Multivariate Craniometric Investigations of Japanese, Asians, and Pacific Islanders

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ABSTRACT

Four separate applications of multivariate statistical procedures are applied to 29 cranial measurements for examining the origins and affinities of the Japanese. The multivariate statistical procedures used include stepwise discriminant function analysis, Mahalanobis' Generalized Distance, and the UPGMA clustering technique. The ten Japanese cranial series include Jomon, Ainu, Ryukyu Islands, Yayoi, Kofun, Kamakura, Edo, and more modern series representing Kyushu Island and the Districts of Kanto and Tohoku on Honshu Island. Further comparisons of these cranial series are made with those representing China and North Asia, Southeast Asia, Australia, and the Pacific Islands.

A consistent finding in these results is an association between Jomon and Ainu skulls which are set off from all remaining Japanese, a separation which implies a separate origin for these two major morphological groups. Cranial series representing the Yayoi and Kofun Periods are closely related, which, in turn, are related to all other near modern Japanese cranial series investigated. The Ryukyu Island cranial series is most similar to the medieval cemetery series from Kamakura, two series which are most similar to the Yayoi and Kofun crania. The Edo and all remaining near modern Japanese form a separate branch which is connected to the latter group. When cranial series representing East Asia, Southeast Asia, Australia, and the Pacific are included, the Japanese (including Ainu and Jomon) occupy a separate branch within a greater Asian subdivision. The integrity of this latter grouping is maintained when Australian and Pacific Island series are included. Polynesians occupy a separate branch within the Asian subdivision. The Melanesian and Australian cranial series form a second major subdivision. All Japanese cranial series, including Jomon, Ainu, Ryukyu, and more modern Japanese, are more closely related to North Asians and Chinese than they are to Southeast Asians. These associations imply a Northeast Asian (espe-

cially Korea, Anyang, Manchuria, Hainan, and Taiwan), rather than a Southeast Asian, origin for both the Japanese and the Jomon-Ainu peoples. Mongolia is consistently the Asian out-group in these analyses.

SKULL MORPHOLOGY

In this paper, biological affinities between the modern and early inhabitants of Japan and the surrounding regions of Asia and the Pacific are investigated through the application of multivariate statistical procedures to cranial measurements. The approach used is model free. Measures of biological distance and discriminant function analysis are used to investigate patterns of craniometric variation for assessing biological relationships, which allow reconstructions of population history regardless of cause. This new craniometric analysis expands on earlier work (e.g., Pietrusewsky, 1990, 1992, 1994, 1995, 1997; Pietrusewsky *et al*., 1992) by focusing attention on the internal relations of Japan and comparisons of the Japanese with other human groups occupying Australasia and the Pacific. The results of the present analysis will be used to evaluate some of the current major hypotheses advanced by other investigators who, using biological data, have addressed the origins of the Japanese.

There is a long history in anthropology of the use of measurements and cranial shape for comparing and relating human populations. The earliest statistical exercises involved the use of one, or a few, indices such as the ubiquitous cranial index, and/or the scanning of rows of means of measurements. Using these crude methods, anthropologists attempted to classify individual specimens to one or more groups or to determine the relationships between human groups. These earliest exercises, primarily typological in nature, were soon replaced by more sophisticated statistical procedures, which when coupled with advances in population and evolutionary biological theory, significantly altered the way physical anthropologists viewed human variation and how they reconstructed human evolution.

The use of multivariate statistical procedures, which allow the simultaneous consideration of multiple measurements recorded in specimens from one or more groups, provide the most objective mathematical means for comparing human groups or for classifying individual specimens. These procedures, among which principal components analysis and discriminant analysis are the best known, involve the transformation of raw measurements into some transformed variable (function), or axis, for viewing morphological differences between groups and/or single specimens.

Unlike single-locus genetic polymorphisms such as blood group substances and serum proteins, cranial variation, both metric and non-metric, is under the control of many genes, which, although subject to adaptation, tends to remain relatively stable through time (Howells, 1973:4). Likewise, heritability studies (e. g., Cheverud *et al*., 1979; Sjøvold, 1984) have demonstrated a strong heritability component for many of the traditionally studied aspects of cranial shape. Furthermore, the exactness and reproducibility of measurements and the amenability of this category (continuous) of variation to multivariate statistical treatment, make craniometry a highly attractive approach for investigating population affinities and origins.

MATERIAL AND METHODS

SAMPLES

Ten samples, representing prehistoric Jomon, Ainu, and modern Japanese since the Yayoi Period, are the focus of the present study. The modern Japanese series represent primarily dissecting room specimens of near modern inhabitants from the 1) Kanto District of eastern Honshu Island (KANTO), 2) Tohoku District (TOHOKU) in northern Honshu Island, and 3) a sample representing Fukuoka and Saga Prefectures on Kyushu Island and adjoining Yamaguchi Prefecture in southern Honshu (KYUSHU). The Late-Latest [ca 3500 yrs. B.P. - 2000 yrs. B.P.] Jomon specimens used in this study are from sites located on Honshu Island. The greatest number of Jomon specimens are from the Tsukumo site in Okayama Prefecture in Chugoku District, and from the Ebishima site in Iwate Prefecture in Tohoku District. The remaining earlier Japanese series include samples representing the Edo, Yayoi, and Kofun Periods, and a medieval sample from the city of Kamakura. A representative sample from the Ryukyu Islands including Sakishima, Okinawa, and Amami Island groups, is further included. The sample of Ainu crania are from abandoned Ainu cemeteries on Hokkaido Island.

In addition to the Japanese cranial series, 43 comparative samples, totaling 2,518 male crania representing Polynesia, Micronesia, Melanesia, Australia, Indonesia, Southeast Asia, East Asia, and North Asia are included in this study. The present data set represents a modification of one used recently by Pietrusewsky and Chang (n.d.). The names, number of crania examined, and other information pertaining to each of these series are given in Table 1. The approximate location of the Japanese cranial series is shown in Figure 1 and the remaining comparative series are shown in the next figure, Figure 2.

CRANIAL MEASUREMENTS

Twenty-nine standard cranial measurements (listed in Table 2), similar to those defined by Martin (1957) and Howells (1973), are used in the present study. This number represents the largest set of measurements recorded for all

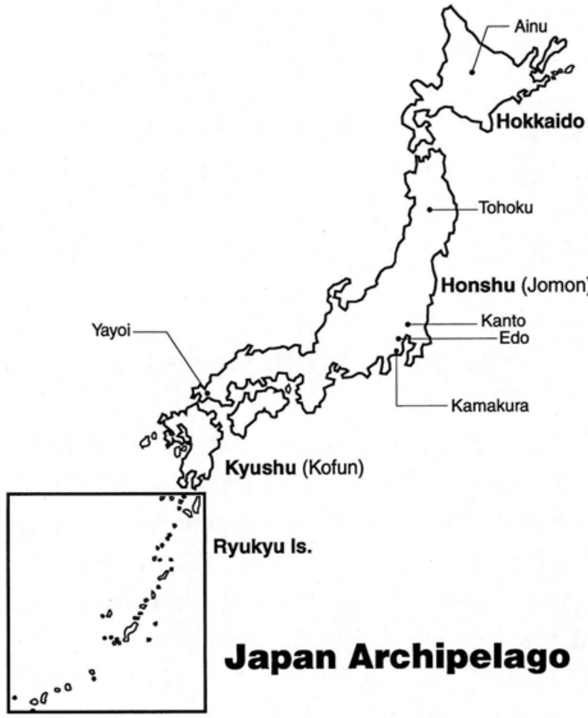

Fig. 1 Map of Japan showing the locations of the 10 Japanese cranial series investigated.

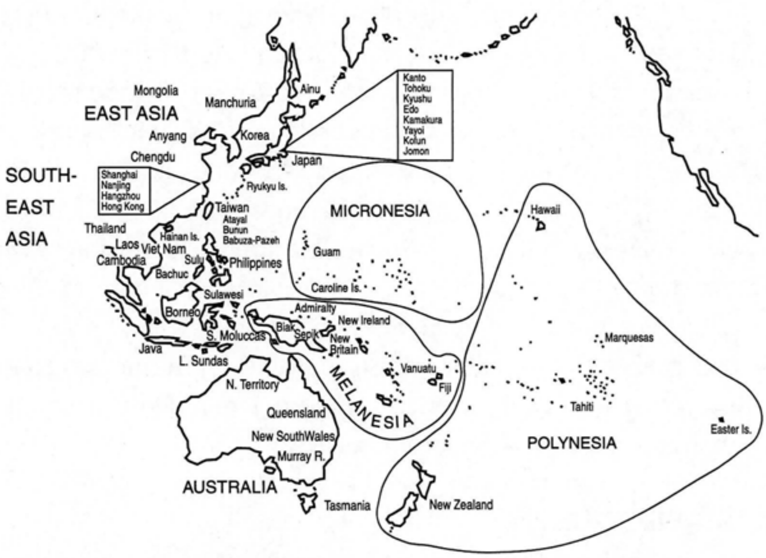

Fig. 2 Map showing the approximate locations of the 53 male cranial series used in the present study.

the comparative series used in the present study. Missing measurements were replaced with regressed values obtained through stepwise regression analysis using the computer program, PAM, of the UCLA Biomedical Computer P-Series (Dixon and Brown, 1979). Because only complete, or nearly complete, specimens were selected, very few of the measurements represent estimated regressed values.

MULTIVARIATE STATISTICS

The two multivariate statistical procedures used in the present study are stepwise discriminant function analysis and Mahalanobis' Generalized Distance.

STEPWISE DISCRIMINANT FUNCTION ANALYSIS

The computer program, BMDP-7M (Dixon and Brown, 1979), was used to perform stepwise discriminant function analysis. The major purpose of discriminant analysis is to maximize the ratio of between-group variance to total variance, while taking into account the intercorrelation of variables, by producing a finite series of orthogonal functions. The measurements used in computing the linear classification functions are chosen in a stepwise manner such that, at each step, the measurement that adds the most to the separation of the groups is entered into the discriminant function in advance of the others (Dixon and Brown, 1979: 711). The first few canonical variates, or functions, account for most of the variation among the groups. The technique further identifies which variables are most responsible for the observed differentiation. In this study, the interpretation of discriminant functions and the patterns of group separation is based on an inspection of standardized canonical, or discriminant, coefficients. Finally, at the end of the stepping process, each individual specimen is classified into one of the original groups based on the several discriminant scores it receives. The results are presented in the form of a classification matrix. The "correct" and "incorrect" classifications provide a general guide for assessing the homogeneity or heterogeneity of the original series. Although originally designed to assign an unknown specimen to one or more groups, discriminant analysis has been shown to be especially useful as a measure of variation between groups (Campbell, 1978). Finally, plots of the group means on the first several canonical variates provide a partial graphic representation of these relationships based on the discriminant function results. The mathematical basis of discriminant analysis is discussed in Goldstein and Dillon (1978). Because many of the general assumptions of multivariate normality and equality of group covariance matrices are rarely met (Corruccini, 1975), tests of significance are not used in interpreting group differences identified in the present study.

MAHALANOBIS' GENERALIZED DISTANCE

Mahalanobis' Generalized Distance (Mahalanobis, 1936) was applied to the same data analyzed by discriminant function analysis. Generalized Distance, or the sum of squared differences, provides a single quantitative measure of dissimilarity (distance) between individual groups using many variables while taking into account the intercorrelation between the variables. The significance of these distances was determined using the method of Rao (1952: 245), following a procedure recommended by Buranarugsa and Leach (1993: 17). The average linkage within group clustering algorithm (Sokal and Sneath, 1973), or Unweighted Pair Group Method Algorithm-UPGMA, was the clustering procedure used to construct the diagrams of relationship, or dendrograms, using Mahalanobis' Distances. The SAHN clustering method in the NTSYS-pc computer software program was the application used to construct the dendrograms (Rohlf, 1993). This latter algorithm combines clusters so that the average distance between all cases in the resulting cluster is as small as possible and the distance between two clusters is taken to be the average between all possible pairs of cases in the cluster. It should be cautioned, however, that clustering procedures, and the dendrograms they produce, provide only a partial graphic summary of some of the results obtained from distance analysis, they should not be viewed to the exclusion of other results obtained from these statistical procedures.

Removal of the Size Based Component: Z-Scores and C-Scores

Several researchers (e.g., Howells 1989; Brace and Hunt 1990; Brace and Tracer 1992; Brace et al., 1990) have advocated the use of C-scores as a way to compensate, at least partially, for the size differences which may then have an unequal influence on the patterns of variation. Recent work (e.g., Pietrusewsky, 1994, 1995; Green, 1990), however, has demonstrated that removal of this size-based component has little or no effect in interpreting patterns of craniometric variation. For that reason, C-score measures are not used in the present study.

RESULTS

The results of two analyses, each using 29 cranial measurements, are reported separately. The first analysis focuses on cranial series from Japan which include prehistoric (Jomon, Yayoi, and Kofun) and near modern Japanese and Ainu specimens. In the second analysis 53 male cranial series, representing Australia, Asia, and the Pacific, are compared to crania from Japan.

Analysis I (10 Japanese Groups, 29 Cranial Measurements)

Stepwise Discriminant Function Analysis

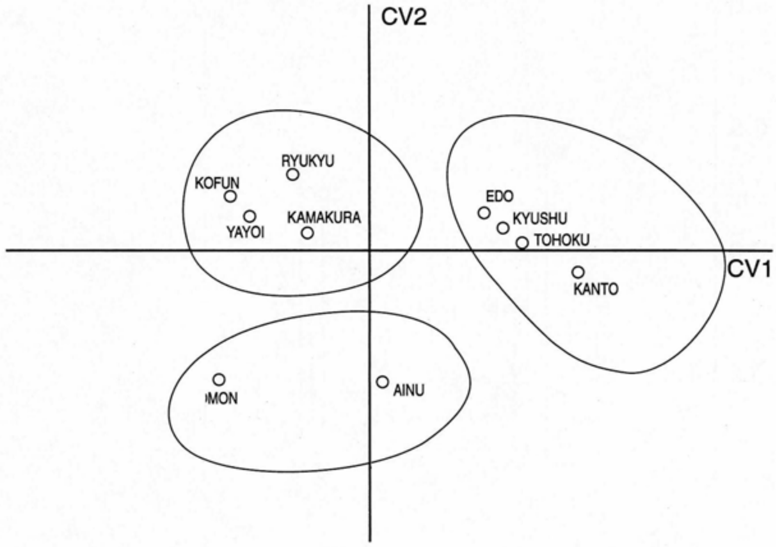

Fig. 3 Plot of 10 male Japanese group means on the first two canonical variates using 29 cranial measurements.

The means and standard deviations for 29 cranial measurements recorded in the 10 Japanese male series are given in Table 2. A summary ranking of 20 of these measurements, ranked according to the F-values received in the final step of discriminant function analysis, is given in the next table, Table 3. In order, the maximum breadth of the cranium, bimaxillary breadth, basion-nasion length, and nasal height are the highest ranked variables in this analysis according to F-values.

Eigenvalues, the percentage of total dispersion, and level of significance for the first nine canonical variates (discriminant functions) are presented in the next table, Table 4. The first three variates account for 72.8% of the total variation in this analysis. The first six eigenvalues are significant at the 1% level.

The canonical coefficients for 29 cranial measurements for the first three canonical variates are given in Table 5. Orbital breadth, cranial vault length, bimaxillary subtense, and nasal breadth are the most important variables in producing group separation in the first canonical variate. Dimensions of the cranial breadth (biorbital breadth and bifrontal breadth), height of the nasal aperture, and cranial base length (basion-nasion) are most responsible for separation produced in the second canonical variate. Length of the maxillo-alveolar arch, biorbital breadth, and cheek height are primarily responsible for the discrimination produced in the third canonical variate.

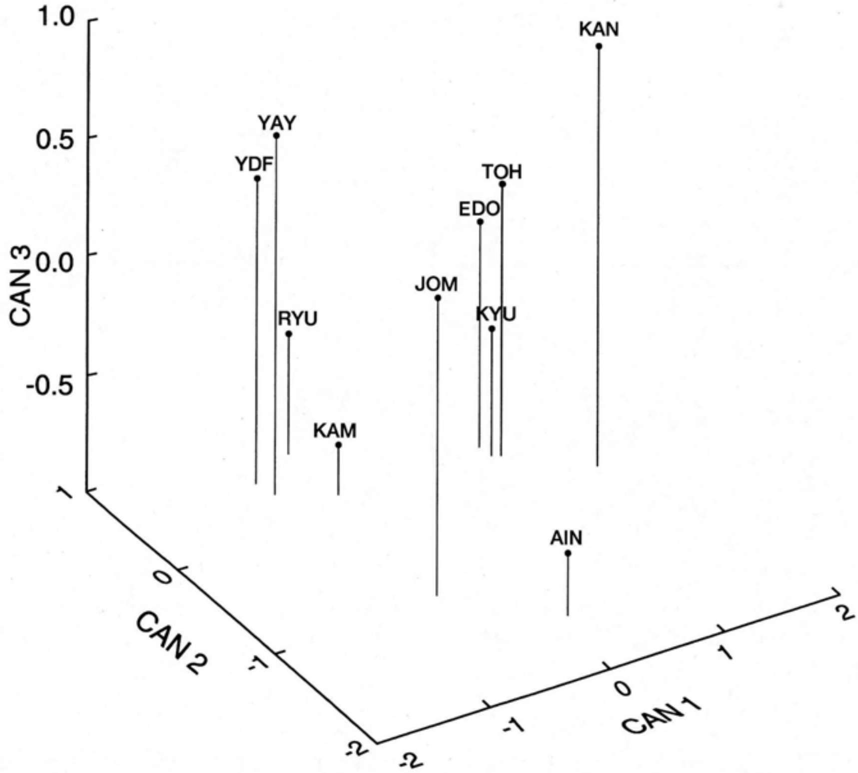

Fig. 4 Plot of 10 male Japanese group means on the first three canonical variates using 29 cranial measurements.

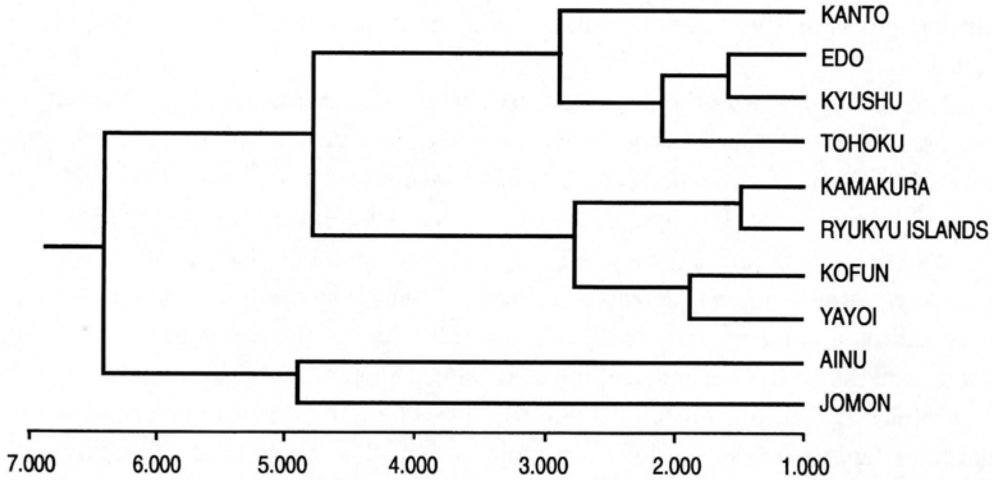

Fig. 5 Diagram of relationship based on a cluster analysis (UPGMA) of Mahalanobis' Generalized Distances using 29 cranial measurements recorded in 10 male Japanese groups.

A summary of the group classification results, based on posterior probabilities (Table 6), indicate that the Jomon, Ainu, and the Kanto are among the series having the best classification results (i.e. the greatest number of cases correctly classified). The Edo, Ryukyu, Kyushu, and Tohoku series achieve the poorest classification results. Four Jomon specimens are classified as Ainu and four more as Kofun. Two Jomon specimens are classified as Yayoi and two more are classified as Ryukyu. Ten of the Edo Period specimens are classified as Kyushu. The Ryukyu specimens are distributed among all remaining groups, a series which ranks the second highest for misclassifications in this particular analysis. Kamakura and Yayoi each receive seven of the specimens originally classified as Ryukyu.

When the group means are plotted on the first two canonical variates (Figure 3), three clusters emerge. Edo clusters with the three near modern cranial series, Kyushu, Tohoku, and Kanto. Yayoi, Kofun, Kamakura, and Ryukyu form a second cluster while Jomon and Ainu occupy a third cluster. A plot of the means for the same groups on the first three canonical variates (Figure 4), again, demonstrates a tripartite divisioning. Further evident in this representation is the relative closeness of the Kofun and Yayoi series, and the tight clustering of the Edo, Tohoku, and Kyushu series.

Mahalanobis' Generalized Distance

Distances, and tests of significance, obtained when Mahalanobis' Generalized Distance is applied to 29 measurements for the 10 groups are presented in Table 7. All, except five, of the distances are significant at either the 1% or 5% level. The non-significant distances are invariably the smallest distances in this analysis, i.e., they imply no significant dissimilarity. The smallest distance in this table is between Ryukyu-Kamakura (1.413) followed by the distances between Edo-Kyushu (1.560), and Tohoku-Edo (1.738). Other small distances include those between Kofun-Yayoi (1.802) and Kyushu-Tohoku (2.423). The largest distances, implying the greatest dissimilarity, are generally between either Jomon or Ainu and all remaining series. Applying the UPGMA clustering technique, results in the dendrogram shown in Figure 5. As is indicated in the canonical plots, three distinct clusters are evident in this diagram. The Edo series and three modern Japanese series form a single cluster, which in turn, is closest to a second cluster that includes the Kamakura, Ryukyu, Kofun, and Yayoi series. Lastly, the Ainu-Jomon grouping forms a peripheral branch in this diagram.

Analysis II (53 Groups, 29 Measurements)

In the second analysis, stepwise discriminant function analysis and Generalized Distance are applied to 29 measurements recorded in 2518 crania representing 53 males groups from Japan, Asia, Australia, and the Pacific.

Stepwise Discriminant Function Analysis

Table 8 presents a summary ranking of the 29 cranial measurements according to F-values received in the final step of discriminant function analysis. In this analysis alveolar length, maximum cranial breadth, basion-nasion length, and maximum cranial breadth are among the most important discriminating measures.

Eigenvalues, percentage of dispersion, and the level of significance for the first 23 canonical variates are shown in Table 9. The first three canonical variates account for 61.6% of the variation produced.

Canonical coefficients for 29 cranial measurements for the first three canonical variates are listed in Table 10. Biorbital breadth, nasio-occipital length, alveolar length, and bimaxillary subtense are among the most important variables producing separation in the first canonical variate. Basion-nasion length, nasal breadth, alveolar breadth, and minimum cranial breadth are among the variables responsible for group separation in the second canonical variate. With the excep-

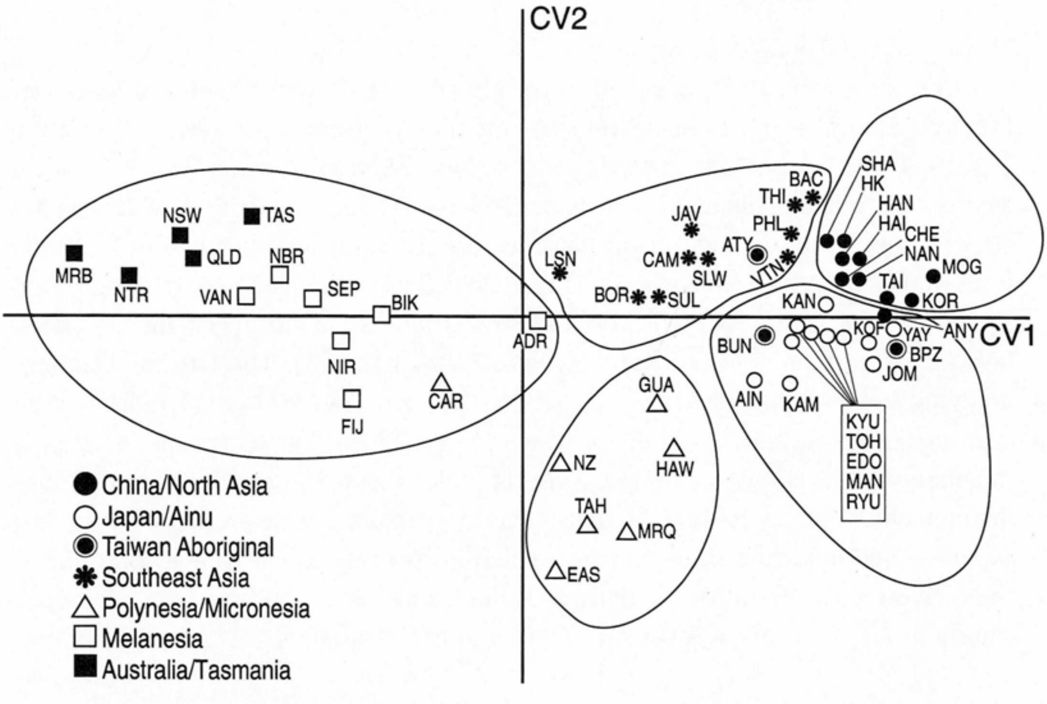

Fig. 6 Plot of 53 male Japanese/Asian/Pacific group means on the first two canonical variates using 29 cranial measurements.

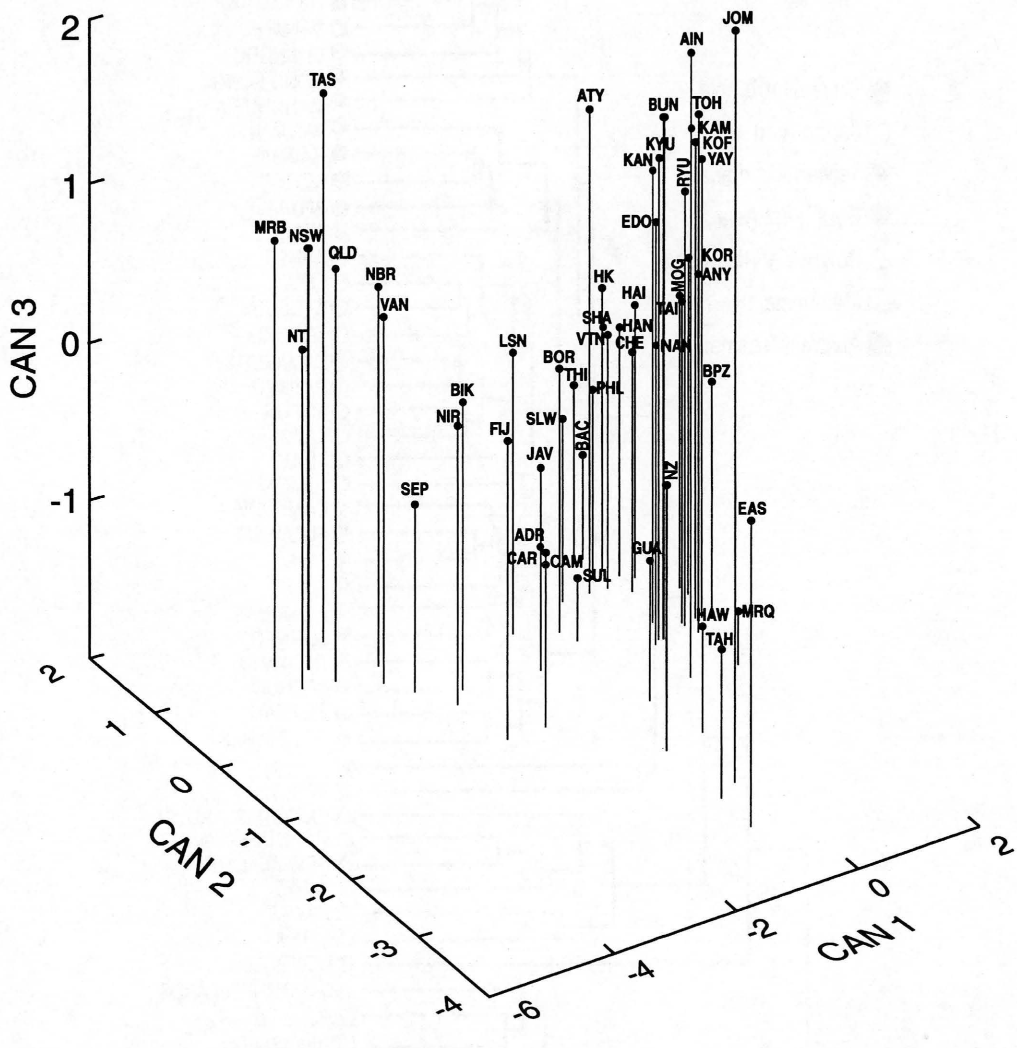

Fig. 7 Plot of 53 male Japanese/Asian/Pacific group means on the first three canonical variates using 29 cranial measurements.

tion of basion-nasion, the second canonical variate is primarily a breadth discriminator. Dimensions of the nasal aperture, bifrontal breadth, and length of the zygomatic bone are primarily responsible for group separation in the third canonical variate.

A summary of some of the classification results of this analysis is given in Table 11. The groups with the highest percentage of correct classifications include Mongolia, Easter Island, Bunun, Babuza-Pazeh, Hawaii, Jomon, and Cambodia-Laos. Two-thirds of the Jomon, and 56% of the Ainu cases, are cor-

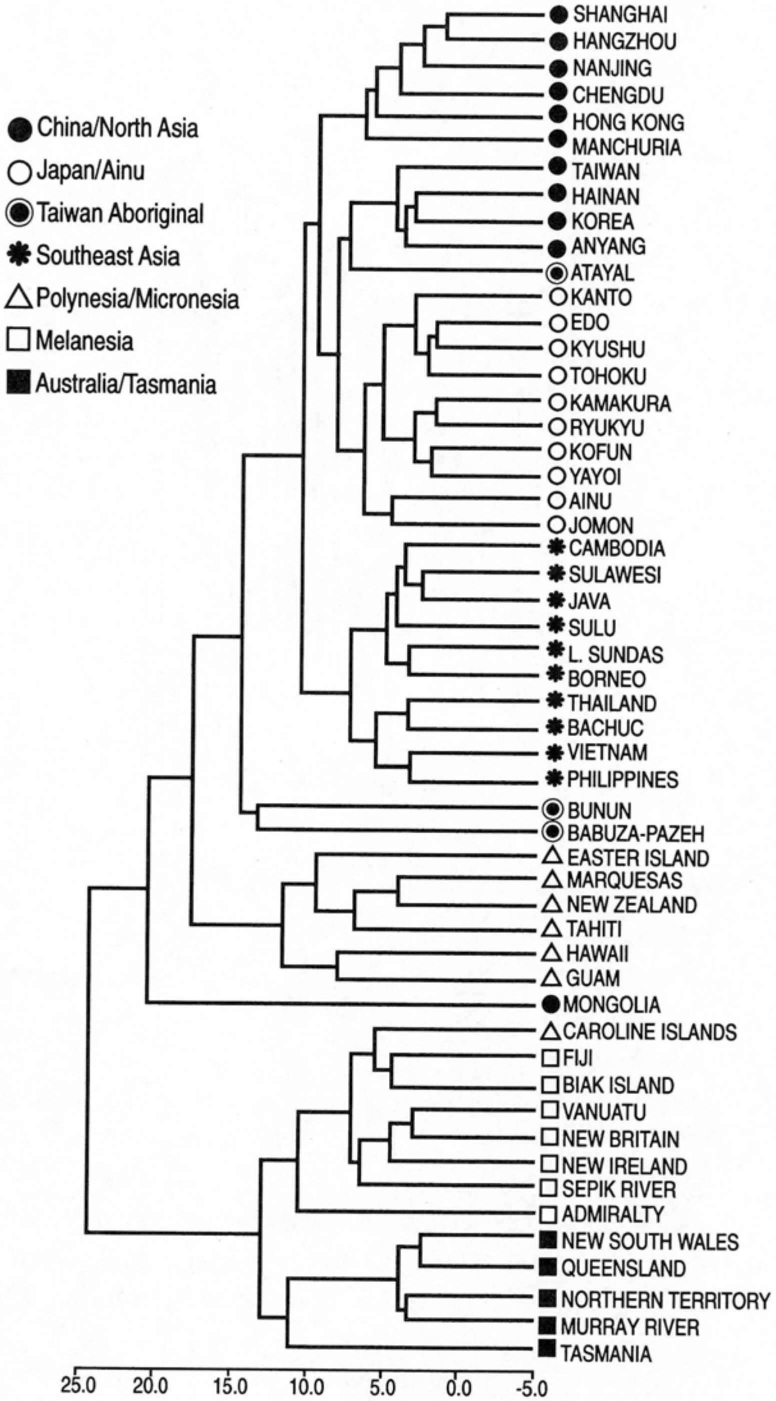

Fig. 8 Diagram of relationship based on a cluster analysis (UPGMA) of Mahalanobis' Generalized Distances using 29 cranial measurements recorded in 53 male Japanese/Asian/Pacific groups.

rectly classified in this analysis. The poorest classification results are those obtained for Edo, Hangzhou, Lesser Sundas, Sulawesi, and the Ryukyu Islands. Four each of the Ainu and the Ryukyu series are misclassified as Jomon. Six of the Tohoku specimens are misclassified as Ainu. Four of the Ainu are classified as Jomon and three of the Jomon skulls are classified as Ainu. Seven Ryukyu crania are misclassified as Kamakura and four more are classified as Jomon.

A plot of the 53 group means on the first two canonical variates is shown in Figure 6. Noteworthy in this diagram is the grouping of the Australian and Melanesian series, a Polynesian (and Guam) cluster, and clusters containing Southeast Asian, Chinese/North Asian, and Japanese groups, respectively. A plot of the 53 groups on the first three canonical variates (Figure 7), reiterates this separation and accentuates the separation of the Ainu and Jomon series. Similarly, the Atayal assume a more isolated position in this representation.

Mahalanobis' Generalized Distance

The distances, including significance levels, obtained when Mahalanobis' Generalized Distance is applied to 29 cranial measurements recorded in 53 groups and levels of significance, are presented in Table 12. Of the 2,756 distances in this table, only 27 have nonsignificant variance ratios. As was the case in the previous analysis, the nonsignificant distances are generally the smallest distances, or the groups having the smallest sample sizes. Some of the smallest distances are those between Korea and Taiwan, Hainan Island, Edo, Tohoku, Kyushu, and the Philippines. The Kamakura-Ryukyu distance (1.445) and Kofun-Yayoi (1.635) are two of the smallest distances in this analysis. Other small distances are those between Edo and the modern Kyushu and Tohoku cranial series. Additional nonsignificant distances are those observed among the Southeast Asian series, especially between Sulawesi and some of the other Southeast Asian groups.

The dendrogram which results when UPGMA clustering algorithm is applied to these distances is shown in Figure 8. The major separation in this diagram is one between Australo-Melanesian and Asian (including Polynesian) groups. Mongolia remains an extreme outgroup of the latter division. The Ainu and Jomon sub-branch connects with other Japanese series before connecting with any of the other Asian series in this analysis.

DISCUSSION

Recently, Professor Kazuro Hanihara (1991) has advanced the "dual structure model" to explain the origins and affinities of the Japanese. According to this model, the modern peoples of Japan are the result of an admixture between two fundamentally distinct groups, an earlier indigenous group, the Jomon, and a later group of migrants, who began appearing roughly during the Yayoi Period. Hanihara has further proposed that the Jomon, and their relatively unmixed descendants, the Ainu and Ryukyuans, are of Southeast Asian origin, while the later immigrants are from Northeast Asia.

There is almost universal agreement among recent researchers, using various lines of skeletal and genetic evidence, that Japan's prehistoric Jomon people and the modern Ainu (and Ryukyu) peoples are closely related (e.g, Brace et al., 1989, Brace and Tracer, 1992; Brace and Hunt, 1990; Dodo, 1986; Dodo and Ishida, 1990, Hanihara, K. 1985; Hanihara, T. 1993; Hanihara K. et al., 1993; Howells, 1966, 1986; Kozintsev, 1990; Matusumura, 1989; Mizoguchi, 1986; Omoto et al., 1996; Ossenberg, 1986, 1992; Turner, 1976, 1987, 1990; Yamaguchi, 1982, 1985, 1992, etc.).

The results of the present craniometric study support a biological link between the Ainu and Jomon, which, in turn, is consistent with the view that the Ainu are the relatively unmixed descendants of the Jomon people who, based on archaeological and other evidence, inhabited Japan for about 10,000 years beginning in ca 12,000 years BP. Likewise, the present results are consistent with the view that the non-Ainu Japanese are the descendants of a later immigrant group that entered Japan beginning during the Yayoi (ca 300 BC - 300 AD) and Kofun (4th - 7th century AD) Periods.

The results presented here, however, while supporting an Ainu-Jomon connection, do not indicate a similarly close relationship between the inhabitants of the Ryukyu Islands, Jomon, and Ainu. Rather, in this analysis, the Ryukyu Islanders were found to be closest to the medieval (ca 1333 AD) massacre victims of Kamakura in eastern Honshu, followed by the Yayoi, Kofun, Edo, and Kyushu cranial series. The Ryukyu sample used in the present study consists of specimens from the Sakishima, Okinawa, and Amami groups of the Ryukyu Island archipelago. Although there is likely to have been some admixture, the Ryukyu Island specimens used in this study are believed to represent the indigenous inhabitants of this island chain. Closer inspection of the distances in Table 12 demonstrates that after Kamakura, Yayoi, Kofun, Edo, and Kyushu cranial series, the Ryukyu series is next closest to Korea, Anyang, Hainan, and Vietnam, followed by the Ainu and Jomon series. Overall, though, the Ryukyu Island series is closest to Kamakura, Kofun, and Yayoi suggesting that these groups either share a common origin or that the Ryukyu Islanders have been more affected by admixture with the later immigrants than have the Jomon-Ainu people.

Brace et al. (1989), Brace and Hunt (1990), and Brace and Tracer (1992), have further argued that the Kamakura Shogunate, founded by Minamoto Yoritomo, who in 1185 AD brought an army of retainers from the east, were, in fact, mostly Ainu (Samurai) from the Kanto plains of present day eastern Honshu. This conclusion is not supported by the present results, which indicate a close similarity between Kamakura and Ryukyu followed by Kofun and Yayoi. Close inspection of the distances in Table 12 further indicates that the Kamakura, in addition to the above named groups, is next closest to modern Kyushu and Tohoku anatomy collections before it is to the Ainu and Jomon series.

Hanihara (1991) and others have further suggested the existence of what they refer to as clinal differences within Japan's non-Ainu population, especially an east/west division separating northeast Honshu from southwestern Honshu and Kyushu. Although the samples used in the present study were not chosen specifically to test this hypothesis, the Kyushu series (made up of specimens from northern Kyushu and southwestern Honshu) is found to be closest to Edo (Tokyo) and Tohoku, two samples from eastern and northeastern Honshu Island, respectively. Beyond the separation of the Kanto (east) series from the Kyushu (west) series, found in the present analysis, there is little else to support a great division between eastern and western Japan in the results presented here.

Regarding the possible origins of Japanese people, there is now major consensus among many researchers that the later immigrants to Japan, commencing during Yayoi times, are most likely from Northeast Asia (i.e. via the Korean Peninsula). The results presented here are consistent with this scenario. The Japanese cranial series were found to be closest to several cranial series from northern and northeastern Asia (e.g., Korea, Manchuria, and northern Bronze-age Chinese). Somewhat inexplicably, though, the Japanese series also share affinities with modern Chinese on Taiwan and Hainan Islands and with Taiwan Aboriginals (Atayal). These latter connections have been previously discussed (Pietrusewsky, 1994), in connection with the linguistic reconstructions of Sargat (1993), who has demonstrated a provocative link between Old Chinese and Proto-Austronesian languages. In the present analysis all Japanese, including Jomon and Ainu, are closest to a branch which includes Anyang, Taiwan, Hainan, Atayal, and Korea. Similar affinities have been reported by Howells (1995:91). The latter researcher has interpreted the Japanese-Anyang connection as indicating a northern origin for the Japanese while acknowledging that modern Hainan Island Chinese, and Taiwanese Atayal are members of this same general morphological complex (Howells, 1989: 76).

Several researchers (e.g., Hanihara, T. 1993; Hanihara, K. 1991; Turner, 1992 a, 1992b) have suggested that Japan's pre-agricultural Jomon populations (and by extension, the Ainu and Ryukyu Islanders) derive from people living in Southeast Asia during the Upper Paleolithic. There is, little, or no, support for this conclusion in the present results . Rather, the Jomon-Ainu cluster, although marginal and isolated, is closest to modern Japanese and, secondarily, it is closest to mainland Asian series and modern Chinese from Taiwan and Hainan Islands. However, closer inspection of the distances in Table 12 does demonstrate that after the Japanese and Korea, the closest distances to Jomon/Ainu include several Southeast Asian (e.g., Vietnam, Borneo, Lesser Sundas) and one Taiwan Aboriginal (Bunun) series, suggestive of a possible southern connection. However, the majority of the results presented overwhelmingly place Jomon and Ainu with the other the Japanese series which are closer to Northern Asia (especially Anyang and Korea) than they are to Southeast Asia. Further, Omoto (n.d.), using genetic data, has found that the Jomon, Ainu, and Ryukyu Islanders are of a Northeast Asian, rather than a Southeast Asian, origin.

CONCLUSIONS

The results of the present analyses allow a number of tentative conclusions regarding the biological relationships of Japan's inhabitants and their relationship to surrounding populations, relationships which further allow some tentative statements regarding the possible origins of these groups.

1. Within Japan two distinct morphological groups are recognized, one includes prehistoric Jomon and modern Ainu whilst the second includes all remaining Japanese cranial series since the Yayoi/Kofun periods. This basic dichotomy, implies separate origins for these two groups.

2. The Yayoi are most similar to Kofun specimens, suggesting these two groups share a common origin.

3. The present-day inhabitants of the Ryukyu Islands are most similar to the medieval series from Kamakura, which together are closest to the Yayoi and Kofun samples.

4. Further inspection of the Japan's internal relationships indicates a second major subdivision which includes Edo Period specimens from Tokyo and modern crania from Kyushu (and adjoining regions of western Japan), Tohoku in northeastern Honshu, and the Kanto District in eastern Honshu. These latter, more modern, groups are separated from the Ryukyu Islands, medieval Kamakura, Yayoi, and Kofun, which may suggest a temporal differentiation.

5. When Japanese cranial series are compared with mainland Asian cranial series, associations with cranial series from Korea, Shang Dynasty Chinese, Taiwan, Hainan Island, and Manchuria are indicated. Jomon and Ainu, although somewhat peripheral to this greater division, are closer to the modern Japanese than they are to Chinese and northern Asian groups.

6. Broader comparisons further indicate that there are two major popula-

tions complexes, one which includes Australian Aboriginals and Melanesians and a second which comprises all the cranial series from Asia. The latter includes separate branches for Polynesia/Guam, Southeast Asia, and Japan, Chinese/North Asia.

7. There is no close connection between Jomon/Ainu and Pacific groups. Jomon and Ainu are members of a greater East/North Asian grouping, their presumed ancestral homeland.

8. The cranial series from Mongolia is the most peripheral of all the Asian crania series investigated.

ACKNOWLEDGMENTS

With a few exceptions, permission to examine the cranial series used in the present study have been previously acknowledged (Pietrusewsky, 1992, 1994; Pietrusewsky and Chang, n.d.). My thanks to Ms. Rona Ikehara-Quebral who assisted in the computer analysis of the data and typing the tables used in this paper. Ms. Billie Ikeda, of the Center for Instructional Support of the University of Hawaii, is responsible for the computer generated graphic work used in the paper. Finally, my sincere thanks to Professor Keiichi Omoto and the International Research Center for Japanese Studies who graciously invited me to participate in the symposium at which an earlier, longer, version of this paper was presented.

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Table 1 Fifty-three Male Cranial Series Used in Present Study

Sample (abbrev.)	No. of Crania	Location[1] and Number	Remarks
Japan			
Kanto Japanese (KAN)	50	CHB-50	A dissecting room population of modern Japanese from the Kanto District of eastern Honshu. The majority of the individuals were born during the Meiji period (1868-1911) and most died well before 1940.
Tohoku Japanese (TOH)	53	SEN-53	Dissecting room specimens of modern Japanese from the Tohoku District in northern Honshu Island.
Kyushu Japanese (KYU)	51	KYU-51	Modern Japanese which derive mostly from Fukuoka Prefecture in Kyushu Island. Other specimens are from Yamaguchi, Saga Nagasaki and adjoining prefectures.
Edo (EDO)	55	NSM-52	The specimens are from the Joshinji (Tokyo) site and date to the Edo Period or approximately the 17th to mid-19th centuries.
Kamakura (KAM)	52	NSM-9;TKO-43	Specimens are from the Medieval mass burial sites of Zaimokuza and Gokurakuji in the city of Kamakura, victims of a war which occurred in 1333.
Kofun (KOF)	62	KYO-5;KYU-53; NSM-4	The Kofun Period follows the Yayoi period. The traditional dates for the Kofun Period are the 4th to 6th century A.D.
Yayoi (YAY)	62	KYU-62	A combined sample of Yayoi specimens from Doigahama (39), Yoshimohama (14) and Nakanohama (2) sites in Yamaguchi Prefecture. The rest (7) are from Koura, Shimane Prefecture, in southern Honshu Island. The dates for the Yayoi Period are approximately 300 B.C. to 300 A.D..
Jomon (JOM)	51	TKO-16;NSM-19 KYO-15;SAP-1	All specimens represent Late to Latest [ca 3500 yrs, B.P. to 2000 yrs. B.P.] Jomon sites on Honshu Island. The largest series are Ebishima (11) in Iwate Prefecture in Tohoku District and Tsukumo (12), Okayama Prefecture in the Chugoku District.
Ainu (AIN)	50	SAP-18 TKM-5 TKO-27	Skeletons collected by Koganei in 1888-89 from abandoned Ainu cemeteries in Hokkaido (Koganei 1893-1894).
Ryukyu Islands (RYU)	62	KYU-34;KYO-18 TKO-10	Specimens are from the Sakishima (13), Okinawa (13) and Amami (49) groups, respectively. Six more are identified only as Ryukyu Island.
East Asia			
Shanghai (SHA)	50	SHA-50	The specimens are mostly from post-Qing cemeteries in Shanghai.
Hangzhou (HAN)	50	SHA-50	Ancient skeletal remains exhumed in the modern city of Hangzhou, Zhejiang Province in eastern China.

Table 1 (cont'd) Fifty-three Male Groups Used in the Present Study

Sample	No. of Crania	Location[1] and Number	Remarks
Nanjing (NAN)	49	SHA-49	Ancient remains exhumed from the modern city of Nanjing, Jiangsu Province in eastern China.
Chengdu (CHE)	53	SHA-10;CHE-43	A majority of these specimens date to the Ch'en Dynasty (A.D. 1796-1908) and are from Chengdu, Sichuan Province in western China. Ten crania are from Leshan, Lizhong County, Sichuan Province.
Hong Kong (HK)	50	HKU-50	Specimens represent individuals who died in Hong Kong between 1978-1979.
An-yang (ANY)	56	TPE-56	Bronze-age (11th century B.C.) Shang Dynasty sacrificial victims excavated at Anyang in northern Henan Province in northern China (Li 1977).
Taiwan Chinese (TAI)	47	TPE-47	Modern Chinese living in Taiwan who trace their immediate origins to Fujian and Guangdong Provinces on the mainland of China.
Hainan Island (HAI)	47	TPE-47	Chinese immigrants originally from the Canton region of China who began arriving around 200 B.C. (Howells 1989:108). This material was excavated by T. Kanaseki in Haikou City on Hainan Island.
North Asia			
Manchuria (MAN)	50	TKO-50	Many of the specimens are from northeastern China or the region formerly referred to as "Manchuria," which today includes Heilongjiang and Jilin Provinces and adjacent northern Korea. A great many of these specimens are identified as soldiers or cavalrymen who died in battle in the late 19th century.
Korea (KOR)	32	KYO-7;SEN-3, TKM-2;TKO-20	Specific locations in Korea are known for most of these specimens.
Mongolia (MOG)	50	SIM-50	The skulls are identified as coming from Ulaanbaatar (Urga), Mongolia and were purchased by A. Hrdlicka in 1912.
Taiwan Aboriginal			
Atayal (ATY)	36	TPE-28;TKM-7; TKO-1	The specimens in Taipei represent slain victims of Atayal, the second largest surviving Aboriginal tribe in Taiwan. The incident took place in 1932 and the specimens were collected by T.Kanaseki in the same year (Howells 1989:109).
Bunun (BUN)	26	NTU-26	Specimens of Bunun curated in the Department of Anatomy, National Taiwan University; measurements supplied by Chang Ching-fang.
Babuza-Pazeh (BPZ)	50	NTU-50	29 specimens of Babuza and 21 Pazeh specimens curated in the Department of Anatomy, National Taiwan University; measurements supplied by Chang Ching-fang.

Table 1 (cont'd) Fifty-three Male Groups Used in the Present Study

Sample	No. of Crania	Location[1] and Number	Remarks
Mainland & Island Southesast Asia			
Viet Nam (VTN)	49	HCM-49	Specimens are from Hanoi (Van Dien Cemetery) and Ho Chi Minh City.
Bachuc (BAC)	51	BAC-51	Victims of the 1978 Khmer Rouge massacre in Bachuc Village in western Angiang Province, Viet Nam.
Cambodia & Laos (CAM)	40	PAR-40	A combined sample of crania from various locations in Cambodia and Laos collected between 1877 and 1920.
Thailand (THI)	56	SIR-50	Most of the specimens represent dissecting room cases from Bangkok.
Philippines (PHL)	28	BER-9;DRE-19	Most specimens are from Luzon Island.
Lesser Sundas (LSN)	45	BAS-5;BER-6; BLU-2;CHA-1; DRE-17;LEP-1; PAR-6;ZUR-7	Crania from Bali, Flores, Sumba, Lomblem, Alor, Timor, Wetar, Leti and Barbar Islands.
Borneo (BOR)	34	BER-2;BRE-2; DRE-6;FRE-4; LEP-8;PAR-12	A great many of the specimens are indicated as representing Dayak tribes, some have elaborate decorations.
Sulawesi (SLW)	41	BAS-7;BER-10; DRE-4;FRE-7; LEP-5;PAR-8	An exact location is known from many of these specimens.
Java (JAV)	50	BER-1;BLU-8; CHA-9;DRE-1; LEP-24;PAR-7	Crania were collected from several different localities in Java.
Sulu (SUL)	38	LEP-1;PAR-37	The specimens in Paris were collected by Montano-Rey circa 1900.
Polynesia			
Easter Island (EAS)	50	BER-5;DRE-9; PAR-36	Most of the crania in Paris were collected by Pinart in 1887 at Vaihu and La Perouse Bay.
Hawai`i (HAW)	49	BPB-49	Specimens represent prehistoric Hawaiians from Mokapu, O`ahu Island.
Marquesas (MRQ)	63	PAR-49;LEP-1; BLU-1;BPB-12	Crania are from four islands, Fatu Hiva, Tahuata, Nuku Hiva and Hiva Oa.
New Zealand (NZ)	50	BRE-3;PAR-21; SAM-1;AIM-13; GOT-1;ZUR-5; DRE-6	A representative sample from North and South Islands of New Zealand.

Table 1 (cont'd) Fifty-three Male Groups Used in the Present Study

Sample	No. of Crania	Location[1] and Number	Remarks
Tahiti (TAH)	44	PAR-33;BPB-11	Crania are from the island of Tahiti, Society Islands.
Micronesia			
Guam (GUA)	46	BPB-42;PAR-4	Most of the specimens in the Bishop Museum were collected by H.G.Hornbostel at Tumon Beach on Guam during WWII.
Caroline Islands (CAR)	24	TKO-7;DRE-9; PAR-4;GOT-3; AMS-1	Specimens are from Kosrae (1), Pohnpei (6) and Truk (7).
Melanesia			
Admiralty Islands (ADR)	50	DRE-20;GOT-9; CHA-6;TUB-15;	Specimens from Hermit, Kaniet and Manus Islands.
Vanuatu (VAN)	47	BAS-47	Most of the specimens were collected by F. Speiser in 1912 from Malo, Pentecost and Espirtu Santo Island.
Fiji (FIJ)	32	BER-1,AMS-3; PAR-8;QMB-1; DRE-4;SAM-3; FRE-3;CHA-1; BPB-8	Crania are from all major islands including the Lau Group in the Fiji Islands.
New Britain (NBR)	50	CHA-20;DRE-30	The specimens in Dresden were collected by A. Baessler in 1900 and those in Berlin were collected by R. Parkinson in 1911.
Sepik R. (SEP)	50	DRE-33;GOT-10; TUB-7	The specimens in Dresden were collected by O. Schlaginhaufen in 1909.
Biak Islands (BIK)	48	DRE-48	Most (45) of the specimens were collected by A.B.Meyer in 1873 on Biak Island (Mysore) in Geelvink Bay, Irian Jaya.
New Ireland (NIR)	53	AMS-4;BER-2; BLU-6;DRE-18; GOT-15;QMB-1; SAM-6;TUB-1	The crania in Dresden were mostly collected by Pohl in 1887-1888 from the end of the island; the specimens in Gottingen were collected during the Sudsee Expedition in 1908.
Australia/Tasmania			
Murray R. (MRB)	50	AIA-39;DAM-11	These crania were collected by G.M.Black along the Murray River (Chowilla to Coobool) in New South Wales between 1929-1950.
New South Wales (NSW)	62	AMS-21;DAS-41	The specimens are from the coastal locations in New South Wales.
Queensland (QLD)	54	AMS-21;DAS-3; QMB-30	This sample is drawn from the southeastern and middleeastern parts of Queensland.

Table 1 (cont'd) Fifty-three Male Groups Used in the Present Study

Sample	No. of Crania	Location[1] and Number	Remarks
Northern Territory (NT)	50	AIA-4;AMS-3; MMS-1;NMV-38; QMB-1;SAM-3	Crania are from Port Darwin (14) and Arnhemland (36).
Tasmania (TAS)	26	THM-22;CHA-1; SAM-2;NMV-1	The crania represent Tasmanian Aborigines.

[1]AIA = Australian Institute of Anatomy, Canberra
AIM = Auckland Institute and Museum, Auckland
AMS = The Australian Museum, Sydney
BAC = Bachuc Village, Angiang Province, Viet Nam
BAS = Naturhistorisches Museum, Basel
BER = Museum fur Naturkunde, Berlin
BLU = Anatomisches Institut, Universitat Gottingen, Gottingen
BPB = B.P.Bishop Museum, Honolulu
BRE = Uber-see Museum, Bremen
CHA = Anatomisches Institut der Chairte, Humboldt Universitat, Berlin
CHB = Chiba University School of Medicine, Chiba
CHE = Dept. of Anatomy, Chengdu College of Traditional Chinese Medicine, Chengdu, PRC
DAM = Dept. of Anatomy, University of Melbourne, Melbourne
DAS = Dept. of Anatomy, University of Sydney, Sydney, Australia
DRE = Museum fur Volkerkunde, Dresden
DUN = Dept. of Anatomy, University of Otago, Dunedin, New Zealand
FRE = Institut fur Humangenetik u. Anthropologie, Universitat Freiburg
GOT = Institut fur Anthropologie, Universitat Gottingen, Gottingen
HCM = Faculty of Medicine, Ho Chi Minh City, Viet Nam
HKU = University of Hong Kong, Hong Kong
KYO = Lab of Physical Anthropology, Faculty of Science, Kyoto University, Kyoto
KYU = Dept. of Anatomy, Faculty of Medicine, Kyushu University, Fukuoka
LEP = Anatomisches Institut, Karl Marx Universitat, Leipzig
MMS = Macleay Museum, University of Sydney, Sydney
NSM = National Science Museum, Tokyo
NMV = National Museum of Victoria, Melbourne
NTU = Dept. of Anatomy, National Taiwan University, Taipei
PAR = Musee de 1'Homme, Paris
QMB = Queensland Museum, Brisbane
SAM = South Australian Museum, Adelaide
SAP = Dept. of Anatomy, Sapporo Medical College, Sapporo
SEN = Dept. of Anatomy, School of Medicine, Tohoku University, Sendai
SHA = Institute of Anthropology, College of Life Sciences, Fudan University, Shanghai
SIM = National Museum of Natural History, Smithsonian Institution, Washington, D.C.
SIR = Dept. of Anatomy, Siriraj Hospital, Bangkok
THM = Tasmanian Museum and Art Gallery
TKM = Medical Museum, University Museum, University of Tokyo
TKO = University Museum, University of Tokyo, Tokyo
TPE = Academia Sinica, Nankang, Taipei
TUB = Institut fur Anthropologie u. Humangenetik, Universitat Tubingen, Tubingen
UHM = Department of Anthropology, University of Hawaii, Honolulu
ZUR = Anthropologisches Institut, Universitat Zurich, Zurich

Table 2 Means and Standard Deviations for 29 Cranial Measurements Recorded in 10 Japanese groups.

	Kanto(N=50)		Edo(N=55)		Kamakura(N=52)	
Measurement	Mean	S.D.	Mean	S.D.	Mean	S.D.
Maximum cranial length	181.4	5.5	181.5	5.8	185.2	6.6
Nasio-occipital length	178.8	5.4	179.2	5.5	183.0	6.5
Basion-nasion	101.8	3.9	101.1	3.3	103.3	4.0
Basion-bregma	138.1	4.7	136.7	4.5	137.8	4.3
Maximum cranial breadth	140.3	6.1	137.7	4.9	136.8	4.5
Maximum frontal breadth	118.5	6.2	117.9	4.9	115.9	4.2
Mimimum frontal breadth	95.4	4.6	95.4	4.7	95.7	4.4
Bistephanic breadth	111.6	6.8	111.8	5.7	109.9	5.2
Biauricular breadth	125.1	4.5	123.6	4.8	124.3	5.2
Minimum cranial breadth	80.2	4.4	77.2	4.0	75.4	4.0
Biasterionic	107.4	4.0	107.0	3.7	108.2	4.5
Nasal height	52.0	3.1	51.7	3.0	50.6	3.0
Nasal breadth	24.1	1.8	24.3	1.8	25.1	2.1
Orbital height, left	33.7	2.4	34.5	2.1	32.9	2.2
Orbital breadth, left	40.9	2.2	41.0	1.9	41.3	2.1
Bijugal breadth	114.1	5.0	114.4	4.1	116.7	4.4
Alveolar length	51.9	3.2	52.8	3.5	53.9	3.0
Alveolar breadth	64.9	4.4	64.8	4.1	65.4	3.1
Mastoid height	28.0	2.4	27.1	3.2	26.0	3.1
Mastoid width	19.7	3.0	20.3	2.9	20.1	3.4
Bimaxillary breadth	97.9	4.6	98.0	5.4	101.6	5.5
Bifrontal breadth	105.8	4.5	105.3	3.7	106.5	3.8
Biorbital breadth	96.6	4.3	95.4	3.6	96.3	3.5
Malar length, inferior	33.4	4.3	34.5	4.1	34.1	3.5
Cheek height	23.5	2.7	23.8	2.3	24.6	2.6
Nasion-bregma chord	111.3	3.8	111.4	4.6	111.9	4.6
Bregma-lambda chord	112.3	5.8	112.0	6.1	116.4	6.0
Lambda-opisthion chord	99.2	6.1	98.2	4.9	98.5	4.0
Bimaxillary subtense	23.4	3.0	23.0	2.8	22.2	2.7

Table 2 Means and Standard Deviations for 29 Cranial Measurements Recorded in 10 Japanese Groups.

Measurement	Kyushu(N=51)		Ainu(N=50)		Ryukyu(N=62)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Maximum cranial length	182.9	5.8	186.8	5.8	181.4	6.7
Nasio-occipital length	180.4	5.6	184.2	5.2	179.4	6.4
Basion-nasion	102.1	4.3	105.0	4.0	101.9	4.0
Basion-bregma	138.6	4.5	137.8	5.3	136.7	4.5
Maximum cranial breadth	137.1	4.5	139.3	3.3	138.2	4.9
Maximum frontal breadth	116.4	5.0	119.5	4.1	117.0	4.7
Mimimum frontal breadth	94.5	4.6	96.8	4.0	95.3	3.7
Bistephanic breadth	111.5	5.9	112.8	5.1	111.9	4.4
Biauricular breadth	123.2	4.8	123.1	5.2	125.2	4.2
Minimum cranial breadth	77.5	3.7	77.1	3.9	76.5	3.9
Biasterionic	107.5	4.8	109.4	5.1	107.4	4.0
Nasal height	51.2	2.6	49.9	2.9	50.8	3.4
Nasal breadth	24.2	2.5	24.3	1.9	25.1	2.0
Orbital height, left	33.5	2.0	33.6	1.8	33.1	2.0
Orbital breadth, left	40.8	1.9	42.1	1.9	40.8	1.8
Bijugal breadth	113.5	5.0	115.6	4.2	116.0	3.9
Alveolar length	53.5	3.0	54.4	3.2	53.6	2.6
Alveolar breadth	65.9	4.1	63.9	3.6	64.8	3.3
Mastoid height	26.9	3.2	26.3	3.0	26.4	3.4
Mastoid width	20.0	2.9	20.2	3.1	20.9	3.3
Bimaxillary breadth	98.5	4.0	98.7	4.9	102.5	3.7
Bifrontal breadth	105.0	4.0	106.1	3.6	106.0	2.9
Biorbital breadth	94.7	3.8	96.8	3.4	95.8	2.7
Malar length, inferior	33.3	3.8	33.9	3.2	34.8	3.1
Cheek height	23.4	2.4	22.9	2.5	24.6	2.4
Nasion-bregma chord	111.6	3.6	112.4	3.8	110.7	5.2
Bregma-lambda chord	114.2	4.8	113.2	5.2	114.4	5.7
Lambda-opisthion chord	99.5	5.5	99.2	4.5	96.9	5.1
Bimaxillary subtense	23.4	2.7	22.3	2.6	21.8	2.6

Table 2 Means and Standard Deviations for 29 Cranial Measurements Recorded in 10 Japanese Groups.

Measurement	Kofun(N=62)		Yayoi(N=62)		Tohoku(N=53)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Maximum cranial length	183.0	5.8	183.3	6.2	183.0	6.3
Nasio-occipital length	181.0	5.6	181.4	6.4	180.4	6.0
Basion-nasion	101.3	4.2	101.6	4.1	101.7	4.5
Basion-bregma	135.6	4.7	135.5	5.2	136.3	4.9
Maximum cranial breadth	141.4	5.0	141.5	5.0	137.2	4.7
Maximum frontal breadth	119.8	5.0	120.5	4.2	117.2	4.8
Mimimum frontal breadth	95.9	3.8	97.2	4.3	95.7	3.8
Bistephanic breadth	114.1	4.8	114.2	4.9	111.4	5.7
Biauricular breadth	128.6	4.6	127.9	4.6	123.6	5.1
Minimum cranial breadth	78.6	4.3	79.0	4.4	77.6	3.3
Biasterionic	110.6	5.3	110.1	5.6	107.9	4.7
Nasal height	51.8	3.1	52.6	3.7	51.7	4.5
Nasal breadth	25.2	1.8	25.2	1.7	23.4	2.2
Orbital height, left	33.6	2.0	34.0	2.0	34.1	1.6
Orbital breadth, left	41.8	2.0	42.1	1.9	40.1	2.2
Bijugal breadth	118.2	4.2	117.9	4.5	114.4	5.3
Alveolar length	53.3	2.6	52.7	2.9	51.6	2.8
Alveolar breadth	65.2	3.8	65.1	3.5	64.5	5.1
Mastoid height	25.3	3.2	26.5	2.8	26.3	2.7
Mastoid width	20.6	2.9	20.3	2.6	20.0	3.1
Bimaxillary breadth	101.6	3.3	103.4	3.9	98.3	5.0
Bifrontal breadth	107.8	4.0	107.3	4.3	104.5	4.1
Biorbital breadth	97.2	3.7	97.7	3.8	95.0	4.1
Malar length, inferior	34.6	3.1	33.9	3.6	33.0	3.7
Cheek height	25.1	2.2	25.3	2.4	23.6	2.5
Nasion-bregma chord	112.0	4.8	112.0	4.9	110.1	3.9
Bregma-lambda chord	113.8	5.6	114.0	6.5	113.5	4.9
Lambda-opisthion chord	98.9	5.6	97.1	4.6	99.0	5.6
Bimaxillary subtense	21.5	3.0	21.6	2.9	22.8	2.2

Table 2 Means and Standard Deviations for 29 Cranial Measurements Recorded in 10 Japanese Groups.

	Jomon(N=51)	
Measurement	Mean	S.D.
Maximum cranial length	184.2	6.3
Nasio-occipital length	181.9	6.4
Basion-nasion	103.8	4.6
Basion-bregma	138.1	5.4
Maximum cranial breadth	143.9	5.7
Maximum frontal breadth	122.1	5.2
Mimimum frontal breadth	99.2	5.2
Bistephanic breadth	117.2	5.2
Biauricular breadth	127.4	5.9
Minimum cranial breadth	78.4	5.0
Biasterionic	110.6	5.1
Nasal height	49.5	2.7
Nasal breadth	25.2	1.4
Orbital height, left	32.9	1.9
Orbital breadth, left	42.3	2.2
Bijugal breadth	119.4	4.9
Alveolar length	52.9	2.5
Alveolar breadth	64.4	3.8
Mastoid height	27.1	3.3
Mastoid width	21.4	3.0
Bimaxillary breadth	101.3	4.9
Bifrontal breadth	108.6	4.0
Biorbital breadth	98.8	4.1
Malar length, inferior	32.4	3.0
Cheek height	23.6	2.3
Nasion-bregma chord	110.3	4.0
Bregma-lambda chord	115.1	4.9
Lambda-opisthion chord	100.1	4.5
Bimaxillary subtense	21.8	3.0

Table 3 Summary Ranking of Cranial Measurements According to F-Values Received in the Final Step of Discriminant Function Analysis (10 Male Groups, 29 Measurements).

Step No.	Meausurement	F-Value	$d.f_B/d.f_W$[1]	p[2]
1	Maximum cranial breadth	12.412	9/537	*
2	Bimaxillary breadth	10.916	9/536	*
3	Basion-nasion length	6.667	9/535	*
4	Nasal height	8.607	9/534	*
5	Orbital breadth	5.013	9/533	*
6	Mastoid height	4.896	9/532	*
7	Inferior malar length	4.831	9/531	*
8	Bijugal breadth	4.578	9/530	*
9	Minimum cranial breadth	5.017	9/529	*
10	Alveolar length	3.550	9/528	*
11	Nasio-occipital length	3.219	9/527	*
12	Bimaxillary subtense	2.972	9/526	*
13	Lambda-opisthion chord	3.172	9/525	*
14	Bregma-lambda chord	3.171	9/524	*
15	Biauricular breadth	2.997	9/523	*
16	Biorbital breadth	2.415	9/522	*
17	Bifrontal breadth	3.079	9/521	*
18	Bistephanic breadth	2.444	9/520	*
19	Minimum frontal breadth	2.579	9/519	*
20	Maximum frontal breadth	2.140	9/518	*
21	Nasal breadth	1.990	9/517	n.s.[3]
22	Cheek height	1.980	9/516	n.s.
23	Basion-bregma height	2.019	9/515	n.s.
24	Orbital height	1.632	9/514	n.s.
25	Maximum cranial length	1.474	9/513	n.s.
26	Mastoid width	1.353	9/512	n.s.
27	Alveolar breadth	1.234	9/511	n.s.
28	Nasion-bregma chord	1.086	9/510	n.s.
29	Biasterionic breadth	0.934	9/509	n.s.

[1] $d.f._B/d.f._W$ = degrees of freedom between/ degrees of freedom within.
[2] $P \leq .01$.
[3] n.s. = not significant.

Table 4 Eigenvalues, Percentage of Total Dispersion, Cumulative Percentage of Dispersion, and Level of Significance for the First 9 Canonical Variates (10 Groups, 29 Measurements).

Canonical Variate	Eigenvalue	% Dispersion	Cumulative % Dispersion	d.f.[1]	p[2]
1	0.71578	33.9	33.9	37	*
2	0.53538	25.4	59.3	35	*
3	0.28544	13.5	72.8	33	*
4	0.18466	8.7	81.5	31	*
5	0.12963	6.2	87.7	29	*
6	0.11870	5.6	93.3	27	*
7	0.07164	3.4	96.7	25	n.s.
8	0.03898	1.8	98.5	23	n.s.
9	0.03115	1.5	100.0	21	n.s.

[1] d.f.=degrees of freedom=(p+q-2)+(p+q-4).

[2] $p \leq 0.01$ when eigenvalues are tested for significance according to criterion $[N-1/2(p+q)]\log_e(\lambda+1)$, where N=total number of crania, p=number of variables, q=number of groups, λ= eigenvalue, all of which are distributed approximately as chi-square (Rao 1952: 323), n.s.=not significant.

Table 5 Canonical Coefficients of 29 Cranial Measurements for the First Three Canonical Variates (10 Groups, 29 Measurements)

Variable	Canonical Variate 1	Canonical Variate 2	Canonical Variate 3
Maximum cranial length	0.11644	-0.07036	-0.06712
Nasio-occipital length	-0.12613	0.01813	0.01356
Basion-nasion length	-0.01188	-0.11102	-0.02558
Basion-bregma height	0.05275	-0.02705	-0.01491
Maximum cranial breadth	0.03601	-0.09954	-0.05843
Maximum frontal breadth	-0.00070	-0.08260	0.01578
Minimum frontal breadth	0.04654	-0.05293	0.01734
Bistephanic breadth	-0.05876	0.05771	-0.01446
Biauricular breadth	-0.02162	0.09180	0.05629
Minimum cranial breadth	0.09494	-0.00471	0.06801
Biasterionic breadth	-0.00946	-0.00617	0.00375
Nasal height	0.04238	0.12091	0.05211
Nasal breadth	-0.12020	0.02160	0.00563
Orbital height	-0.04101	-0.06021	-0.00135
Orbital breadth	-0.17227	-0.10538	-0.01841
Bijugal breadth	-0.09406	-0.04955	0.00129
Alveolar length	-0.04227	-0.05638	-0.15945
Alveolar breadth	0.04348	0.02110	0.00720
Mastoid height	0.10088	-0.03412	0.04786
Mastoid breadth	-0.05378	-0.02423	-0.00098
Bimaxillary breadth	-0.09053	0.08237	-0.07071
Bifrontal breadth	-0.00204	0.13228	-0.05451
Biorbital breadth	0.07789	-0.13547	0.14259
Malar length, inferior	0.07059	0.10639	-0.05168
Cheek height	-0.04722	0.10720	0.12677
Nasion-bregma chord	-0.00110	0.04677	-0.03879
Bregma-lambda chord	-0.04498	0.04652	-0.00085
Lambda-opisthion chord	0.01983	-0.00412	0.01826
Bimaxillary subtense	0.12351	0.01623	0.02976

Table 6 Summary of Classification Results from Discriminant Function Analysis(Number of Cases Classified into Groups) 10 Groups, 29 Mesurements.

Group	KAN	EDO	KAM	KOF	YAY	TOH	KYU	AIN	RYU	JOM
Kanto	33	3					1	1	2	3
Edo	5	17	3	3	5	5	10	5	1	1
Kamakura	3	3	24	5	2	3	3	1	7	1
Kofun		5	6	31	6	3	2	2	3	4
Yayoi	4	3	5	5	33	2	1	2	5	2
Tohoku	6	5		2	2	26	3	4	4	1
Kyushu	4	4	4	3	2	4	25	1	3	1
Ainu	3	1	3	1		1	3	34	1	3
Ryukyu	2	2	7	4	7	1	4	7	1	4
Jomon			1	4	2	1	1	4	2	36
Total CasasOrig Assign.	50	55	52	62	62	53	51	50	62	51
No. Correctly Assign.	33	17	24	31	33	26	25	34	28	36
% Correct Assign.	66.0	30.9	46.2	50.0	53.2	49.1	49.0	68.0	45.2	70.6

Table 7 Mahalanobis' Generalized Distances (Upper Half) and Variance Ratios (Lower Half) for 10 Japanese Groups Using 29 Cranial Measurements.

Group	KAN	EDO	KAM	KOF	YAY	TOH	KYU	AIN	RYU	JOM
Kanto		2.658	6.782	7.323	6.633	2.959	3.004	6.774	6.542	8.292
Edo	1.75*		3.530	4.084	4.137	1.738	1.560	4.991	3.197	7.694
Kamakura	4.29**	2.39**		2.753	3.217	3.766	2.886	4.662	1.413	5.538
Kofun	5.21**	3.11**	2.01**		1.802	50122	4.492	7.101	2.490	5.265
Yayoi	4.72**	3.15**	2.35**	1.48†		4.661	5.652	6.323	2.431	5.457
Tohoku	1.90*	1.19†	2.48**	3.80**	3.45**		2.423	5.700	4.274	7.597
Kyushu	1.88*	1.04†	1.85*	3.24**	4.08**	1.58†		5.114	3.262	7.587
Ainu	4.17**	3.28**	2.95**	5.05**	4.50**	3.66**	3.19**		6.666	4.857
Ryukyu	4.65**	2.43**	1.03†	2.05**	2.00**	3.17**	2.35**	4.74**		6.334
Jomon	5.18**	5.13**	3.55**	3.80**	3.94**	4.94**	4.80**	3.03**	4.57**	

* =significant at 5% level.
** =significant at 1% level.
† =not significant.

Table 8 Summary Ranking of Cranial Measurements According to F-Values Received in the Final Step of Discriminant Function Analysis (53 Male Groups, 29 Measurements).

Step No.	measurement[1]	F-Value	$d.f._B/d.f._W$[1]	p[2]
1	Aleveolar length	37.619	52/2464	*
2	Maximum cranial breadth	30.584	52/2463	*
3	Basion-nasion length	19.722	52/2462	*
4	Minimum cranial breadth	17.562	52/2461	*
5	Nasal height	14.959	52/2460	*
6	Orbital breadth	14.693	52/2459	*
7	Nasio-occipital length	12.422	52/2458	*
8	Basion-bregma height	12.443	52/2457	*
9	Bimaxillary subtense	10.679	52/2456	*
10	Malar length, inferior	10.411	52/2455	*
11	Nasal breadth	9.726	52/2454	*
12	Biauricular breadth	9.847	52/2453	*
13	Maximum cranial breadth	9.029	52/2452	*
14	Bimaxillary breadth	7.627	52/2451	*
15	Bifrontal breadth	7.495	52/2450	*
16	Bijugal breadth	8.291	52/2449	*
17	Alveolar breadth	7.015	52/2448	*
18	Biorbital breadth	6.982	52/2447	*
19	Nasion-bregma chord	6.478	52/2446	*
20	Cheek height	5.599	52/2445	*
21	Orbital height	5.677	52/2444	*
22	Lambda-opisthion chord	5.309	52/2443	*
23	Bistephanic breadth	5.038	52/2442	*
24	Maximum frontal breadth	6.308	52/2441	*
25	Mastoid height	4.064	52/2440	*
26	Bregma-lambda chord	3.798	52/2439	*
27	Biasterionic breadth	3.183	52/2438	*
28	Mastoid width	3.025	52/2437	*
29	Minimal frontal breadth	2.936	52/2436	*

[1] $d.f._B/d.f._W$ = degrees of freedom between/degrees of freedom within.
[2] $p \leq .01$.

Table 9 Eigenvalues, Precentage of Total Dispersion, Cumulative Percentage of Dispersion, and Level of Significance for the First 23 Canonical Variates (53 Groups, 29 Measurements).

Canonical Varate	Eigenvalue	% Dispersion	Cumulative % Dispersion	d.f.[1]	p[2]
1	3.33551	40.7	40.7	80	*
2	0.91664	11.2	51.9	78	*
3	0.79834	9.7	61.6	76	*
4	0.56514	6.9	68.5	74	*
5	0.45781	5.6	74.1	72	*
6	0.31865	3.9	78.0	70	*
7	0.26598	3.3	81.3	68	*
8	0.22331	2.7	84.0	66	*
9	0.19404	2.4	86.4	64	*
10	0.16333	2.0	88.4	62	*
11	0.13646	1.6	90.0	60	*
12	0.12027	1.5	91.5	58	*
13	0.10501	1.3	92.8	56	*
14	0.09168	1.1	93.9	54	*
15	0.08510	1.0	94.9	52	*
16	0.06253	0.8	95.7	50	*
17	0.05574	0.7	96.4	48	*
18	0.05267	0.6	97.0	46	*
19	0.04474	0.6	97.6	44	*
20	0.03816	0.4	98.0	42	*
21	0.03498	0.5	98.5	40	*
22	0.03074	0.3	98.8	38	*
23	0.02507	0.3	99.1	36	*

[1] d.f. = degrees of freedom = (p + q-2) + (p + q-4).

[2] $p < 0.01$ when eigenvalues are tested for significance according to criterion $[N-1/2(p+q)]\log_e(\lambda+1)$, where N = total number of crania, p = number of variables, q = number of groups, λ = eigenvalue, all of which are distributed approximately as chi-square (Rao 1952 : 323).

Table 10 Canonical Coefficients of 29 Cranial Measurements for the First Three Canonical Variates (53 Groups, 29 Measurements).

Variable	Canonical Variate 1	Canoncal Variate 2	Canonial Variate 3
Maximum cranial length	-0.10718	0.04171	0.04168
Nasio-occipital length	0.13274	-0.07601	0.11272
Basion-nasion length	0.03546	-0.12441	0.03742
Basion-bregma height	0.01919	0.00454	-0.02025
Maximum cranial breadth	-0.04901	0.04315	0.01181
Maximum frontal breadth	-0.01305	0.06819	0.01249
Minimum frontal breadth	-0.04149	0.00556	0.00762
Bistephanic breadth	-0.03930	0.05624	-0.01253
Biauricular breadth	0.01141	-0.06737	0.01251
Minimum cranial breadth	0.09231	0.10769	0.05988
Biasterionic breadth	-0.02871	0.02508	0.02740
Nasal height	-0.00506	0.00188	-0.13429
Nasal breadth	-0.04136	0.11527	-0.13649
Orbital height	0.03707	-0.02128	-0.10531
Orbital breadth	-0.05968	-0.07521	-0.04373
Bijugal breadth	0.03786	-0.10928	0.01447
Alveolar length	-0.12170	-0.00389	-0.00148
Alveolar breadth	-0.02140	0.11295	0.04689
Mastoid height	-0.01648	-0.04575	-0.04246
Mastoid breadth	0.03888	-0.03638	0.00548
Bimaxillary breadth	0.06133	0.03026	-0.02193
Bifrontal breadth	0.04519	0.06695	0.12474
Biorbital breadth	-0.14816	0.01707	-0.06356
Malar length, inferior	-0.08780	0.07578	-0.11614
Cheek height	0.10138	-0.03780	-0.09124
Nasion-bregma chord	-0.04133	-0.04126	-0.07574
Bregma-lambda chord	-0.01134	0.01853	-0.03462
Lambda-opisthion chord	0.00161	-0.02418	-0.05325
Bimaxillary subtense	-0.10719	-0.04811	-0.03264

Table 11 Summary of Classification Results from Discriminant Function Analysis (Number of Cases Classified into Groups) 53 Groups, 29 Measurements.

Group	Total Cases Orig. Assigned	No. Correct Assign.	% Correct Assign.
Shanghai	50	15	30.0
Hong Kong	50	25	50.0
Chengdu	53	28	52.8
Hangzhou	50	10	20.0
Nanjing	49	16	32.7
Taiwan	47	20	42.6
Hainan Is.	47	15	31.9
Atayal	36	25	69.4
Manchuria	50	25	50.0
Anyang	56	28	50.0
Mongolia	50	41	82.0
Korea	32	10	31.3
Kanto	50	20	40.0
Edo	55	5	9.1
Kamakura	52	20	38.5
Kofun	62	26	41.9
Yayoi	62	22	35.5
Tohoku	53	18	34.0
Kyushu	51	18	35.3
Ainu	50	28	56.0
Ryukyu	62	17	27.4
Jomon	51	34	66.7
Cambodia-Laos	40	28	70.0
Thailand	50	23	46.0
Vietnam	49	19	38.8
Bachuc	51	30	58.8

Table 11 Summary of Classification Results from Discriminant Function Analysis (Number of Cases Classified into Groups) 53 Groups, 29 Measurements.

Group	Total Cases Orig. Assigned	No. Correct Assign.	% Correct Assign.
Sulawesi	41	11	26.8
Sulu	38	18	47.4
Philippines	28	11	39.3
L.Sundas	45	10	22.2
Borneo	34	13	38.2
Java	50	17	34.0
Babuza-Pazeh	50	37	74.0
Bunun	26	20	76.9
Easter Is.	50	41	82.0
Hawaii	49	37	75.5
Marquesas	63	28	44.4
New Zealand	50	27	54.0
Tahiti	44	27	61.4
Guam	46	31	67.4
Caroline Is.	24	9	37.5
Admiralty	50	27	54.0
Vanuatu	47	24	51.1
Fiji	32	15	46.9
New Britain	50	22	44.0
Sepik R.	50	30	60.0
Biak Island	48	25	52.1
New Ireland	53	24	45.3
New South Wales	62	34	54.8
Queensland	54	22	40.7
Murray R.	50	30	60.0
Tasmania	26	19	73.1
N.Territory	50	27	54.0

Table 12.1 Mahalanobis' Generalized Distances and Level of Significance for 53 Male Groups Using 29 Cranial Measurements [All Distances are Significant at 1% Level When Variance Ratios are Tested Unless Otherwise Indicated:*=Significant at 5 % Level; †=Not Significant]

Group	SHA	HK	CHE	HAN	NAN	TAI	HAI	ATY	BUN	BPZ
Shanghai	-									
Hong Kong	4.165	-								
Chengdu	4.122	7.930	-							
Hangzhou	0.734†	4.140	3.839	-						
Nanjing	2.425†	4.338	2.612*	1.667†	-					
Taiwan	10.603	8.641	8.941	9.635	7.772	-				
Hainan	8.154	6.902	9.658	8.238	7.280	3.371*	-			
Atayal	13.743	13.322	11.574	12.598	10.715	7.908	6.967	-		
Bunun	13.062	13.407	15.534	12.501	12.712	17.693	14.430	12.059	-	
Bab-Pazeh	13.945	18.407	17.113	13.771	13.445	15.855	13.257	18.241	13.107	-
Manchuria	6.590	6.556	6.268	6.008	3.740	6.666	6.188	9.779	13.127	17.866
Anyang	9.428	8.430	9.452	8.167	6.203	3.807	3.612	7.703	15.666	14.326
Mongolia	12.210	20.966	11.233	10.885	12.294	22.749	21.548	23.331	19.490	22.066
Korea	6.680	7.094	7.491	5.913	4.783	4.009†	2.563†	5.826*	11.458	11.793
Kanto	7.699	7.333	11.832	7.915	8.006	9.149	6.725	9.321	8.494	14.859
Edo	6.056	6.225	7.823	6.009	5.047	7.134	4.600	6.795	8.183	13.498
Kamakura	10.980	10.510	11.589	10.143	8.654	7.986	7.311	8.212	10.280	14.088
Kofun	7.892	9.389	8.153	7.035	6.956	7.987	7.102	9.967	11.662	15.473
Yayoi	6.695	9.143	7.164	5.807	5.379	9.124	8.055	9.480	9.689	12.578
Tohoku	9.337	10.082	10.232	8.935	7.054	8.167	6.969	6.933	8.117	14.724
Kyushu	9.071	7.655	12.025	9.074	8.362	7.843	5.488	6.998	10.035	15.551
Ainu	13.617	14.400	17.323	12.768	12.976	16.227	14.270	12.414	9.297	17.640
Ryukyu	8.877	7.926	9.904	7.832	6.523	6.588	5.015	7.537	10.921	13.729
Jomon	14.993	16.789	19.548	14.238	15.185	16.820	13.406	16.176	11.165	16.208
Camb/Laos	11.306	13.783	14.298	11.123	12.205	13.700	8.306	14.803	20.665	15358

Table 12.2 Mahalanobis' Generalized Distances and Level of Significance for 53 Male Groups Using 29 Cranial Measurements [All Distances are Significant at 1% Level When Variance Ratios are Tested Unless Otherwise Indicated:* = Significant at 5 % Level; † = Not Significant]

Group	SHA	HK	CHE	HAN	NAN	TAI	HAI	ATY	BUN	BPZ
Thailand	6.124	5.623	11.798	6.594	9.025	8.720	5.066	12.503	16.092	16.602
Vietnam	6.409	5.141	7.232	5.668	6.063	6.352	4.756	9.046	11.784	13.025
Bachuc	9.836	8.220	13.842	9.625	11.812	9.278	4.810	14.404	20.786	16.966
Sulawesi	7.235	9.810	9.934	6.736	8.104	11.617	6.829	10.685	15.252	13.834
Sulu	11.269	14.589	13.833	11.083	13.194	15.310	10.659	16.115	17.393	13.383
Philippines	7.463	6.690	8.315	6.415	6.614	7.711	5.750*	8.269	14.613	15.358
L.Sundas	8.298	8.828	10.285	8.480	8.945	11.613	7.911	10.114	14.713	18.038
Borneo	8.499	9.754	11.156	8.011	8.932	12.369	8.493	10.165	11.488	13.705
Java	7.291	10.289	12.107	7.514	9.512	11.895	7.129	14.735	19.462	14.611
Easter Is.	27.067	25.236	26.928	25.260	21.689	23.008	24.753	25.142	21.505	27.754
Hawaii	15.067	17.092	17.516	14.926	15.467	18.702	16.588	25.244	20.717	19.131
Marquesas	17.930	20.331	15.723	17.178	16.169	18.368	18.528	21.471	17.572	22.035
New Zealand	16.603	18.302	15.983	15.932	14.376	17.401	16.042	15.755	12.866	18.708
Tahiti	21.219	22.710	21.376	21.424	19.810	19.707	20.244	26.099	27.104	27.357
Guam	14.082	18.060	13.745	14.535	12.039	18.141	16.632	19.841	23.739	17.905
Caroline	17.078	16.865	18.114	16.828	15.331	19.533	18.534	18.417	21.160	26.116
Admiralty	14.703	15.484	14.744	13.207	14.328	16.223	15.821	17.712	16.251	20.987
Vanuatu	24.578	25.609	25.210	25.674	26.200	30.959	27.138	24.251	24.817	36.515
Fiji	20.280	21.046	21.966	20.504	20.387	25.843	24.176	23.776	22.670	29.549
New Britain	23.084	23.002	24.404	23.307	23.356	27.657	25.342	21.658	26.830	35.890
Sepik R.	23.519	22.820	26.967	24.101	24.867	28.235	23.131	24.116	26.760	34.231
Biak Is.	18.098	17.740	18.579	18.065	18.823	22.171	20.475	18.116	20.070	28.686
New Ireland	20.490	20.413	21.688	20.548	19.948	24.726	21.560	20.617	22.864	30.341
New South Wales	27.701	31.028	30.847	29.011	31.468	37.560	32.294	26.992	31.806	42.587
Queensland	28.666	29.327	31.230	29.400	31.123	34.358	30.162	24.979	28.924	40.523
Murray R.	38.060	40.533	40.989	39.081	41.387	47.099	41.540	33.769	39.490	49.860
Tasmania	32.494	31.441	34.409	33.769	36.782	40.640	34.550	28.863	25.472	44.112
N.Territory	32.793	32.927	35.811	33.665	35.453	39.360	33.971	29.921	34.711	43.514

Table 12.3 Mahalanobis' Generalized Distances and Level of Significance for 53 Male Groups Using 29 Cranial Measurements [All Distances are Significant at 1% Level When Variance Ratios are Tested Unless Otherwise Indicated:* = Significant at 5 % Level; † = Not Significant]

Group	MAN	ANY	MOG	KOR	KAN	EDO	KAM	KOF	YAY	TOH
Manchuria	-									
Anyang	6.859	-								
Mongolia	16.215	20.480	-							
Korea	4.245*	3.365+	16.295	-						
Kanto	6.743	8.395	21.705	4.416*	-					
Edo	3.546	6.039	18.281	2.777+	2.634*	-				
Kamakura	7.734	5.116	20.516	5.528	7.065	3.633	-			
Kofun	6.946	6.293	13.421	4.111	7.477	4.208	2.940	-		
Yayoi	6.235	6.975	10.318	4.758	6.725	4.030	3.239	1.635+	-	
Tohoku	5.097	6.868	20.859	3.586+	3.059*	1.762+	3.805	5.190	4.571	-
Kyushu	5.894	6.144	24.311	3.415+	2.752*	1.412+	3.081*	4.897	5.640	2.210+
Ainu	11.407	13.216	21.902	9.201	6.872	4.643	4.367	6.613	5.783	5.295
Ryukyu	6.412	4.429	17.711	3.816*	6.661	3.181	1.445+	2.444	2.296*	4.206
Jomon	15.040	13.163	22.047	9.907	8.498	7.631	5.301	5.196	5.347	7.053
Camb/Laos	14.023	12.459	20.242	9.919	14.202	11.533	15.547	14.831	13.591	16.472

Table 12.4 Mahalanobis' Generalized Distances and Level of Significance for 53 Male Groups Using 29 Cranial Measurements [All Distances are Significant at 1% Level When Variance Ratios are Tested Unless Otherwise Indicated:* = Significant at 5 % Level; † = Not Significant]

Group	MAN	ANY	MOG	KOR	KAN	EDO	KAM	KOF	YAY	TOH
Thailand	10.490	9.465	20.102	5.668	6.587	6.962	12.698	9.643	10.048	11.254
Vietnam	8.886	7.725	18.703	4.624*	7.331	4.951	7.802	6.890	6.762	7.919
Bachuc	12.402	10.284	25.776	7.162	10.390	9.002	14.728	12.605	13.154	13.351
Sulawesi	9.242	9.024	15.264	6.008	10.044	7.098	9.974	8.369	7.998	11.103
Sulu	14.800	14.162	20.917	10.668	13.458	10.491	13.697	13.468	12.394	14.726
Philippines	10.066	7.635	19.539	5.492+	10.489	7.202	10.685	10.121	9.718	10.904
L.Sundas	9.790	10.392	22.027	8.428	9.692	5.317	7.556	9.123	9.474	9.732
Borneo	11.426	9.911	20.324	7.654	9.869	6.916	7.343	8.462	8.052	9.346
Java	11.287	10.899	20.006	7.786	11.332	8.444	12.052	11.234	10.814	13.254
Easter Is.	20.317	19.455	35.542	20.485	21.083	15.946	14.330	20.621	21.220	18.523
Hawaii	15.588	16.821	21.790	13.591	15.397	12.015	14.516	14.395	15.042	18.335
Marquesas	13.236	16.394	25.251	15.480	16.863	11.554	13.478	14.668	15.091	15.590
New Zealand	13.743	14.016	28.958	14.256	13.061	9.254	10.977	14.801	14.828	12.036
Tahiti	13.807	20.143	34.546	18.297	19.025	13.992	16.153	18.723	19.484	18.483
Guam	16.914	15.221	21.696	13.955	18.133	12.992	14.191	15.703	14.985	18.063
Caroline	14.118	18.897	33.431	17.943	16.529	12.129	16.432	20.498	19.924	16.019
Admiralty	13.986	19.659	27.400	16.896	16.225	12.601	16.102	18.618	16.927	16.634
Vanuatu	24.225	29.358	39.865	28.948	25.201	20.405	21.515	25.294	26.480	25.322
Fiji	18.943	24.433	35.980	23.128	20.400	14.199	16.469	21.490	20.961	18.593
New Britain	22.910	26.780	39.588	26.013	23.101	18.702	19.240	23.566	24.731	23.296
Sepik R.	23.210	27.681	45.255	26.868	23.998	18.765	22.921	29.379	29.007	24.214
Biak Is.	17.966	21.423	35.735	21.000	20.122	13.854	15.547	20.095	20.514	18.025
New Ireland	18.028	24.619	37.243	21.776	19.930	14.340	17.785	21.360	22.100	18.798
New South Wales	31.094	34.847	43.856	32.946	28.265	23.703	27.025	31.674	32.472	29.939
Queensland	30.466	32.106	42.309	31.531	27.454	23.127	25.139	30.228	31.231	29.304
Murray R.	39.981	42.914	52.756	41.880	36.859	32.689	33.671	39.238	40.393	39.449
Tasmania	35.057	38.413	42.349	34.918	28.401	27.323	28.195	30.570	32.242	31.967
N.Territory	34.639	37.649	50.634	36.700	32.648	26.793	29.270	35.176	36.267	34.507

Table 12.5 Mahalanobis' Generalized Distances and Level of Significance for 53 Male Groups Using 29 Cranial Measurements [All Distances are Significant at 1% Level When Variance Ratios are Tested Unless Otherwise Indicated:* = Significant at 5 % Level; † = Not Significant]

Group	KYU	AIN	RYU	JOM	CAM	THI	VTN	BAC	SLW	SUL
Kyushu	-									
Ainu	4.841	-								
Ryukyu	3.477	6.016	-							
Jomon	7.466	4.288	6.069	-						
Camb-Laos	14.374	20.837	12.142	20.706	-					
Thailand	8.344	15.033	8.982	15.600	5.999	-				
Vietnam	7.249	10.993	5.500	11.692	8.215	4.375	-			
Bachuc	10.316	19.896	10.749	19.081	6.747	3.269	5.167	-		
Sulawesi	9.284	13.286	7.112	14.905	2.636+	4.797	6.113	6.432	-	
Sulu	12.831	17.497	11.670	17.745	3.197+	7.526	7.998	6.998	3.648+	-
Philippines	9.849	14.612	7.158	15.941	6.838*	5.805	2.815+	6.241	4.767+	8.068
L.Sundas	7.255	10.681	6.547	15.053	6.573	7.226	5.227	8.777	3.583*	6.003
Borneo	7.828	11.697	6.845	13.161	5.922	7.310	4.948	8.374	3.846+	4.506+
Java	11.006	15.036	9.540	16.695	3.456*	4.549	6.176	5.952	2.463+	4.129
Easter Is.	17.373	16.160	16.741	22.851	23.791	26.405	20.894	29.700	20.549	20.750
Hawaii	14.590	15.016	14.466	18.482	11.516	12.977	13.096	16.436	10.029	8.568
Marquesas	14.527	16.429	15.017	21.297	17.044	19.151	16.238	20.757	13.734	11.707
New Zealand	11.471	14.159	12.544	18.045	14.452	17.669	14.561	20.140	12.071	10.380
Tahiti	15.907	19.368	17.334	25.060	20.166	21.272	19.688	22.291	16.966	15.036
Guam	15.488	19.214	14.473	22.483	11.814	16.700	12.243	19.335	12.062	10.596
Caroline	14.436	20.372	16.602	27.907	13.582	17.040	15.836	18.510	12.526	12.232
Admiralty	16.721	19.472	15.062	24.727	11.859	14.629	10.901	15.909	11.180	8.953
Vanuatu	22.590	25.267	23.661	32.337	22.109	25.886	23.377	30.842	18.463	19.411
Fiji	16.395	18.136	19.170	26.621	19.138	22.027	18.619	23.700	17.034	13.858
New Britain	20.369	22.376	20.550	30.646	20.063	23.351	21.088	28.238	15.873	19.198
Sepik R.	21.043	25.955	22.500	34.855	17.406	21.644	20.025	22.685	16.063	15.216
Biak Is.	15.736	19.796	16.777	27.315	17.820	19.827	15.399	20.257	14.057	12.656
New Ireland	17.101	19.586	18.340	26.770	15.132	19.682	17.115	22.809	13.004	13.742
New South Wales	25.996	25.847	30.434	36.992	25.587	28.532	26.858	32.958	21.675	23.192
Queensland	25.032	26.205	28.591	35.347	23.062	26.990	25.034	31.146	21.513	21.922
Murray R.	33.308	34.062	38.016	45.695	31.811	37.623	37.186	42.412	27.779	29.745
Tasmania	27.613	28.118	31.217	34.584	28.583	29.350	28.861	36.991	24.428	25.598
N.Territory	28.728	30.981	31.792	41.996	25.423	30.805	29.154	32.792	23.116	23.833

Table 12.6 Mahalanobis' Generalized Distances and Level of Significance for 53 Male Groups Using 29 Cranial Measurements [All Distances are Significant at 1% Level When Variance Ratios are Tested Unless Otherwise Indicated:* =Significant at 5 % Level; †=Not Significant]

Group	PHL	LSU	BOR	JAV	EAS	HAW	MAR	NZ	TAH	GUA
Philippines	-									
L.Sundas	5.542*	-								
Borneo	6.736*	3.245+	-							
Java	5.870	4.070	5.179	-						
Easter Is.	21.920	15.665	16.432	24.042	-					
Hawaii	14.512	10.558	11.465	9.823	10.918	-				
Marquesas	18.151	12.671	12.520	17.009	8.710	6.870	-			
New Zealand	14.532	9.047	9.644	15.280	7.644	10.173	3.892	-		
Tahiti	22.398	14.154	16.282	17.619	11.051	9.198	4.429	9.071	-	
Guam	13.946	10.302	10.534	12.101	13.944	7.516	13.096	11.742	15.371	-
Caroline	16.578	7.798	9.730	15.531	10.784	15.403	10.312	6.602	10.373	13.679
Admiralty	12.710	8.095	9.261	10.923	19.778	15.485	12.188	9.499	14.676	19.426
Vanuatu	25.504	10.123	15.061	20.850	24.344	24.891	19.576	13.378	20.846	24.418
Fiji	22.197	8.461	10.926	16.603	14.016	15.664	12.250	9.481	12.577	14.679
New Britain	21.468	7.608	13.744	17.677	21.900	23.965	22.514	14.712	22.008	21.802
Sepik R.	20.173	8.452	13.849	16.825	21.635	23.384	19.731	13.173	18.603	24.866
Biak Is.	16.234	6.275	9.570	15.797	18.093	20.122	13.701	9.343	15.189	19.003
New Ireland	18.302	6.707	11.282	15.104	16.661	18.468	15.385	9.624	15.194	18.992
New South Wales	28.075	11.660	18.364	21.296	29.240	27.371	27.386	20.780	28.190	25.255
Queensland	26.743	11.792	16.500	22.298	24.621	25.774	25.450	18.711	27.590	22.673
Murray R.	38.076	18.215	23.830	29.462	34.221	33.824	33.114	25.861	33.940	30.522
Tasmania	32.145	17.550	21.225	28.308	36.716	31.343	32.292	25.079	38.670	33.715
N.Territory	30.028	12.622	18.872	24.071	27.788	29.124	27.465	20.565	28.032	26.602

Table 12.7 Mahalanobis' Generalized Distances and Level of Significance for 53 Male Groups Using 29 Cranial Measurements [All Distances are Significant at 1% Level When Variance Ratios are Tested Unless Otherwise Indicated:* =Significant at 5 % Level; †=Not Significant]

	CAR	ADR	VAN	FIJ	NBR	SEP	BIK	NIR	NSW	QLD	MRB	TAS	NT
Caroline Is.	-												
Admiralty	9.105	-											
Vanuatu	10.530	13.262	-										
Fiji	5.097†	10.891	7.904	-									
New Britain	9.219	12.810	2.775†	8.478	-								
Sepik R.	6.767	8.856	7.385	8.989	6.959	-							
Biak Is.	5.824*	8.052	5.125	4.225*	5.925	4.986	-						
New Ireland	4.409†	8.622	4.654	5.638	3.401	4.325	4.657	-					
New South Wales	15.689	20.406	6.340	9.778	5.950	11.369	9.945	10.026	-				
Queensland	13.221	19.709	6.101	8.420	6.531	12.423	9.303	9.743	2.259	-			
Murray R.	19.946	27.830	7.794	13.717	7.789	17.175	14.589	14.319	2.861	3.520	-		
Tasmania	24.611	24.632	8.178	18.546	11.250	20.184	15.793	15.464	10.760	8.982	10.713	-	
N.Territory	13.015	19.460	6.251	9.431	5.306	9.123	8.763	8.702	3.264	3.001*	3.263*	13.229	-