A Multivariate Analysis of the Cranial Measurements of the Ryukyu Islanders (Males)

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Abstract The cranial measurements of the Ryukyu Islanders (males) were examined by multivariate analysis. There is a clear separation between the Okinawa and Amami districts among the Ryukyu populations. As a result of a comparison among 8 populations in the Ryukyu Islands and Honshu-Kyushu, it is clear that the Ryukyu Islanders are a local group of the Japanese people. Comparison among the Ryukyu people, Honshu-Kyushu Japanese and their surrounding populations clarified that the populations closest to the Ryukyu people are the Honshu-Kyushu Japanese followed by some of the southern people and that the population closest to the Ainu is the Ryukyu Islanders among the populations compared here. The Ryukyu people are almost equally close to the modern, proto-historic and prehistoric Japanese and the Ainu, and are comparatively far from Korean.

Since BAEZ ('11) drew attention to the significance of physical anthropological studies on Ryukyu Islanders with reference to the racial affinities of the Japanese population, there have been a number of publications concerning the physical traits of these islanders, based upon data of somatometry, dermatography, serology, etc., while little information on the human skeletal remains of the prehistoric period has been brought to light. Reports which deal with a relatively large number of modern crania are regionally restricted to the Amami district, the northern part of the Ryukyu Islands, and craniological studies on islanders of the Okinawa district, that is the southern part of the Ryukyu Islands, were found on small samples with the exception of Okinawa Honto (HSÜ '48). They are as follows: Yonaguni (ADACHI 1895, KANASEKI '63,

NAGAI and SANO '66) and Okinawa Honto (KINTAKA '29, HSÜ '48).

Recently, one of the authors obtained craniometrical data of modern crania from Nagabaka in Miyako Island, the Okinawa district, and compared them with those of modern populations in the adjacent area, using relative deviations and mean relative deviations of each population from Nagabaka (IKEDA '74). In this paper, the cranial measurements of the Ryukyu Islanders including some new data from Miyako, Iriomote, Okinawa Honto, Tokunoshima and Kikai, are examined by multivariate analysis to clarify the mutual relationships among the populations of the surrounding districts and the prehistoric and protohistoric Japanese populations. These relationships do not seem to have been examined in any previous report.

MATERIALS AND METHOD

The adult crania without mandibles from the following islands were measured: Miyako-1 (Nagabaka; 85 males, 48 females, 2 sex unknown), Miyako-2 (Karimata; 16 males, 14 females), Iriomote (Haimi; 36 males, 23 females), Okinawa Honto-2 (Tokuchi, Unten and Tamagusuku; 11 males, 10 females), Tokunoshima-2 (Honkawa Cave; 24 males, 29 females), Kikai (Akaren, Onozu, Oasado, Shiomichi and Keraji; 7 males, 2 females). The data of the last were used only for calculation of within-group matrix but not for comparison with other populations. The crania from both Miyako and Iriomote were examined at the cemeteries, and the others, which were collected by MIYAKE and others, at the Laboratory of Physical Anthropology, Kyoto University. The materials from Nagabaka and Karimata are probably of approximately the same period, and the age of the former was estimated not to be more than 200 years (IKEDA '74). The skulls from Haimi are judged by documentary evidence to be of people living during the period from 1734 to 1920. Most of the materials from the other islands are presumed to belong to recent times, though the precise chronological dates are unknown. Thus, all the materials are regarded as a modern cranial series of the Ryukyu Islanders. Only the measurements of males are used for comparison in this study.

Comparative data were obtained from the following modern populations, the maximum number of samples among the

measurements and the name of the researchers being enclosed in parentheses. The Ryukyu Islanders: Okinawa Honto-1 (48, HSÜ '48), Yoron (38, OYAMA '56), Tokunoshima-1 (57, IWAI '59), Yoro (25, KIKUCHI '59) and Kikai (17, NAKANO '58). Populations of areas adjacent to the Ryukyu Islanders: Northern Kyushu (108, HARADA '54), Central Kyushu (67, MATSUMOTO '67), Kinki (30, MIYAMOTO '24), Kanto (144, MORITA '50), Hokuriku (30, OTSUKI, '30), Tohoku (65, YAMAZAKI *et al.* '67), Yakumo Ainu (52, WATANABE '38), Central Korea (178, SHIMA '34), Fushun (77, SHIMA '33), Hainan (193, HUANG '48), Fukien (154, ASAI '42), Seil Peipo (56, YUANG '60), Atayal (74, CHANG '49), Tagalog (31, BONIN '31), Dayak (55, BONIN '31). Prehistoric and protohistoric crania, which are used for comparison, are as follows: Jomon crania, Yoshigo (57 KINTAKA '28); Yayoi crania, Doigahama (55, KANASEKI *et al.* '60); Kofun crania, Western Japan (31, Jo '38).

Multiple discriminant analysis is used for comparison among the populations. For interpretation of the nature of each discriminant function, discriminant loadings, or the within-group correlations between the function and the measurements, are used. Mahalanobis' D-squares are also calculated to express the whole information carried by the full set of the functions.

Within-group variance-covariance matrix was calculated for each of five groups; Ryukyu (67 samples), Kinki (27), Sakhalin Ainu (16), Tagalog (15), Dayak (27). Sakhalin Ainu (HIRAI '27) was not in

cluded in the populations compared. As a result of chi-square test, difference of matrices between Ryukyu and Kinki is not significant at 5% level, but that of matrices among Ryukyu, Kinki and Dayak is strikingly significant even at 1% level. Since there are no marked differences among the correlation matrices of these five groups, however, the mean of five matrices weighted by the sample sizes is used as the common within-group matrix. Among-group matrix is calculated from the mean of each measurement, regardless of sample sizes of the populations. Some of the data used in this analysis are not of individual samples but the mean values for the populations, however, and no statistical technique is as yet available for testing the significance of among-group differences or eigen values.

The same data were re-examined by

three different techniques; the Q-mode correlation coefficient, the shape distance of Penrose and the multiple discriminant analysis on the Q-mode standardized data (CORRUCCINI '73). Since all these results are highly consistent with those obtained by multiple discriminant analysis on the unmodified data, only the results obtained by the latter analysis will be discussed in the next section.

RESULTS AND DISCUSSION

1. Comparison among Ryukyu populations

FUNCTIONS AND LOADINGS (Fig. 1, Table 1)

The first four functions account for about 82% of the variation among 10 populations in the Ryukyu Islands.

Function 1: The difference between the Okinawa and Amami districts is clearly

Table 1. Discriminant loadings. Comparison among the Ryukyu populations.

Function	1	2	3	4
Cumulative trace (%)	40.3	63.6	74.1	82.3
1. Max. cranial ln.	.036	-.164	.440	-.000
2. Cranial base ln.	.159	-.029	.108	-.072
3. Max. cranial br.	-.182	.137	.126	-.446
4. Min. frontal br.	.141	-.386	.189	.018
5. Basion-bregma ht.	.145	-.159	-.125	.216
6. Horizontal circ.	.202	.020	.436	-.055
7. Transverse arc	-.208	-.093	.277	.065
8. Sag. frontal arc	-.059	-.080	.083	-.041
9. Sag. parietal arc	-.018	-.100	.366	.069
10. Sag. occipital arc	-.083	-.090	.110	.117
11. Facial ln.	-.088	.106	.246	-.339
12. Bizygomatic br.	.239	.050	.345	.051
13. Upper facial ht.	.145	-.244	.425	-.090
14. Orbital br.	-.144	-.563	.039	.181
15. Orbital ht.	.009	-.118	-.011	.088
16. Nasal br.	.044	.110	.459	-.267
17. Nasal ht.	-.052	.129	.410	.267

Fig. 1. Plot of the Ryukyu populations on the first four functions.

recognizable. As the arrangement of the populations on this function is generally in accordance with the geographical distribution of the populations excepting both Iriomote and Tokunoshima-2, this function might well reflect the regional differences of cranial traits in the Ryukyu Islands. There are no striking differences of loadings among the measurements, but horizontal circumference, transverse arc and bizygomatic breadth have a little higher loadings than the others.

Functions 2 and 3: About 34% of inter-group variation is carried by these two functions; there seems, however, to be no clearly discernible overall tendency. Loadings are notably high in a breadth component of the frontal part (orbital breadth, minimum frontal breadth, with the negative sign) for function 2, and in a general size component (maximum cranial length, horizontal circumference, sagittal parietal arc, bizygomatic breadth, upper facial height, nasal breadth and height, with the positive sign) for function 3.

Function 4: On this function, it is possible to discriminate between the Okinawa and Amami districts though not so clearly as in the case of function 1. Combination of these two functions completely separates both districts. Maximum cranial breadth and facial length have high loadings.

D-SQUARES (Table 2)

Values among 7 populations consisting of Tokunoshima-2 and Yoron of the Amami district as well as the whole Okinawa district, excepting Miyako-1 v.s. Okinawa Honto-1 (6.86), are below 5.60. On the other hand, D-squares between each of these seven and the remaining three populations of the Amami district, with the exception of Tokunoshima-2 v.s. Yoro (3.77), are all above 5.90. Tokunoshima-2 and Yoron of the Amami district as well as the whole Okinawa district, excepting Miyako-1 v.s. Okinawa Honto-1 (6.86), are below 5.60. On the other hand, D-squares between each of these seven and the remaining three populations of the Amami district, with the exception of Tokunoshima-2 v.s. Yoro (3.77), are all above 5.90. Tokunoshima-2 and Yoron of the Amami district as well as the whole Okinawa district, excepting Miyako-1 v.s. Okinawa Honto-1 (6.86), are below 5.60. On the other hand, D-squares between each of these seven and the remaining three populations of the Amami district, with the exception of Tokunoshima-2 v.s. Yoro (3.77), are all above 5.90.

Table 2. D-squares among the Ryukyu populations.

	Miyako -1	Miyako -2	Okinawa Honto-2	Iriomote	Tokuno- shima-2	Okinawa Honto-1	Yoron	Tokuno- shima-1	Yoro
Miyako-2	4.81								
Okinawa Honto-2	4.03	3.77							
Iriomote	3.75	2.31	3.73						
Tokunoshima-2	5.56	2.73	3.44	1.42					
Okinawa Honto-1	6.86	4.09	4.19	3.52	2.75				
Yoron	5.03	5.00	4.43	4.22	3.93	5.18			
Tokunoshima-1	9.02	10.30	6.83	6.60	7.95	7.26	6.48		
Yoro	13.68	8.19	8.25	5.94	3.77	6.53	6.63	11.27	
Kikai	14.88	12.99	12.04	7.93	7.74	7.60	6.97	7.89	4.74

shima-2 and Yoron are quite close to most of the rest, while Kikai is far from all but Yoron. Values for each pair of the populations in the same islands (Miyako, Okinawa-Honto, Tokunoshima) are not always smaller than those for other pairs.

IKEDA ('74) pointed out that there is no significant separation between the Okinawa and Amami districts, on the grounds that the difference between Miyako-1 and Okinawa Honto-1 are greater than those between Miyako-1 and Iriomote or Yoron, while the differences between Okinawa Honto-1 and the populations of Amami district are greater than those between Okinawa Honto-1 and Miyako-1 or Iriomote. Multivariate analysis in this paper, however, shows clear discrimination between the Okinawa and Amami districts, though some of D-squares are not in accordance with this result.

Seven populations, including all of the Okinawa district, and Tokunoshima-2 and Yoro, are close to each other, but the remaining three, Tokunoshima-1, Yoro and Kikai, are distant from all populations of the Okinawa district, particularly from both populations of Miyako. Each of these three seems to be craniometrically isolated, although Tokunoshima-2 and Yoro are relatively close.

According to anthropometrical studies published to date, the inhabitants of the Kunigami region in Okinawa Honto come close to those of Hateruma, the seashore region of Kikai and Amami Oshima, but are different from those of Yoron and the average of Okinawa Honto (TOYAMA '59). On the other hand, in Okinawa Honto,

the people of the northern region are similar to those of Tokunoshima (OYADOMARI '68, TOMIZAWA '69), and that of the central region to both of them (SAKIHARA '68), but the people of the southern region are different from other two regions (ARAGAKI '68). AOKI ('59) stated that Miyako islanders have the closest relationship to those of Yonaguni, followed by those of Amami Oshima and other Ryukyu islanders, and that the further north the populations under comparison are off from Miyako, for example, from Yakushima to Tanegashima through Kuchinoshima, the more different they are from the Miyako islanders. On the other hand, OMORI *et al.* ('66) suggested that Miyako anthropometrically resembles Ishigaki, and that both islands have a closer relationship to Tanegashima and Tokunoshima than to Okinawa Honto. Recently, NAITO ('73) stated that the differences among the inhabitants of the Nansei Islands are not significantly marked and that Miyako alone is distant from all the others.

Relationships among the Ryukyu Islanders are not shown very clearly as a result of multiple discriminant analysis of modern crania, but this seems to be reasonable enough, considering the small samples within each population and confusing effects, such as a genetic drift, which can be caused by such small samples. The findings of this study partially coincide with those of the anthropometrical comparison mentioned above. For example, the inhabitants of Okinawa Honto, particularly the northern and central

regions, come close to those of Tokunoshima and are quite different from all the others except Yoro. It may be given as a conclusion, however, that the most sharp distinction recognizable is between the Okinawa and Amami districts mainly on function 1.

2. Comparison among Ryukyu, Honshu and Kyushu populations.

Considering the clear discrimination between the Okinawa and Amami districts, the populations in each district were grouped together and compared with 6 populations in Honshu and Kyushu. Measurements for both of Ryukyu populations were represented by the means of measurements, unweighted by sample sizes, for five populations from each district.

FUNCTIONS AND LOADINGS (Fig. 2, Table 3)

The first two functions explain about 64% of variation among 8 populations.

Function 1: This function separates the group of Kinki, Northern and Central Kyushu from the group of Amami, Okinawa, Kanto, Hokuriku and Tohoku. Central Kyushu and Tohoku are located on both extremes and far from the rest of each group. Loadings are relatively high in a general height component (ba-

Fig. 2. Plot of the Ryukyu, Kyushu and Honshu populations on the first two functions.

Table 3. Discriminant loadings. Comparison among the populations in Ryukyu, Kyushu and Honshu.

Function	1	2
Cumulative trace (%)	38.1	64.5
1. Max. cranial ln.	.145	-.077
2. Ba-na ln.	-.080	-.085
3. Max. cranial br.	.024	-.100
4. Min. frontal br.	-.019	.012
5. Basion-bregma ht.	-.265	-.110
6. Horizontal circ.	.013	.070
7. Transverse arc	.019	.176
8. Frontal arc	-.121	.033
9. Parietal arc	-.146	-.141
10. Occipital arc	-.035	.084
11. Facial ln.	.036	-.273
12. Bizygomatic br.	.048	-.180
13. Upper facial ht.	-.281	.145
14. Orbital br.	.035	-.329
15. Orbital ht.	.016	.235
16. Nasal br.	-.204	-.176
17. Nasal ht.	-.105	.130

sion-bregma height, upper facial height, with the negative sign).

Function 2: Arrangement of populations on this function coincides with their geographical distribution from the south to the north in Japan, with only Central Kyushu not according with this distribution. The Amami and Okinawa districts are strikingly discriminated from Kanto and Tohoku, and such separation is not perceptible on function 1. Facial measurements, particularly those of orbit, (facial length, orbital breadth with the negative sign and orbital height with the positive sign) have relatively high loadings. Discordance of the sign among three measurements seems to reflect a close relationship between this function and facial, especially orbital, shape.

Table 4. D-squares among the populatios in Ryukyu, Kyushu and Honshu.

	Okinawa	Amami	North Kyushu	Kinki	Central Kyushu	Kanto	Hokuriku
Amami	2.78						
North Kyushu	5.29	4.68					
Kinki	5.40	4.69	2.72				
Central Kyushu	11.38	8.01	5.18	4.21			
Kanto	6.03	6.42	5.63	2.94	7.30		
Hokuriku	7.00	6.88	9.40	8.96	14.33	3.81	
Tohoku	8.57	7.36	9.41	8.73	8.51	5.02	7.24

D-SQUARES (Table 4)

Pairs of the populations which have relatively low D-squares are Northern Kyushu v.s. Kinki (2.72), Okinawa v.s. Amami (2.78), Kinki v.s. Kanto (3.81). Central Kyushu and Tohoku are quite distant from the others, D-squares being for the former 7.30-14.33 excluding 4.21 (v.s. Kinki) and 5.18 (v.s. Northern Kyushu), and for the latter 7.24-8.57, excepting 5.02 (v.s. Kanto). Consequently, it would be reasonable to divide 8 populations into three clusters; Ryukyu Islands (Amami, Okinawa), Western Japan (Northern and Central Kyushu, Kinki) and Eastern Japan (Kanto, Hokuriku, Tohoku). This clustering is parallel to the geographical division and distances among the three clusters are approximately equal as shown in Table 6.

There is general agreement on the idea that anthropometrical data for the Ryukyu Islanders fall within the range of variation of the Honshu-Kyushu people, and KANASEKI ('55) concluded that the inhabitants of the Nansei Islands somatometrically resemble those of Southern Kyushu and differ from those of Northern Kyushu. IKEDA ('74) also presumed that Miyako and Okinawa Honto should be a

local group of the Japanese population but was not able to choose the population closest to them amongst the Honshu-Kyushu people, since there is no significant difference among their mean relative deviations. The results in this study also indicate that Amami and Okinawa should be regarded as a local group of the Japanese population, but do not seem to distinguish any of Honshu-Kyushu people as the closest to the Ryukyu Islanders though D-squares show a slight tendency indicating, perhaps, that Northern Kyushu and Kinki come close to both Okinawa and Amami. Discussion of the discrepancy between this result and KANASEKI's suggestion must be left here, because data pertaining to Southern Kyushu are not included in this analysis. Judging from the loadings of function 2, on which all populations occupy their positions in a pattern similar to that on a geographic map, the features characteristic to the Ryukyu crania seem to be found in the facial part and this has already been mentioned by many authors.

3. Comparison among three Japanese clusters and their surrounding populations. FUNCTIONS AND LOADINGS (Fig. 3, Table 5)

Fig. 3. Plot of the Japanese clusters and their surrounding populations on the first two functions.

Table 5. Discriminant loadings. Comparison among Japanese clusters and their surrounding populations.

	Function	1	2
Cumulative trace (%)		39.1	57.4
1. Max. cranial ln.		.268	.222
2. Ba-na ln.		.184	.298
3. Max. cranial br.		-.008	.250
4. Min. frontal br.		.232	-.003
5. Basion-bregma ht.		-.208	.191
6. Horizontal circ.		.172	.437
7. Transverse arc		-.069	.388
8. Frontal arc		.015	.002
9. Parietal arc		-.115	-.004
10. Occipital arc		-.031	.210
11. Facial ln.		.389	.268
12. Bizygomatic br.		-.023	.197
13. Upper facial ht.		-.307	.473
14. Orbital br.		.161	.347
15. Orbital ht.		-.031	.295
16. Nasal br.		.042	-.180
17. Nasal ht.		-.257	.310

The first two functions account for only 57.4% and four functions more than 80% of variation among 12 populations. It seems, however, that only the first two are worth special mention.

Function 1: On this function, Yakumo Ainu is located at one end and Korea at the other. The Chinese populations oc-

cupy positions near Korea, and the Japanese and the Indonesian, including Tagalog and Dayak, occupy an intermediate position between both ends. Western Japan is located near the Chinese-Korean side, and Ryukyu and Eastern Japan near the Ainu side, but Yakumo Ainu stands apart from any other population. Three components which have relatively high loadings can be recognized; a general length component (maximum cranial length, cranial base length, horizontal circumference, facial length, with the positive sign), a general height component (basion bregma height, upper facial height, nasal height, with the negative sign) and a breadth component in the frontal region (minimum frontal breadth, orbital breadth, with the positive sign).

Function 2: This locates Fushun at one end and Atayal at the other. Generally speaking, discrimination between the northern and southern populations in East Asia is discernible on this function. Loadings are relatively high in a general size component (maximum cranial length, horizontal circumference, transverse arc, cranial base length, upper facial height, orbital height, nasal height, orbital breadth, facial length, with the positive sign).

D-SQUARES (Table 6)

D-squares display a rather complicated picture of inter-population relationships, but a relatively conspicuous contrast is discernible between Yakumo Ainu and Chinese-Korean populations, as already shown on Function 1. Values of D-squares for mutual combinations among the group

Table 6. D-squares among Japanese clusters and their surrounding populations.

	Ryukyu	West. Japan	East. Japan	Yakumo Ainu	Korea	Fushun	Hainan	Fukien	Seil Peipo	Atayal	Taga- log
West. Japan	4.53										
East. Japan	4.56	5.23									
Yakumo Ainu	6.75	14.44	7.50								
Korea	9.64	2.95	10.49	25.11							
Fushun	11.60	4.35	7.71	20.91	5.77						
Hainan	5.13	1.91	7.33	17.31	2.42	5.39					
Fukien	11.89	8.08	12.53	26.58	10.66	9.70	7.45				
Seil Peipo	9.82	6.07	6.80	20.83	8.45	10.62	7.55	8.93			
Atayal	5.49	10.02	9.07	15.18	14.29	16.43	7.23	11.09	13.15		
Tagalog	6.51	3.29	9.90	15.47	7.49	10.64	3.93	11.65	10.13	8.63	
Dayak	5.22	4.43	7.03	12.38	8.27	8.64	3.20	9.59	11.62	6.54	2.83

are as follows;

Western Japan, Eastern Japan,

Ryukyubelow 5.23

Korea, Fushun, Hainan, Western

Japanbelow 5.77

Hainan, Western Japan, Ryukyu,

Dayak, Tagalogbelow 6.51

Ryukyu, Dayak, Atayalbelow 6.54

Ryukyu, Yakumo Ainu 6.74

Western Japan, Eastern Japan,

Seil Peipobelow 6.80

To Fukien, which has D-squares above 7.0 for all other populations, the nearest population is Hainan (7.45) and the farthest one Yakumo Ainu (26.58). D-squares of Yakumo Ainu are above 12.0 for most of the populations under comparison, and are quite high for Chinese-Korean group (above 17.0), but relatively low for Ryukyu (6.75) and Eastern Japan (7.50). It seems reasonable that the population closest to Ryukyu is Western Japan (4.53) and next one Eastern Japan (4.56) and that D-squares between Ryukyu and southern people, that is, Hainan (5.13), Dayak (5.22), Atayal (5.49), are

not very high. Moreover, it should be noticed that the population closest to Yakumo Ainu is Ryukyu, followed by Eastern Japan.

It may be concluded that the Ryukyu Islanders are craniometrically one of the local groups of Japanese population and come close to some of the southern populations and to Yakumo Ainu, while most of the Chinese-Korean populations and Seil Peipo in Formosa are different from the Ryukyu people. These results accord well with IKEDA's conclusion that the Ryukyu people are different from the populations in the northern part of the Asian Continent and close to the southern people and that some of the cranial traits peculiar to the Ryukyu crania are found in the Ainu crania in more exaggerated form. A close genetic affinity between the Ryukyu Islanders and the Ainu was suggested by BAEZ ('11) and ADACHI ('37), but SUDA ('50), KANASEKI ('55) and other many authors regard the Ryukyu Islanders as a local group of the Japanese population. Recently, however, HANIHARA

et al. ('74) pointed out that the affinity of dental characteristics between the Ryukyu Islanders and the Ainu is closer than that between the Honshu-Japanese and the Ainu. The same results were sustained serologically by NAKAJIMA *et al.* ('67) and MISAWA & HAYASHIDA ('68).

4. Comparison among Ryukyu, Jomon, Yayoi and Kofun crania

MIYAKE ('40) stated that some physical traits of the Stone Age Japanese had remained in the people of the secluded regions such as the Ryukyu Islands, where practice of marriage within a limited area had prevailed, and that Ainu-like physical characteristics found in these regions might be taken as clear evidence for this. On the other hand, this analysis was ascertained that the population closest to Yakumo Ainu is Ryukyu and the one closest to Korea is Western Japan, where some populations from the Asian Continent might have immigrated in or after the Yayoi Age. In the light of these results and suggestions, it is necessary to compare the Ryukyu crania, and also the other modern Japanese, the Ainu and Korean crania, with the prehistoric and protohistoric crania in the Jomon, Yayoi and Kofun Age. Eight populations, including Ryukyu, Western and Eastern Japan, Yakumo Ainu, Korea, Yoshigo (the later Jomon Age), Doigahama (the early Yayoi Age) and Western Japan (Kofun Age) were used.

FUNCTIONS AND LOADINGS (Fig. 4, Table 7)

Function 1: On this function, which accounts for 57.3% of inter-group varia-

Fig. 4. Plot of the populations including the Jomon, Yayoi and Kofun Age populations on the first three functions.

Table 7. Discriminant loadings. Comparison among the populations including protohistoric and prehistoric populations.

Function	1	2	3
Cumulative trace (%)	57.3	75.8	88.0
1. Max cranial ln.	.327	.086	-.076
2. Ba-na ln.	.197	.017	-.028
3. Max. cranial br.	.057	-.306	-.111
4. Min. frontal br.	.229	-.147	-.177
5. Basion-bregma ht.	-.179	-.261	.360
6. Horizontal circ.	.263	.017	-.263
7. Transverse arc	-.069	-.202	.358
8. Frontal arc	-.016	.055	.032
9. Parietal arc	-.024	-.210	-.069
10. Occipital arc	.013	-.008	.023
11. Facial ln.	.349	-.027	-.072
12. Bizygomatic br.	.065	-.378	-.326
13. Upper facial ht.	-.377	.295	-.238
14. Orbital br.	-.018	.002	-.034
15. Orbital ht.	-.075	.309	.043
16. Nasal br.	.058	-.155	-.293
17. Nasal ht.	-.318	.232	-.233

tion, Yakumo Ainu is in striking contrast to Korea. Kofun is close to Ainu, to which Jomon is the population closest; Western Japan is close to Korea. The remaining three populations, Eastern Japan, Ryukyu and Yayoi, are somewhere in-between Korea and Ainu. Loadings in a size component of the cranial vault (maximum cranial length, horizontal cir-

cumference, minimum frontal breadth, cranial base length, facial length, with the positive sign) and in a general height component (basion-bregma height, upper facial height and nasal height, with the negative sign) are significantly high.

Functions 2 and 3: About 30% of inter-group variation is carried by these two functions. Jomon on function 2 and Yayoi on function 3 are distinguishable from the other populations. The nearest population to Jomon on function 2 is Ryukyu and that to Yayoi on function 3 is Kofun. Loadings are relatively high in a general size component (maximum cranial breadth, basion-bregma height, transverse arc, sagittal parietal arc, bizygomatic breadth, with the negative sign) and in a facial height component (upper facial height, orbital height and nasal height, with the positive sign) for function 2, and in the measurements of the brain case (basion-bregma height, transverse arc, with the positive sign, and horizontal circumference with the negative sign) and a facial size component (bizygomatic breadth, upper facial height, nasal height and breadth, with the negative sign) for function 3.

D-SQUARES (Table 8)

All D-squares of Ryukyu fall within a narrow range between 4.50 (v. s. Kofun) and 6.75 (v. s. Yakumo Ainu), with the exception of 9.63 for Korea. Almost the same tendency is seen in the case of Yayoi, Kofun and Eastern Japan. These results accord fairly well with that on function 1. Western Japan and Korea on one hand, and Yakumo Ainu and Jomon on the other, show the same relationships to other populations respectively, though D-square of Western Japan for each population is lower than that of Korea.

The Ryukyu Islanders are equally close to all the populations under comparison, except for the Korean. HANIHARA *et al.* ('74) suggested that the similarities between the Ryukyu Islanders and the Ainu were probably caused by the conservative trends in more or less isolated populations and that they still retained some generalized characteristics of the ancient populations in East Asia. If this is correct, similarities among the Ryukyu Islanders, Jomon Age people and the Ainu could be explained, but what interpretation can be made of the resemblances among the Ryukyu Islanders, the other modern Japanese,

Table 8. D-squares among the populations including the protohistoric and prehistoric populations.

	Korea	West. Japan	East. Japan	Ryukyu	Yakumo Ainu	Kofun	Yayoi
West. Japan	2.95						
East. Japan	10.49	5.23					
Ryukyu	9.64	4.53	4.56				
Yakumo Ainu	25.11	14.44	7.50	6.75			
Kofun	15.64	7.59	5.31	4.06	4.27		
Yayoi	10.25	4.80	6.96	4.80	10.28	3.92	
Jomon	21.92	14.64	12.09	5.24	7.54	8.65	10.20

the Yayoi and Kofun Age people? The question of whether the similarity between the Ryukyu and the Ainu depends on genetic or environmental factors needs further investigation.

Finally, we shall discuss a genealogical problem of the Japanese, though this deviates from the main subject of this paper. A close affinity between the Western Japanese and the Korean and that between the Jomon Age people and the Ainu, and also a marked diversity between the Korean and the Jomon-Ainu morphology, have been recognized by many authors and have supplied arguments for discussions on the origin of the Japanese. KOGANEI (1890) and others, who regarded such an affinity or contrast as the product of hereditary changes, advocated a substitution theory, that the Jomon Age people, the aboriginal pre-Ainu or Ainu, were replaced by the ancestors of the modern Japanese, the immigrants from the Asian Continent in the Kofun Age. On the other hand, HASEBE ('49) and SUZUKI ('69) attached importance to microevolutional changes in the Japanese population and proposed a transformation theory, that the Jomon Age people are the direct ancestors of modern Japanese. Moreover, KIYONO *et al.* ('49) and KANASEKI ('58) believe that the Jomon Age people, the aboriginal proto-Japanese, mixed with some Mongoloid races from the Asian Continent in the Yayoi and Kofun Age. Without advancing any interpretation, we can say that a close connection between the Western Japanese and the Korean and that between the

Jomon people and the Ainu are clarified in function 1 and D-squares of this analysis. The distribution pattern of the populations on function 1, excluding the Yayoi people, however, can be explained by either a transformation theory or a metisation theory. Discussions regarding the interpretation of craniometrical affinities of the Ryukyu Islanders to the prehistoric and protohistoric people in Japan, with reference to the origin of the Japanese, should be made on more extensive data in the future.

ACKNOWLEDGMENT

We wish to extend our appreciation to Mr. S. OYAMA, Mr. C. KISHABA, Mr. S. TAWADA, Dr. C. NOHARA and Dr. T. KANO of Naha City, and Mr. K. SHIMOJI, Mr. K. OKAMATO of Hirara City, as well as many other persons in the Ryukyu Islands, and Mr. T. MOURI, the Laboratory of Physical Anthropology, Kyoto University, for their sympathetic assistance to us in the carrying out of our field research. This study was made possible in part by a grant from the Ministry of Education, and statistical calculations were processed by the FACOM 230-60/75 computers of the Data Processing Center, Kyoto University.

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(Received August 13, 1976)

Appendix. Cranial measurements and indices

	Iriomote			Miyako (Karimata)		
	n	Mean	S.D.	n	Mean	S.D.
1 Maximum cranial length	35	180.84	6.24	16	182.56	6.23
3 Glabella-lambda length	36	176.28	6.25	16	178.44	6.49
5 Basion-nasion length	31	102.05	3.77	11	102.05	5.09
8 Maximum cranial breadth	35	139.53	4.68	16	142.31	9.10
9 Minimum frontal breadth	35	93.41	4.87	16	91.56	4.71
10 Maximum frontal breadth	36	112.97	3.96	16	113.50	4.95
11 Biauricular breadth	35	125.24	4.67	16	125.31	6.07
12 Maximum occipital breadth	35	109.04	3.66	16	108.31	4.25
13 Bimastoid breadth	33	107.50	3.80	13	105.96	5.08
17 Basion-bregma height	31	137.53	4.95	11	138.05	3.91
20 Auricular height	36	117.44	5.03	15	119.90	3.40
23 Horizontal circumference	35	514.41	12.87	16	519.13	17.34
24 Transverse arc	35	313.70	11.25	16	318.06	9.82
25 Sagittal arc	30	371.33	13.49	13	376.27	12.99
26 Frontal arc	36	125.11	7.06	16	128.69	6.12
27 Parietal arc	36	128.53	8.83	16	130.19	6.35
28 Occipital arc	30	117.03	6.43	13	119.88	5.71
29 Frontal chord	36	110.44	5.46	15	113.23	4.91
30 Parietal chord	36	114.86	7.03	15	115.57	4.20
31 Occipital chord	30	98.80	3.98	13	101.65	4.30
40 Facial length	24	101.58	3.97	10	103.20	2.91
43 Upper facial breadth	35	104.93	3.66	15	103.37	4.05
44 Biorbital breadth	33	98.35	3.17	13	99.04	6.10
45 Bizygomatic breadth	32	135.72	4.86	11	137.32	5.34
46 Middle facial breadth	32	100.31	3.07	13	101.58	4.21
48 Upper facial height	29	67.05	3.84	15	65.77	5.90
50 Interorbital breadth	33	17.98	1.73	16	17.00	1.93
51 Orbital breadth (<i>l</i>)	34	42.56	1.50	16	42.44	1.84
52 Orbital height (<i>l</i>)	34	32.56	1.50	16	33.25	2.27
54 Nasal breadth	32	26.09	1.66	15	26.43	2.05
55 Nasal height	34	51.88	2.98	16	50.94	4.44
60 Alveolar length	26	54.38	3.39	7	56.07	2.37
61 Alveolar breadth	24	64.29	3.09	8	63.50	2.39
62 Palatal length	27	45.76	3.11	9	45.17	2.55
63 Palatal breadth	18	40.33	2.87			
8/ 1 Cranial I.	35	77.17	3.57	15	76.93	2.77
17/ 1 Height-length I.	31	75.97	2.64	11	76.54	1.13
17/ 8 Height-breadth I.	31	98.51	4.41	11	97.38	5.77
20/ 1 Auricular height-length I.	35	64.85	2.82	15	65.93	1.43
20/ 8 Auricular height-breadth I.	35	84.10	3.12	14	85.94	2.66
9/10 Transverse frontal I.	35	82.62	3.20	16	80.61	2.88
9/ 8 Transvers frontoparietal I.	34	66.87	3.05	15	65.22	2.45
27/26 Sagittal frontoparietal I.	35	103.66	6.58	16	101.25	4.24
29/26 Sagittal frontal I.	36	88.28	1.62	15	88.24	1.45
30/27 Sagittal parietal I.	35	89.54	1.41	15	89.15	1.23
31/28 Sagittal occipital I.	30	84.44	2.22	13	84.76	1.55
48/45 Upper facial I.	26	49.48	1.99	10	48.84	3.92
52/51 Orbital I. (<i>l</i>)	34	76.33	4.65	16	78.08	4.09
50/44 Interorbital I.	33	17.86	1.53	13	17.13	1.94
54/55 Nasal I.	32	49.86	4.40	15	51.30	3.98
61/60 Alveolar I.	23	117.67	6.60	7	113.30	6.75
63/62 Palatal I.	16	87.33	10.38			
45/ 8 Craniofacial I.	32	97.14	2.69	11	97.10	3.16
9/43 Frontobiorbital I.	35	88.96	3.08	15	89.11	4.27
9/45 Zygo-frontal I.	31	68.69	2.95	11	68.01	2.70

of the Ryukyu Islanders' skulls (males).

Okinawa Honto			Tokunoshima			Kikai		
n	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.
11	180.50	7.95	24	180.13	5.88	7	182.36	6.34
11	177.14	7.39	24	176.04	5.59	7	178.07	5.68
10	100.60	3.93	22	102.68	3.54	5	101.90	2.51
11	143.32	4.31	23	140.37	4.66	7	143.36	4.71
11	92.50	5.64	24	92.67	3.87	7	96.36	2.67
11	115.68	3.76	24	115.67	3.73	7	118.50	4.16
11	125.32	5.93	23	125.63	4.57	7	127.50	5.42
11	104.95	5.32	24	107.21	4.22	7	107.50	4.24
11	102.50	7.40	20	105.65	3.36	7	105.93	2.99
10	136.20	3.56	22	136.32	4.91	5	138.50	1.87
11	115.95	3.59	24	115.46	4.40	7	117.07	3.55
11	512.86	19.03	23	515.15	12.76	7	521.50	15.99
11	317.50	7.32	23	312.24	11.55	7	316.64	7.54
11	371.86	13.92	21	368.26	13.11	5	377.10	17.91
11	127.05	5.77	24	126.71	4.99	7	125.50	6.35
11	129.32	6.85	24	127.17	9.04	7	125.93	4.08
11	116.41	8.32	21	115.12	8.65	5	125.50	12.55
11	110.50	4.31	24	111.08	4.04	7	111.21	4.82
11	114.59	8.02	24	113.00	6.85	7	112.93	4.04
11	97.50	6.02	21	97.69	5.24	5	102.30	4.97
8	101.38	5.30	15	101.37	4.53	3	100.83	5.86
11	104.95	4.11	24	105.33	3.52	7	106.50	2.38
11	98.14	3.20	22	97.41	2.31	6	99.00	3.08
10	132.00	6.04	22	134.91	6.57	7	137.50	6.03
10	101.70	4.73	22	102.82	4.87	6	103.00	4.14
8	66.13	4.57	17	67.44	4.94	5	70.50	8.46
11	18.32	2.60	24	18.29	1.79	7	18.64	1.86
11	42.32	1.54	24	41.83	1.58	7	42.36	0.69
10	32.90	1.78	24	33.25	1.80	7	34.21	0.95
10	26.80	1.77	23	26.20	1.58	7	26.79	3.20
10	48.80	3.27	24	51.75	3.07	7	52.36	4.06
7	52.36	3.08	14	53.50	3.31	3	54.50	1.00
7	61.93	3.36	16	64.81	2.96	3	66.50	1.73
9	43.83	2.29	19	45.18	1.73	5	44.90	4.51
4	41.75	0.96	11	40.41	1.22	3	41.83	0.58
11	79.43	2.97	23	78.01	3.70	7	78.62	3.37
10	76.03	2.22	22	75.78	3.22	5	75.74	2.46
10	95.55	3.35	21	97.21	2.82	5	96.44	2.91
11	64.20	2.02	24	64.02	2.28	7	64.16	2.74
11	80.88	2.78	23	82.31	3.69	7	81.67	3.47
11	79.87	4.17	24	80.05	2.89	7	81.29	2.53
11	64.39	2.88	23	65.92	2.31	7	67.13	1.89
11	101.89	5.45	24	100.38	6.29	7	100.49	4.46
11	86.97	2.17	24	87.64	1.39	7	88.61	1.66
11	88.54	3.31	24	88.90	1.93	7	89.63	1.11
11	83.76	2.45	21	84.96	3.14	5	81.79	4.53
8	50.08	1.93	15	50.06	4.72	5	50.10	4.35
10	77.53	3.36	24	79.24	3.25	7	80.56	2.42
11	18.22	2.31	22	18.10	1.61	6	18.26	1.73
10	54.55	3.44	23	50.42	4.68	7	50.79	5.86
7	118.51	2.61	12	121.46	7.16	2	122.00	2.31
4	92.71	0.95	11	88.78	3.39	3	92.41	8.74
10	92.54	3.45	20	97.47	3.12	7	95.90	2.54
11	88.04	3.04	24	87.93	2.70	7	90.45	2.58
10	69.17	2.93	21	67.63	2.63	7	70.02	1.69

頭骨計測値の多変量解析からみた現代琉球人（男性）

多賀谷 昭・池田 次郎

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現代琉球人男性頭骨の17計測値について、沖縄地方と奄美地方を比較した結果、両地方間に明瞭な差がみられ、本州、九州の6地方型とこの両地方の分析では、琉球人が日本人の地方型の一つであることが明らかとなった。次いで琉球、西日本、東日本を朝鮮、中国、台湾、インドネシアの諸種族および八雲アイヌと比較した結果、南方のいくつかの種族が本州、九州に次いで琉球に近いこと、比較集団中、アイヌにもっとも近いのが琉球であることが示された。最後に、縄文、弥生、古墳人骨との比較では、琉球はこれらおよび現代日本人、アイヌに同程度に近く、朝鮮人とは比較的遠いという結果がえられた。