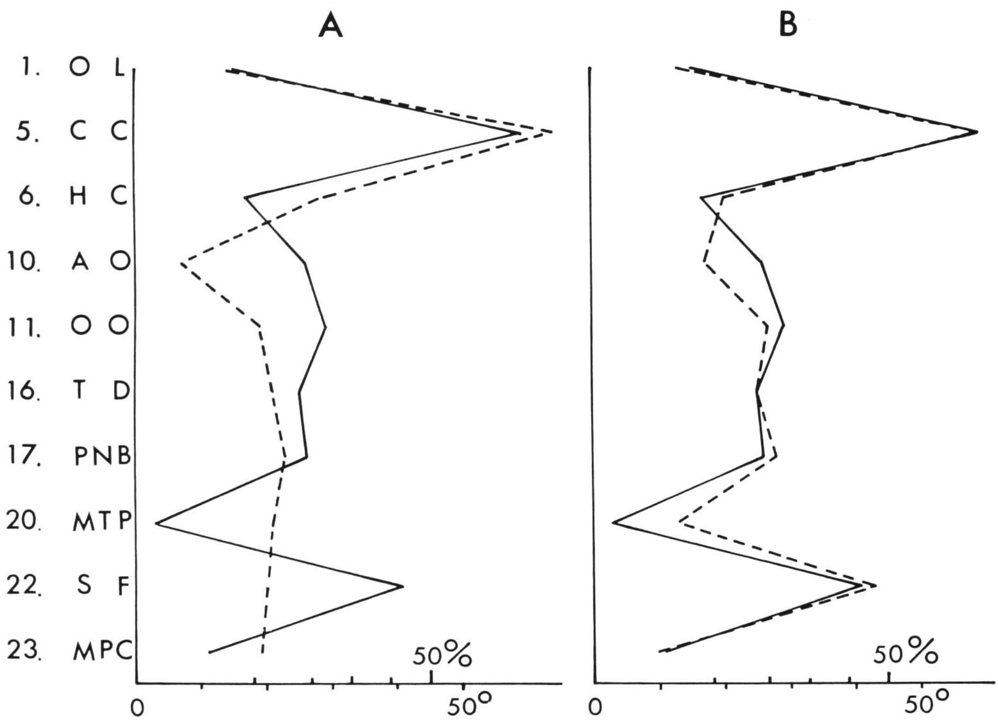

Fig. 2. Graphic comparisons of the incidences of ten traits. Proportions are transformed into angles by FISHER's formula $\theta = \arcsin \sqrt{p}$.

A: Protohistoric (——) and Jōmon series (- - - -). B: Protohistoric (——) and Korean series (- - - -).

Recent Japanese and Northern Chinese
Koreans and Northern Chinese

General configuration of the six series is approximately visualized in Fig. 1 by means of principal coordinates analysis (GOWER, 1972) of the MMDs given in Table 5. It shows that (i) the prehistoric Jōmon series is isolated from the rest; (ii) the recent East-Asian Mongoloid series from North China, Korea and Japan form an explicit cluster; (iii) the Protohistoric series from Japan is the farthest from the Jōmon and the closest to the recent Korean series.

Remarkable parallelism between the Protohistoric Japanese and the recent Koreans in the incidence pattern of the ten traits is illustrated in Fig. 2, as contrasted with striking disparity between the former and the Jōmon people.

Discussion and Conclusion

The foregoing comparisons have shown that in the incidence pattern of non-metric cranial variants the Protohistoric series from eastern Japan is considerably apart from the prehistoric Jōmon series of the same geographical region, and is much closer to the series of recent Mongoloid populations, especially that of the Koreans.

The striking morphological difference between the Jōmon and the Protohistoric populations has long been known since the craniometric studies by Jō (1938) and SUZUKI (1969). KIYONO (1938) and KANASEKI (1966, 1976) assumed some genetic influence, due to immigration from the Asiatic mainland during the Yayoi and Kofun periods, as one of the factors of the sudden changes that occurred in the physical characters of the population especially in the western part of Japan. However, SUZUKI (1969, 1981) denied significant genetic contribution by immigrants except in the westernmost part of Japan and attributed the drastic morphological changes almost exclusively to the evolutionary processes that were accelerated by radical change in subsistence from hunting and gathering to rice cultivation.

SUZUKI's argument was developed mainly on the ground that the Japanese population have actually experienced a similar or even greater morphological change since the end of the Edo period without undergoing any significant genetic influence from the outside. He interpreted the rapid secular changes in the stature, head form and other physical characters of the modern Japanese as caused by the revolutionary changes in the conditions of life that started in the mid-nineteenth century, and argued that similarly rapid changes could have occurred to the indigenous Jōmon population while a new agrarian system of subsistence was introduced from the Asian mainland.

This argument is well-grounded as long as the morphological changes that occurred during those two revolutionary phases in the Japanese history are of much the same range, as is the case with some metrical variations. However, so far as the incidence patterns of non-metric cranial variants are concerned, that is not the case, because the difference between the Edo and recent series is so slight and insignificant that it can hardly bear comparison with the highly significant divergence between the Jōmon and

Protohistoric series.

It should be kept in mind that the skeletal remains excavated mainly from the cave-type tombs in southern Kantō may hardly be recognizable as an unbiased sample of the entire Protohistoric population in eastern Japan. Nevertheless, in view of the epigenetic nature of many of the discrete traits (BERRY, 1968; SJØVOLD, 1984) and the remarkable convergence of the Protohistoric series and the Korean series, the above finding seems to suggest that the genetic influence from the Continent cannot be ignored, even in the eastern part of Japan, as one of the possible factors causing the rapid morphological changes of the inhabitants during the Yayoi and Kofun periods. In other words, the result of this study may be taken to imply that the post-Jōmon process of Mongoloidization of the Japanese population, as postulated earlier by the present author (YAMAGUCHI, 1982), had well been under way in the Protohistoric eastern Japan.

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