ABO BLOOD-GROUP GENE FREQUENCIES IN THE INDIAN SUB-CONTINENT: A STATISTICAL STUDY OF PATTERNS OF VARIATION

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CHAPTER I

INTRODUCTION AND SUMMARY

1.1 The background

The main objective of this thesis is to discover patterns of variation between geographical regions and socio-religious groups in the Indian sub-continent in respect of the distribution of ABO genes controlling the O-A-B-AB blood group system through a comprehensive, unified statistical analysis of all the relevant data available till 1977.

The possibility of using the O-A-B-AB blood groups as a marker for population genetic studies was first discovered by Dr. and Mrs. Hirschfeld in 1919. The data collected by them from army personnel belonging to various population groups showed clear-cut differences and generated a lot of interest among anthropologists. Initially data were obtained from blood-transfusion centres, but, in course of time, anthropological blood-group studies became 'less and less a series of accidental off-shoots of blood transfusion work and more and more a planned and integrated investigation' (Mourant, 1961).

Though Wright (1931, 1940) had earlier regarded the ABO genes as selectively neutral, and later a number of studies established their associations with several diseases (Mourant, Kopec and Domaniewska-Sobczak, 1978), 'a study of populations with a known history suggests that over periods as long as 1000 or 2000 years we can assume that gene frequencies have remained sufficiently near constancy for us to be able to use them for purposes of classification and in tracing relationships between populations' (Mourant, 1959).

A large number of studies have been conducted in different parts of the world (see Mourant, Kopec and Domaniewska-Sobczak, 1976, for a recent compilation), in which the O-A-B-AB blood groups have been utilized for finding similarities and dissimilarities among population groups, and for tracing local population movements, etc. Although a large number of blood-group investigations have been carried out in the Indian sub-continent since 1919, and a vast volume of data have been collected, barring a recent study by Balakrishnan (1978), there has hardly been any comprehensive statistical analysis of the data. This thesis is an attempt to fill this gap.

1.2 The structure of the thesis

The thesis has been organized in eight chapters, a list of references and an appendix. In the first chapter a general introduction to and a summary of the thesis has been

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given. A short review of the blood-group studies carried out in the Indian sub-continent till 1977 has been given in the second chapter. In the third chapter the data - an identification code, maximum likelihood estimates of ABO gene frequencies and results of statistical tests for conformity with Hardy-Weinberg random-mating hypothesis for each of 899 data sets - have been presented. In chapter four, the statistical procedures used in this analysis have been described. In the fifth chapter, a preliminary analysis of the data has been attempted, using graphical representations and chi-square tests to assess the magnitudes of variation between and within geographical zones and socio-religious categories. In chapter six, the technique of single-linkage cluster analysis has been used to form 'rational homogeneous clusters' out of these data sets, which have then been grouped into statistically homogeneous 'super-clusters'. The resemblances amongst these superclusters have been represented by means of a dendrogram. In chapter seven, an analysis of the reduction in heterogeneity of ABO gene frequencies within geographical zones upon a consideration of micro-locational variation (in terms of latitudes and longitudes of the places of sampling) has been made. In the final chapter, the problem of finding the directions of maximum and minimum variation of ABO gene frequencies within geographical x socio-religious subsets has been considered. The basic data - names of population groups, locations of sampling, sample sizes, O-A-B-AB blood group frequencies and the sources of the data - have been presented in the appendix.

1.3 The data

The data considered for the present analysis were collected from published reports, papers and also from unpublished sources through correspondence, with an attempt to cover exhaustively all substantive ABO blood-group studies carried out upto 1977, relating to what can be broadly described as the Indian sub-continent. In all, a total of 899 data sets covering 222,764 individuals were compiled for this study.

Each data set was initially identified by a five-digit code: the first two digits being the serial number of the 'area' from where the data had been collected, the areas having been arranged alphabetically, and the last three digits being the serial number of the data set within the area, arranged in chronological order of the study. The basic data, giving the identification code, population group, specific location, sample size, phenotype frequencies and source have been presented in Appendix 1. In Table 3.1 the names of the 'areas' and the area-wise distribution of the data sets and individuals have been presented. Maximum likelihood estimates of the ABO gene frequencies p, q, r together with their standard errors, the D/σ

statistic for measuring the deficiency of AB phenotype frequency from that expected under random mating and the chi-square statistic χ^2_{HW} for testing goodness-of-fit of the Hardy-Weinberg random mating model have been presented in Table 3.2.

For examining the pattern of variation, the data sets have been corss-classified in two ways: into six geographical zones - Northern, Eastern, Southern, Western, Central and Himalayan - more or less in accordance with the recommendations of the National Atlas Organization, and again into ten socio-religious categories - Hindu: Upper Castes, Middle Castes and Lower Castes, Muslims, Christians/Anglo-Indians, Parsees, Tribals: Australoid, Mongoloid, Caucasoid and Negrito. In Tables 3.4 and 3.5 the allocations of the data sets into the geographical zones and socio-religious categories have been presented.

1.4 The statistical methods used

The statistical methods used in analysing the data have been described in chapter four. Except for certain innovations, most of the methods used are standard.

Maximum likelihood estimates of the gene frequencies and their asymptotic dispersion matrix have been computed using an iterative procedure based on the method of scoring due to Rao (1952). The standardised 'deficiency' statistic D/σ has been used to examine the deficiency of the phenotypic frequency of AB blood-group from the frequency expected under the Hardy-Weinberg random mating model. The goodness-of-fit chi-square statistic χ^2_{HW} with one degree of freedom has been used to examine the general agreement of phenotype frequencies with the model.

The estimated gene frequencies $(\hat{p}, \hat{q})$ have been presented graphically on the triangular chart (Li, 1955), together with elliptical confidence regions defined as the set of points (p, q) satisfying

$$n\left\{\hat{I}_{pp}(p-\hat{p})^2 + 2\hat{I}_{pq}(p-\hat{p})(q-\hat{q}) + \hat{I}_{qq}(q-\hat{q})^2\right\} < -2\log_e(1-\alpha)$$

where n is the sample size, $\hat{I}_{pp}$, etc., denote the estimated information matrix per unit observation and α is the confidence coefficient. This geometrical representation is useful for a preliminary examination of the nature of variability in the gene frequencies. The significance of this variability was examined by means of the standard chi-square test of heterogeneity.

It is, however, important to point out that because hypotheses were formulated and tested on the basis of the same empirical data, traditional probabilistic interpretations of standard statistical tests are not strictly valid.

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The main technique used for discovering similarities and dissimilarities among population groups is the technique of cluster analysis. The distance function used for this purpose is

$$d = \arccos\left(\sqrt{p_1p_2} + \sqrt{q_1q_2} + \sqrt{r_1r_2}\right)$$

between two populations with ABO gene frequencies (p_1, q_1, r_1) and (p_2, q_2, r_2). This distance measure is due to Bhattacharyya (1946) and is based on a geometrical representation of the two population groups as points with co-ordinates $(\sqrt{p_1}, \sqrt{q_1}, \sqrt{r_1})$ and $(\sqrt{p_2}, \sqrt{q_2}, \sqrt{r_2})$ on the unit sphere and the distance is defined as the angle subtended by these two points at the centre of the unit sphere. The measure has several desirable asymptotic properties too (Bhattacharyya, 1946).

Although there are several clustering algorithms, for the present study the single-linkage method was adopted because this is computationally the simplest and has several optimal properties (Sibson, 1972).

Subsets of population groups, the so-called 'clusters' have then been formed in such a way that, loosely speaking, those belonging to a cluster are nearer to each other in terms of the distance given above than those which belong to different clusters. A geometrical representation showing how the population groups have been combined to form clusters at different

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stages, indicating at each stage the distance at which they were combined, is called a dendrogram, and in this thesis most of the dendrograms have been represented through linear lists. Statistically homogeneous clusters have been identified by performing chi-square tests at the different nodes of agglomeration in a dendrogram. The entire procedure of cluster analysis - computing the distance matrix, constructing the dendrogram, representing it as a linear list and identifying statistically homogeneous clusters - have been explained in detail in section 4.7 by considering the 21 Upper Caste population groups of the Western zone.

In section 4.8, the procedure for least squares estimation of the parameters of the model

$$p_{ij} = p_i + \delta_{pT}.T_{ij} + \delta_{pt}.t_{ij}$$

$$q_{ij} = q_i + \delta_{qT}.T_{ij} + \delta_{qt}.t_{ij}$$

has been presented, where within a socio-religious category p_{ij}, q_{ij}, T_{ij} and t_{ij} denote, respectively, the A and B gene frequencies and the latitude and longitude of the j-th data set belonging to the i-th geographical zone ($i = 1,2,\ldots,k$, $j = 1,2,\ldots,n_i$).

In order to study the direction of maximum variation of ABO gene frequencies, it is necessary to determine constants a and b such that the variability of $\lambda = ap + bq$ measured in terms of the appropriate chi-square statistic is maximised. The algebra for carrying this out has been presented in section 4.9, which is analogous to that of finding the principal components in multivariate analysis.

1.5 Preliminary analysis

A preliminary analysis of the data has been carried out in chapter five. The first step was to check the quality of the basic data by examining the distribution of the D/σ and the χ^2_{HW} values computed for each data set. If random-mating prevails, the distribution of D/σ should be standard normal, and that of χ^2_{HW} should be the chi-square distribution with one degree of freedom. Departure of the observed distribution from these indicate not merely departures from random-mating, but on closer analysis may reveal systematic errors in sampling or blood-typing in the laboratory.

The frequency distribution of D/σ values has been computed separately for four subsets: (i) data published upto 1950, (ii) data published between 1951 and 1960, (iii) data published between 1961 and 1970, and (iv) data published after 1970, and each was compared with the standard normal distribution.

It is interesting to note that significant departure from normality has been found in the last two groups and, in general, large values of D/σ has been more frequent than expected indicating AB-deficiency.

The observed frequency distribution of χ^2_{HW} values has been found to be significantly different from the chi-square distribution with one degree of freedom, there was a great excess of large χ^2_{HW}-values but not so much of an excess of small values. This indicates the possibility of real departures from random-mating in some of these population groups, but rules out the suspicion of data being smoothed to conform to the random-mating model.

Graphical analysis of the data has then been carried out through representation of the estimated gene frequencies on triangular charts together with their confidence regions to examine the variation between population groups within geographical zones as well as within socio-religious categories. Wide variability within both these classifications has been evident, later sustantiated through chi-square tests of homogeneity. For the purpose of using the chi-square test and subsequent analysis only those data sets (405 in all) where the sample size was greater than 100 and the χ^2_{HW} was not significant have been used.

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These 405 data sets have then been cross-classified in two-ways into geographical (6) x socio-religious (10) subsets. Of these 60 subsets, only 32 have been found to be non-empty. Chi-square tests have been carried out to test the homogeneity of the population groups within each of these 32 subsets. The hypothesis of homogeneity has not been rejected only in 12 of the subsets at the 1% level of significance. One subset contained only one data set and there was no question of heterogeneity there, but the remaining 19 were significantly non-homogeneous.

1.6 Cluster analysis

The technique of cluster analysis has then been used to partition each of the 19 heterogeneous geographical x socio-religious subsets into statistically homogeneous subsets. Using the procedures described in section 4.7, these 19 subsets have been partitioned into 93 homogeneous clusters. Including the 13 homogeneous subsets, the 405 data sets have thus been grouped into 106 (= 13+93) 'rational homogeneous clusters' (RHC's), which are homogeneous not only in respect of ABO gene frequencies, but also geographical location and socio-religious criteria. The compositions and the combined gene frequencies of the 106 RHC's have been presented in Table 6.2

The RHC's formed the starting point of the next stage of the present analysis. Since the RHC's were formed only within the two-way classified geographical x socio-religious subsets, in order to find similarities among the RHC's belonging to different subsets, cluster analysis has been performed once again. Using the combined estimates of ABO gene frequencies of RHC's 'superclusters' (consisting of RHC's) have been formed, which are again such that the RHC's belonging to each super-cluster are statistically homogeneous in respect of the gene frequencies of the RHC's. It is to be noted that the super-clusters may not generally be homogeneous in respect of geographical location or socio-religious criteria. The structures of the superclusters have been presented as linear lists in Table 6.3.

A third application of the technique of cluster analysis yielded the final dendrogram describing the resemblances among the superclusters. This has been presented in Figure 6.1.

The compositions of the rational homogeneous clusters and superclusters has been found to be generally in accordance with the available ethnohistorical evidence.

1.7 Micro-geographical variation

Compared to the entire Indian sub-continent, the geographical zones apart from being relatively more uniform spatially are also ecologically quite homogeneous. The reduction in heterogeneity within socio-religious categories upon a cross-classification by geographical zones, therefore, not only represents the effect of spatial variation at a macro-level, but also the effects of macro-ecological variation. There is, however, a large amount of spatial variation even within a geographical zone. It is, therefore, of interest to examine whether a consideration of micro-geographical variation within a zone further helps in reducing the heterogeneity of ABO gene frequencies. This problem has been dealt with in chapter seven. The micro-geographical variation has been studied by considering the latitudes and longitudes of the locations of sampling. Thus, for this analysis, fitting of the following model has been tried:

$$p_{ij} = p_i + \delta_{pT}.T_{ij} + \delta_{pt}.t_{ij}$$

$$q_{ij} = q_i + \delta_{qT}.T_{ij} + \delta_{qt}.t_{ij},$$

where, within a socio-religious category, p_{ij}, q_{ij}, T_{ij} and t_{ij} denote respectively, the A and B gene frequencies and the latitude and longitude of the location of sampling for the j-th data set belonging to the i-th geographical zone ($i = 1,2,\ldots,k$, $j = 1,2,\ldots,n_i$). This analysis revealed that the δ-values are generally significant for all socio-religious categories except the Upper castes, which indicates that, in general, the consideration of micro-geographical variation within zones is useful in a further reduction of the variation in gene frequencies. It was, however, also seen that although the amount of heterogeneity explained by classifying data sets into macro-geographical categories (zones) were rather high, the further reduction in heterogeneity brought about by the consideration of micro-geographical variation were generally rather low. It must, however, be mentioned that the conclusions of this analysis should be considered as tentative since the number of data sets that could be included for this analysis was not large; the exact locations of sampling were available for only 252 data sets.

1.8 Directions of maximum and minimum variation of ABO gene frequencies

When the A and B gene frequencies of a set of population groups had been plotted on a two-dimensional plane, in many cases a large amount of variability was observed. It was then considered pertinent to ask whether this large variability could be explained in terms of variation in any one particular direction. Thus, within heterogeneous geographical x socio-religious subsets directions λ_1 and λ_2 have been found, where each λ is a linear compound of the A and B gene frequencies of the form ap + bq, and λ_1 is the linear combination which has the maximum variability between the populations and λ_2 the smallest variation. The proportion of the total heterogeneity explained by the linear combination λ_1 has also been computed for each subset. The results of this analysis have been presented in Table 8.1

of chapter eight, from which it has been seen that for most cross-classified subsets the variation appears to be spread all over the two dimensional plane and not much of it can be ascribed to variation in any single direction. Among the Mongoloid tribal groups of the Eastern and Himalayan zones, however, the percentage variation explained by λ_1 has been found to be greater than 80%.

1.9 Main findings of the thesis

The present study is the first comprehensive statistical analysis of all the ABO blood group data that have so far been collected from the Indian sub-continent. In all, 899 data sets have been used for this study.

A preliminary graphical examination of the data indicated wide variability in all geographical zones and most socio-religious categories. Data sets (405 in all) conforming to the random-mating model and with sample size greater than 100, were then subjected to a chi-square test of homogeneity of gene frequencies, which confirmed that all geographical zones and all socio-religious categories, excepting the Parsees and Negrito tribals, are indeed heterogeneous in respect of ABO gene frequencies. The preliminary statistical tests also suggested the possibility of the existence of certain laboratories in India where the blood-group data generated may not be very reliable.

Chi-square tests of homogeneity performed within the 32 non-empty geographical x socio-religious subsets showed that the following 13 subsets are homogeneous in respect of ABO gene frequencies: Northern Muslims (N-MU), Northern Australoid tribes (N-AT), Eastern Upper Castes (E-UC), Eastern Muslims (E-MU), Eastern Negrito Tribes (E-NT), Southern Upper Castes (S-UC), Western Muslims (W-MU), Western Parsees (W-PA), Central Upper Castes (C-UC), Central Muslims (C-MU), Central Australoid Tribes (C-AT), Central Mongoloid Tribes (C-MT) and Himalayan Middle Castes (H-MC).

Thus it is seen that though the Muslims when considered all over the sub-continent are highly heterogeneous, when sub-divided into geographical zones, they are homogeneous in the Northern, Eastern, Western and Central zones, though not in the Southern zone. The Upper caste Hindus are homogeneous in the Eastern, Southern and Central zones, but not in the Northern and Western zones. Australoid tribes are homogeneous in the Southern and Central zones, but not elsewhere. Mongoloid tribes are homogeneous in the Central zone, but not anywhere else. Middle caste Hindus are homogeneous only in the Himalayan zone.

The technique of cluster analysis performed within each of the 19 heterogeneous subsets revealed that five of these subsets were 'largely homogeneous' in the sense that if only one or two population groups were excluded from these subsets, they turned out to be homogeneous. These are:

Northern Upper castes (N-UC), Northern Middle castes (N-MC), Eastern Middle castes (E-MC), Eastern Australoid tribes (E-AT) and Central Middle castes (C-MC).

Cluster analysis also revealed that the population groups of the Indian sub-continent can be classified into 106 groups in such a way that these groups are not only homogeneous in respect of ABO gene frequencies, but also geographical location and socio-religious criteria. Also, from a purely statistical standpoint, the Indian populations can be grouped into at most 42 classes, in such a way that the populations belonging to any one of these groups are statistically homogeneous in respect of ABO gene frequencies.

A consideration of micro-locational variation within geographical zones does not seem to bring about a substantial reduction in the heterogeneity of ABO gene frequencies.

For most of the cross-classified categories, the variation in ABO gene frequencies appears to be spread all over the two-dimensional plane and not much of it can be ascribed to variation in any single direction. The Mongoloid population groups of the Eastern and Himalayan zones are, however, exceptions to this general finding.

CHAPTER II

REVIEW OF BLOOD GROUP STUDIES IN INDIA

2.1 The pioneering studies (1919-1930)

Blood group investigations in India started with the Hirschfelds (1919) who, during World War I, examined a large number of soldiers, including Indians. They found a very high frequency of B blood group among Indian soldiers. The Hirschfelds did not publish the data separately caste-wise, but pooled the data of Gurkhas, Garowalis, Jats, Kumaons, and Rajputs with that of lower caste people from all over India, who were in the Labour Transport Corps, and reported this pooled data as 'Indians'. This body of data brought out a striking fact regarding the blood group composition of Indian soldiers - the percentage of B blood group was exceedingly high. The classical Hirschfeld data were the first landmark in blood group studies in India, and it prompted serologists to initiate investigations to confirm and find out reasons for the high B blood group incidence in India.

In the decade succeeding the study by the Hirschfelds, only one study was published. Bais and Verhoef, reported data on Tamil coolies working in tea gardens in Sumatra in 1927. The samples were very heterogeneous and belonged to several low-caste groups of South India and Ceylon.

In 1929, Malone and Lahiri published data on more than 2000 people drawn from different parts of the country. These investigators presented data on three racial types - three out of the six racial types of Risley (1915) - Turko-Iranians (represented by Baluchis, Hazaras and Pathans), Indo-Aryans (represented by Jats, Khatris and Rajputs) and Dravidians (represented by Mundas, Santhals and Uraons). Apart from these, they also presented data on a pooled sample of 'Hindus' drawn from various castes of United Provinces. Most of these data were collected from Indian troops stationed at Quetta or from patients attending the Pasteur Institute, Kasauli. The study of Malone and Lahiri was a big step forward in blood group studies in India. It showed, for the first time, that among castes belonging to the same geographical region, there are large differences in the blood group frequencies. It also confirmed the preponderence of B blood group in several regions of India. Malone and Lahiri also indicated that the frequencies of both A and B tend to diminish (and, naturally, that of O tends to increase) from the Ganges Valley upwards to the North West Frontier of India.

2.2 Studies published between 1930 and 1940

Chaudhuri (1931) collected data on 154 Bengalis, but this included family members, and hence the 154 samples cannot be taken as independent. This fact was pointed out, for the first time, by Chatterji and Mitra (1941-'42), who also made an attempt to 'correct' the data. These authors listed 'the total of 30 families, that is, 60 parents ... with considerable hesitation, there being no information that sibs are not included' (Chatterji and Mitra, 1941-'42).

In an attempt to find out if blood group has any influence on the incidence of disease, Mitra (1933) published data on 2000 persons of Dibrugarh (Assam). These individuals included both healthy and sick at a hospital as out-patients or admitted cases. The former composed chiefly of medical students. These data were also not kept caste-wise. Of course, in a later paper, Mitra (1935) stated that 'on the whole the population dealt with might be taken as a fair sample of the population of upper Assam although many of the students will have come from other areas'.

During the rest of the thirties, a number of useful studies were conducted. Apart from the work done by the British Association Research Committee on Blood groups Among Primitive Peoples (1939) in the Naga Hills, Assam, most of the remaining studies were through individual efforts. During a health investigation, Pandit (1934) collected data on Todas of Nilgiri Hills. From South India, Aiyappan (1936, 1939) collected data on tribal pre-Dravidians (Paniyans) and Nayadis. Apart from the data collected by the British Association from Assam, Mitra (1936) collected data on Angami, Naga and Lushai tribes, and Basu (1938) on Khasis. Blood grouping was also done on a group of Tibetans in Gyantse by Gates (1936). During this decade, two review articles also appeared (Sarkar, 1937 and Macfarlane, 1938). Sarkar's article also contained fresh data from the Santal Parganas in Bihar, which he compared descriptively with data published earlier. Macfarlane's (1938) review was with special reference to Bengal. She republished all the ABO blood group data published upto 1938. For each population group she plotted the histograms of A and B gene frequencies and also calculated the 'serological values' of the difference between the incidence of A and B blood groups. From these computations she made the following observations :

> The percentages of both A and B blood groups in lower Bengal increase from the higher to lower castes,
>
> The highest percentage of O blood group in lower Bengal is among the caste Hindus,
>
> The Bengali 'depressed classes' have the highest percentage of B yet found in India. (It is to be noted that the group 'depressed classes' is an extremely heterogeneous group comprising several lower-castes.)
>
> The Bengali Mohammedans have a blood group distribution similar to that of their low-caste Hindu neighbours,
>
> The only peoples of India thus far discovered to have more A than B are the Nairs and lower castes of Cochin and the pre-Dravidians (Veddoids) of the south-west,
>
> There is very little B in Cochin because the Malabar coast has been missed by the migratory movements from further north in the past. Here there is more B in the higher castes who have some northern admixture than among the lower castes who came from the south,

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The B gene has been in India for millenia and may have originated in the ancestors of the lower castes of the north-east, whence it has diffused into the higher castes. The amounts of O and B vary inversely, therefore, there may be genes for O in these low castes with a relatively high mutation rate for B.

2.3 The period : 1940-1950

The next decade witnessed a lot of activity. Data were collected on the serological status of several population groups from different parts of India. In many of these studies the data were gathered from Blood Transfusion Service records (Greval and Chandra, 1940), hospital records (Reddi, 1943b), blood-bank records (Reddi, 1943a), etc.

Three comprehensive studies were also carried out by D.N. Majumdar during this decade. In connection with the Census operations of 1941, Majumdar conducted a racial survey of the United Provinces, between 1941 and 1943. During this period he studied the serological status of more than 4000 individuals belonging to 19 caste and tribal groups and two heterogeneous groups of students of the United Provinces. An analysis of these data (Majumdar and Kishen, 1947) revealed that the caste and tribes examined were heterogeneous in respect of the p gene frequency. A correlation of blood groups with social status was also found, and the serological findings were in close correspondence with the anthropometric. The results of the U.P. Survey raised great hopes among both anthropologists and statisticians, and at the instance of Prof. P.C. Mahalanobis, and the Indian Statistical Institute, Calcutta, a racial survey of Bengal, on lines similar to those of the U.P. Survey, was carried out by Majumdar in 1945. The other important study conducted by Majumdar during this decade was a similar survey in Gujarat. Twentytwo castes and tribes were examined in Kathiawar and Cutch with respect to their somatology and serology. An analysis of these data is presented in Majumdar and Kishen (1948). In contrast to Macfarlane's (1938) finding that the Muslims of Bengal are close to the low-caste groups in respect of the distribution of ABO blood groups, Majumdar and Kishen (1948) found that the Muslims of Gujarat show close resemblance to the high-caste groups, particularly the Luhanas, Bhatias and Brahmins. This contrasting finding is not surprising in view of the fact that the Muslims of Bengal are mostly converts from the low-caste groups (Sarkar, 1954), while the upcountry Muslims have resulted from the intermixture between the immigrant Muslims (e.g. Baluchis) and higher Hindu castes (Majumdar and Kishen, 1948). Apart from these studies which were conducted with the intention of collecting fresh data from population groups, two review articles were also published by Macfarlane and Sarkar (1941) and Chatterji and Mitra (1941-'42). Macfarlane and Sarkar (1941) compared descriptively the existing blood group data in samples of over 100 persons from 12 aboriginal tribes of India. They discovered a general increase in the frequencies of A and B genes from the south towards the north and in blood groups B and AB from east to west across central India. They also suggested that there may have been two original racial stocks in India, one resembling the Paniyan or Māler with little B, and the other resembling the Oraons, with low A frequency and high B frequency. The Santals and related Mundari speaking peoples possibly entered India later. In Chatterji and Mitra's (1941-'42) study, like that of Macfarlane's (1938), the focus of attention was Bengal. These authors analyzed the distribution of Bengali blood groups with the following objectives in view :

To determine whether any stratification is noticeable in the castes in respect of this character,

To determine if the blood groups are distributed in the same frequency uniformly throughout the country, and the same stratification is present everywhere,

To determine whether blood group distribution is similar and the groups appear in the same frequency in the neighbouring provinces as in Bengal,

To determine whether the Bengalis are differentiated in any way from the aboriginal and Mongolian tribes.

It may be mentioned here that most of the above mentioned hypotheses formulated by Chatterji and Mitra (1941-'42) stemmed out of Macfarlane's (1938) study. Upon a critical examination (mainly descriptive) of the data, Chatterji and Mitra (1941-'42) arrived at the following conclusions :

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The evidence for a general stratification of ABO blood groups is not convincing, although the 24-Parganas population showed some stratificational difference in respect of the O gene frequency,

The blood groups are not distributed in the same frequency even throughout Bengal,

Bengal, or at least south-west Bengal, appears to form a part of a zone of high B concentration, which seems to embrace the Gangetic plains of north India,

The aboriginal groups show considerable divergence among themselves in respect of blood groups.

Apart from these conclusions, Chatterji and Mitra (1941-'42) also strongly criticized Macfarlane's (1938) contention that the blood group B originated in the ancestors of a certain (depressed) section of the population of north-eastern India on the grounds that the existing data to substantiate this are extremely scanty, and that the grouping 'depressed class' is artificial and heterogeneous. This study also pointed out the need for data from different parts of India. Sarkar (1942) analysed the Indian blood group data with special reference to the Oraons. The analysis revealed that there are 'two centres of A concentrations, one in the south and the other in the north-eastern frontier, whereas B appears to be a sort of wedge driven in between them'.

In 1949, Sanghvi and Khanolkar conducted an interesting genetical study in and around Bombay. They selected six endo-gamous groups of Maharashtra whose physical characters were

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studied previously by others. The purpose of their study was to compare their conclusions derived on the basis of physical measurements with those reached on the basis of blood groups and other genetical characters. They found that some of the groups which had previously been classified under the same 'physical type'/'race' differed significantly among themselves in respect of genetical characters.

2.4 Studies published between 1950 and 1960

During the following decades, a large number of anthropologists from all over India took an active interest in gathering serological data of population groups. In 1951 was published a comprehensive anthropometric, somatoscopic and serological study of Maharashtra (Karve and Dandekar, 1951). In this survey, data were collected from a large number of castes and tribes from all over Maharashtra. ABO blood group data were collected from a total of 60 castes and tribal groups. An analysis of those data showed that there were significant differences in gene frequencies between the various groups. Some clusters of population groups possessing similar gene frequencies were also discernible, but the pattern of clustering was very haphazard - groups with no apparent ethnological affinity were often included in the same cluster. The clusters obtained on the basis of ABO gene frequencies also did not correspond with those obtained on the basis of anthropometric data. It may be mentioned that the clusters obtained on the basis of anthropometric observations generally were in concordance with ethnological data. Because of these facts, Karve and Dandekar (1951) felt that 'blood group data are of little value in discovering caste configurations within Maharashtra'. It should, however, be mentioned that the sample sizes for the population groups included in their study were very small - only 8 of the 60 populations studied were represented by samples of size greater than 50. The gene frequencies calculated on the basis of such small sample sizes may be subject to large sampling errors, which are possibly reflected in the non-correspondence of the clusters obtained through serological and anthropometric data. It may be mentioned here that Majumdar and Kishen (1947 and 1948) had noted a close agreement between serological and anthropometric findings in the U.P. and Gujarat surveys.

In 1951-'52, Majumdar and Bahadur republished the 99 sets of data that were collected till then. They indicated the following defects in the papers published on blood groups in India :

> Full and complete details about ethnic groups tested, where they live, and how the samples were selected, are not given,
>
> Often when the investigation is carried out in one locality on more than one cultural or ethnic group, the data are not presented separately for each,

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Often cumulative data are published, without mentioning about the previous publications,

Percentage values of phenotypes often do not add up to 100,

There is no systematic method of publishing the data - sometimes actual numbers of observed phenotypes are given, sometimes only percentage frequencies, without any indication of the sample size.

It should be mentioned that little attention was paid by later workers in rectifying these defects, and many of these persist even till today. Majumdar and Bahadur (1951-'52) made an analysis (mostly descriptive in nature) of all these data and drew a map of ABO clines. Their major conclusions were as follows :

High B gene frequencies are found in the Proto-Australoid groups of south India, while this gene frequency is low in central India,

Maha Gujarat, comprising Gujarat, Cutch and Kathiawar, has groups with higher percentage of B than those for central India,

Most of the U.P. groups, except the tribal groups of Mirzapur, have high values of B. The range extends to the groups of the cis-Himalyan region,

The population groups of Orissa and Bengal, in general, have a high frequency of the B gene,

The Assam tribes like the Nagas, Lushais and Konyaks, have very low percentage of B.

In 1958, was published the report of the Bengal anthropometric survey (Majumdar and Rao, 1958) which, as has been mentioned earlier, was carried out by D.N. Majumdar in 1945 under the auspices of the Indian Statistical Institute, Calcutta. During this survey, serological data were gathered on more than 2000 individuals belonging to 10 population groups of Bengal (including both west and east - now Bangladesh). An analysis of the data showed that there were considerable differences in the incidence of ABO blood types among these population groups. The Brahmins of Bengal have a lower incidence of A than is obtained among the Brahmins of U.P. In general, the B gene frequency is found to be rather high in Bengal.

The Bengal Anthropometric Survey report also contained a statistical assessment by C.R. Rao of some of the existing data on the ABO blood groups of Bengalees. In all, Rao examined 33 sets of data. From the shape of the empirical distribution of Hardy-Weinberg goodness-of-fit chi-square values for these sets of data, he concluded that in many of the studies random sampling scheme had not been followed. He had also found significant investigator differences in the case of Brahmins and Baidyas. It ought to be mentioned, however, that although Rao attributed significant differences in gene frequencies for a particular population group to investigator differences, actually, however, both investigator differences and geographical differences were confounded. He also indicated that differences between caste groups and tribals seem to exist, with tribals having a lower frequency of the O gene and somewhat higher frequency of the B gene.

N.T. Mathew, working on the relationship between stature and blood groups, published a large series of data in 1959. He collected the data from soldiers of the Indian army. He, however, failed to classify all his data by endogamous group, and blanket identities like Assamese, Andhras, etc., were used in several cases. Moreover, for several groups studied the sample sizes were less than 20. In any case, this paper did contain a good amount of serological data from several parts of India.

During this period individual efforts of several anthropologists have added a great deal to the Indian blood group data. Of these, the studies of S.S. Sarkar and P.N. Bhattacharjee deserve special mention. Both these anthropologists travelled far and wide to collect blood group data. Sarkar, for the first time, collected blood group data from Andaman and Nicobar Islands in 1952. During this period, he also collected data from Bengal (Sarkar et al., 1953), Bihar (Sarkar, 1949, 1954, etc.), Kerala (Sarkar, 1954), Madhya Pradesh (Sarkar, 1950) and Orissa (Sarkar, 1956). Bhattacharjee also collected a lot of data from Bengal (Bhattacharjee, 1956), Assam (Bhattacharjee, 1954), Nagaland (Bhattacharjee, 1957), etc. Two other studies which yielded a good deal of data from Western India may be mentioned. These are by Sanghvi (1954)

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and Vyas et al. (1958). Whereas Sanghvi (1954) collected data on Marathas and Mahars from several regions of Maharashtra, Vyas et al. (1958) reported data on six endogamous groups of Gujarat.

2.5 1960 and the following years

Although serious blood grouping work started in India since the 1940's, about 70% of the existing data have been collected after 1960. Almost all the anthropological laboratories in India which traditionally collected anthropometric data added a new dimension to their work from the early 1960's, and started doing serological work. It is practically impossible to make individual mention of the huge number of studies conducted since 1960. Certain laboratories became very well-established during this period and generated a great deal of serological data. Of these, mention may be made of the Indian Statistical Institute at Calcutta in Eastern India, Cancer Research Centre of the Tata Memorial Hospital and the Blood Group Reference Centre of the Haffkine Institute at Bombay in Western India, and the Anthropological laboratories of the Universities of Delhi and Punjab in Northern India. Even during this period, however, data were collected mainly through the efforts of individual anthropologists/serologists. No serious attempts have been made by anthropological laboratories, or even the

2.15

apex body for conducting and co-ordinating anthropological research in India - the Anthropological Survey of India, to organise collection of serological data on an all-India scale, although Prof. Gates had pointed out long ago that 'the work of blood grouping should be properly organized in different parts of the country' (Majumdar and Bahadur, 1951-52).

During this period a number of review articles were also published (e.g., Bhalla, 1966, Bhattacharjee, 1977, Chatterjee and Mukherjee, 1979, etc.). While most of these articles were descriptive in nature, a few have performed chi-square tests of homogeneity of phenotype frequencies among populations. Although, by the early 1970's a huge amount of data were already available on ABO blood groups from the Indian sub-continent, nobody has attempted a through statistical analysis of the data. A recent study by Balakrishnan (1978) deserves special mention since, to date, this is the most comprehensive statistical study on blood groups from the Indian sub-continent. In this study, Balakrishnan computed genetic distances among 102 selected populations of the Indian sub-continent on the basis of ABO and Rh gene frequencies and also performed a cluster analysis. The main conclusions of his study are :

Most tribal populations stand out distinctly from the non-tribal population,

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The population groups of the Indian sub-continent can be placed in one of the four main ethnic clusters - Caucasoid-Aryan, Caucasoid-Dravidian, Australoid and Mongoloid.

2.6 Some general observations

Before concluding this section, it will be appropriate to briefly review the shifts of emphasis in the ABO blood-group studies of populations in India.

The major shift of emphasis has been in the choice of populations. In the first few decades of blood grouping work in India, as has already been mentioned, data were collected from not-very-well-defined groups, like Indians (Hirschfeld and Hirschfeld, 1919), Turko-Iranians (Malone and Lahiri, 1920), Bengalis, Punjabis, etc. The Indian caste and tribal groups have retained their endogamy inspite of centuries of contact. Moreover, especially due to foreign invasions, there has been admixture in varying degrees and of varying types in the different regions of India. For these reasons, 'it is clear that the ultimate aim should be to treat endogamous units as separate groups and gradually to build up a knowledge of their differences' (Mahalanobis, 1958). Greater realisation of this fact by anthropologists have led to the collection of data from 'properly defined' endogamous population groups.

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The second major shift of emphasis has been regarding the procedures for drawing of samples from populations. In the initial stages of blood grouping work in India, most of the data were collected from hospital records, blood-bank records, etc. Chaudhuri (1931) collected his Kayastha data from family members. In several studies the data were also collected from persons assembled at fairs, markets, etc. Such methods of sampling have several obvious defects. In the case of hospital records, as Rao (1958) has rightly pointed out, 'the correlation of diseases with blood groups, if it exists, would given them a higher representation'. In the case of blood bank records, there are invariably some professional donors, thus resulting in a multiple enumeration of samples. Again, in fairs, markets, etc., people generally assemble from places far and wide. The geographical location and the social status of the samples are difficult to obtain properly in these cases. Realisation of these errors in sampling led workers to become more and more careful while selecting their samples. Because of obvious practical difficulties, however, statistically sound sampling designs are generally impossible to adopt strictly in practice. In fact, perhaps the only serological survey where a rigorous statistical sampling design was put to practice was one among the Santhals of Midnapore district in West Bengal, conducted by the Indian Statistical Institute, Calcutta (Hanurav, 1964). But in any case, care is generally taken to avoid multiple enumeration of samples, related samples, etc.

CHAPTER III

THE DATA

3.1 Description of the data

The data used in the present study were collected from published reports, as well as from unpublished sources through personal correspondence. An attempt was made to cover exhaustively all ABO blood group studies carried out upto 1977, relating to various population groups of the Indian sub-continent - mainland India, Bangladesh, North-West Pakistan, Bhutan, Tibet and Nepal, and the islands of Andaman and Nicobar, Lakshadweep, Amindive and Minicoy, Maldives and SriLanka. Studies based on fewer than 20 observations were excluded from this study, and in a few cases where A_1A_2BO frequencies were available, the sub-classification was ignored.

Each data set was categorised into an 'area' based on the geographical location from where the samples of the study were drawn. These 'areas' generally coincided with the present 'States' of the union of India. There were, however, a few exceptions. West Bengal and Bangladesh, for example, were classified as one 'area'. They constituted one State - Bengal, before 1947, and it was found impossible to partition

3.2

much of the data collected from Bengal into West Bengal and Bangladesh. Because of their geographical separation from mainland India, the islands of Andaman and Nicobar, etc., have been treated as separate 'areas'. The 'areas' were arranged lexicographically, and were given two-digit identification codes. In all, a total of 899 data sets, comprising 222,764 individuals, were compiled for this study. The distribution of the total number data sets among the 'areas' have been presented in Table 3.1.

The basic data included in this analysis have been presented in Appendix 1, in the following format : (1) a serial number, (2) a five-digit identification code of the data set, in which the first two digits denote the 'area' code, and the next three digits is the serial number within the 'area', (3) name of the population group, (4) location of sampling within the 'area', wherever available, (5) the sample size, n, (6) - (9) the percentage frequencies of blood-groups O, A, B and AB, and, (10) the source of the data. It is to be noted that within each 'area' the studies have been arranged chronologically.

3.3

3.2 Gene frequencies and some basic statistics

Since in many of the early publications gene frequencies were not calculated, and because in the later studies no uniform method was followed in calculating gene frequencies, maximum likelihood estimates of the frequencies of genes A, B and O were recalculated for all the 899 data sets, using iterative scoring method, described in section 4.1. The agreement of the observed phenotype frequencies with those expected under Hardy-Weinberg equilibrium was examined for each data set by calculating the D/σ value and the goodness-of-fit chi-square value, χ^2_{HW}. Methods of calculating the D/σ and χ^2_{HW} values have been described in sections 4.2 and 4.3, respectively

The maximum likelihood estimates of A, B and O gene frequencies, their standard errors and the D/σ and χ^2_{HW} values have been presented in Table 3.2 for all the data sets included in this study.

3.3 Classification of the data

3.3.1 Geographical classification . An analysis of the gene frequencies in terms of the 'areas' described in section 3.1 may not be of much value in indicating the nature and extent of geographical variation, since in most cases the 'areas'

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coincide with political States, and political boundaries are generally extremely artificial. Natural/ecological classifications, however, generally cut across boundaries of political or administrative units like States, and in quite a few studies the location is described only in terms of the State where the study area falls. Adopting such a geographical classification would, therefore, entail the discarding of a number of studies. The geographical classification suggested by the National Atlas Organization of the Government of India does not cut across States, and this classification was adopted for this study with some minor modifications. The Indian sub-continent was thus divided into six geographical zones given in Table 3.3 and Figure 3.1, where each zone is identified by a single-letter code.

Mixed samples like 'Hindus', 'Depressed Class', 'Jains and Vaishyas', etc., and those for which the χ^2_{HW} value turned out to be significant at the 5% level were excluded from further analysis. The distribution of the remaining data sets in the six geographical zones have been presented in Table 3.4.

3.3.2 Socio-religious classification . Because of linguistic and cultural differences, the people of the Indian sub-continent are divided into a large number of endogamous

3.5

population groups. Over 3000 such endogamous groups have been identified in India. They can broadly be placed in one of the two categories: (i) groups falling within the Hindu caste system, and (ii) groups falling outside the caste system. The groups falling outside the caste system are the various tribal groups and the religious groups like Muslims, Christians, Parsees, etc. The nature of the Hindu caste-system also allows the caste groups to be arranged hierarchically.

On the basis of anthropological considerations, the population groups were divided into the following ten socio-religious categories (Malhotra, 1978), each shown with a two-letter identification code.

1. Hindu Upper Castes (UC)
   - comprising the Brahmins,

2. Hindu Middle Castes (MC)
   - other than Brahmins and lower castes,

3. Hindu Lower Castes (LC)
   - comprising mostly the Scheduled Castes,

4. Muslims (MU),

5. Christians/Anglo-Indians (CH),

6. Parsees (PA),

7. Tribals - Australoid (AT)
   - found chifly in central and southern India,

8. Tribals - Mongoloid (MT)
   - found mainly in north-east India and the Himalayan region,

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9. Tribals - Caucasoid (CT)
   - found sporadically in southern India,

10. Tribals - Negrito (NT)
    - found mainly in the Andaman islands.

As mentioned earlier, data sets for which the χ^2_{HW} turned out to be significant at the 5% level, and mixed samples were excluded from further analysis. Moreover, because of lack of information, a few population groups could not be classified into any socio-religious category.

The distribution of the data sets into the 10 socio-religious categories has been presented in Table 3.5.

Table 3.1 Arcawise distribution of number of data sets and total sample sizes

'area' code (1)	'area' (2)	no. of data sets (3)	total sample size (4)
01	Andaman and Nicobar Is.	11	1718
02	Andhra Pradesh	45	15314
03	Assam	26	8305
04	Bengal (West Bengal and Bangladesh)	75	22726
05	Bhutan, Tibet and Nepal	30	6863
06	Bihar	44	15250
07	Goa	10	1832
08	Gujarat	42	6485
09	Jammu and Kashmir	14	3869
10	Karnataka	10	2559
11	Kerala	50	5597
12	Lakshadweep Is.	1	113
13	Madhya Pradesh	46	5483
14	Maharashtra	137	21383
15	Maldive Is.	1	211
16	Nagaland	12	2108
17	North-West Pakistan	10	1493
18	Orissa	51	8750
19	Punjab, Himachal Pradesh, Haryana and Delhi	93	43176
20	Rajasthan	10	5453
21	Sri Lanka	22	10910
22	Tamilnadu	63	14389
23	Tripura	7	1195
24	Uttar Pradesh	89	17282
	total	899	222764

Table 3.2 Maximum likelihood estimates (± s.e.) of ABO gene frequencies, D/σ and χ^2_{HW} values for population groups of the India sub-continent

Cumulative sl.no.	Identification code: Area	Identification code: Sl.no. within Area	maximum likelihood estimates ± s.e.: p	q	r	D/σ	χ^2_{HW}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	01	001	0.540±0.075	0.091±0.007	0.368±0.066	-0.5325	0.29[illegible]
2	01	002	0.440±0.089	0.225±0.011	0.335±0.060	1.2792	1.614
3	01	003	0.019±0.008	0.053±0.000	0.929±0.008	0.5360	0.288
4	01	004	0.243±0.032	0.334±0.004	0.423±0.017	-0.6204	0.392
5	01	005	0.123±0.022	0.261±0.002	0.615±0.015	1.2799	1.607
6	01	006	0.119±0.031	0.035±0.001	0.846±0.030	-0.8100	0.648
7	01	007	0.039±0.008	0.070±0.000	0.890±0.007	-0.1696	0.029
8	01	008	0.054±0.016	0.043±0.000	0.904±0.016	0.6962	0.484
9	01	009	0.169±0.012	0.245±0.001	0.586±0.008	0.1068	0.013
10	01	010	0.073±0.018	0.207±0.001	0.720±0.013	-0.3569	0.128
11	01	011	0.020±0.007	0.036±0.000	0.944±0.007	0.5519	0.305
12	02	001	0.129±0.028	0.291±0.002	0.580±0.018	0.8894	0.776
13	02	002	0.258±0.033	0.139±0.003	0.603±0.028	-0.3834	0.148
14	02	003	0.138±0.039	0.224±0.003	0.638±0.028	0.5127	0.260
15	02	004	0.084±0.030	0.330±0.002	0.586±0.017	1.1971	1.393
16	02	005	0.225±0.019	0.196±0.002	0.579±0.014	-1.1927	1.443
17	02	006	0.158±0.023	0.194±0.002	0.648±0.018	0.0953	0.010
18	02	007	0.118±0.014	0.253±0.001	0.629±0.010	0.6728	0.450
19	02	008	0.137±0.014	0.181±0.001	0.682±0.011	-1.1736	1.374
20	02	009	0.133±0.003	0.203±0.000	0.665±0.003	1.8148*	3.283
21	02	010	0.137±0.018	0.249±0.001	0.614±0.013	-0.2277	0.052
22	02	011	0.188±0.018	0.297±0.002	0.515±0.011	-0.7264	0.533
23	02	012	0.182±0.020	0.182±0.002	0.635±0.016	0.8360	0.692
24	02	013	0.218±0.018	0.176±0.002	0.606±0.014	-1.0142	1.039
25	02	014	0.237±0.016	0.263±0.002	0.499±0.011	-2.1252*	4.641*

* significant at the 5% level

Note: Names of population groups, sample sizes, blood-group phenotype frequencies and source are given in Appendix 1 (page 216)

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
26	02	015	0.140±0.022	0.290±0.002	0.570±0.014	-3.6306*	13.953*
27	02	016	0.206±0.020	0.152±0.002	0.642±0.016	-0.5778	0.336
28	02	017	0.222±0.014	0.209±0.001	0.568±0.011	-0.2496	0.062
29	02	018	0.293±0.029	0.235±0.003	0.472±0.020	-0.0334	0.001
30	02	019	0.262±0.024	0.232±0.002	0.505±0.017	-1.8657*	3.596
31	02	020	0.102±0.018	0.162±0.001	0.736±0.015	0.9494	0.906
32	02	021	0.139±0.043	0.090±0.002	0.770±0.039	1.0661	1.126
33	02	022	0.159±0.027	0.189±0.002	0.652±0.021	0.9925	0.970
34	02	023	0.216±0.028	0.283±0.003	0.501±0.018	0.5868	0.340
35	02	024	0.167±0.007	0.210±0.001	0.623±0.005	2.2902*	5.191*
36	02	025	0.170±0.028	0.288±0.003	0.542±0.017	-0.5417	0.294
37	02	026	0.127±0.023	0.302±0.002	0.571±0.014	-0.2781	0.079
38	02	027	0.184±0.019	0.230±0.002	0.586±0.014	-0.0789	0.006
39	02	028	0.132±0.020	0.268±0.002	0.601±0.014	0.5403	0.290
40	02	029	0.166±0.023	0.256±0.002	0.577±0.016	1.1223	1.313
41	02	030	0.147±0.033	0.236±0.003	0.617±0.023	0.7994	0.628
42	02	031	0.162±0.010	0.222±0.001	0.616±0.007	1.1032	1.209
43	02	032	0.118±0.020	0.189±0.001	0.693±0.016	0.4980	0.247
44	02	033	0.123±0.024	0.210±0.002	0.667±0.018	0.1989	0.040
45	02	034	0.039±0.019	0.266±0.001	0.695±0.013	0.1133	0.013
46	02	035	0.155±0.025	0.160±0.002	0.684±0.020	-0.1238	0.015
47	02	036	0.196±0.012	0.201±0.001	0.603±0.009	2.6101*	6.681*
48	02	037	0.204±0.035	0.213±0.003	0.583±0.025	1.6955*	2.940
49	02	038	0.070±0.013	0.229±0.001	0.701±0.009	0.6672	0.443
50	02	039	0.165±0.038	0.186±0.003	0.649±0.030	-0.3890	0.118
51	02	040	0.240±0.013	0.228±0.001	0.533±0.009	-0.2318	0.054
52	02	041	0.258±0.046	0.141±0.004	0.601±0.038	-0.7208	0.529
53	02	042	0.231±0.023	0.211±0.002	0.558±0.017	1.3253	1.722
54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
54	02	043	0.291±0.035	0.231±0.004	0.479±0.024	1.3699	1.807
55	02	044	0.197±0.016	0.322±0.002	0.481±0.009	0.8379	0.694
56	02	045	0.156±0.023	0.296±0.002	0.548±0.014	2.2132*	4.708*
57	03	001	0.186±0.006	0.237±0.001	0.577±0.005	-0.8468	0.719
58	03	002	0.106±0.032	0.211±0.002	0.683±0.024	-0.0059	0.000
59	03	003	0.278±0.024	0.173±0.002	0.550±0.019	-2.2738*	5.314*
60	03	004	0.178±0.024	0.299±0.002	0.523±0.014	0.3854	0.150
61	03	005	0.346±0.027	0.246±0.003	0.408±0.018	-1.7943*	3.415
62	03	006	0.240±0.014	0.177±0.001	0.583±0.011	-1.4840	2.229
63	03	007	0.313±0.026	0.147±0.002	0.541±0.021	1.5734	2.418
64	03	008	0.290±0.013	0.222±0.001	0.488±0.009	-0.7776	0.609
65	03	009	0.216±0.014	0.146±0.001	0.639±0.011	0.0380	0.001
66	03	010	0.244±0.023	0.211±0.002	0.545±0.017	1.0226	1.029
67	03	011	0.278±0.024	0.209±0.002	0.512±0.018	-0.1943	0.038
68	03	012	0.247±0.023	0.298±0.003	0.455±0.014	-0.6440	0.420
69	03	013	0.248±0.023	0.115±0.002	0.636±0.020	2.3665*	5.460*
70	03	014	0.256±0.019	0.175±0.002	0.569±0.015	1.0187	1.016
71	03	015	0.177±0.020	0.116±0.001	0.707±0.017	0.9214	0.854
72	03	016	0.214±0.022	0.168±0.002	0.618±0.018	-0.4132	0.172
73	03	017	0.177±0.019	0.081±0.001	0.742±0.017	-0.8156	0.669
74	03	018	0.198±0.021	0.071±0.001	0.731±0.020	0.6999	0.488
75	03	019	0.145±0.022	0.157±0.001	0.697±0.018	0.2822	0.085
76	03	020	0.165±0.013	0.208±0.001	0.627±0.010	0.9310	0.874
77	03	021	0.156±0.014	0.217±0.001	0.627±0.010	1.0904	1.205
78	03	022	0.081±0.016	0.279±0.001	0.640±0.010	0.5765	0.330
79	03	023	0.144±0.024	0.221±0.002	0.635±0.018	0.0627	0.004
80	03	024	0.146±0.021	0.214±0.002	0.640±0.016	-1.8219*	3.384
81	03	025	0.165±0.022	0.181±0.002	0.654±0.018	1.6190	2.569
82	03	026	0.226±0.020	0.142±0.002	0.631±0.017	0.3268	0.107

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
83	04	001	0.151±0.015	0.242±0.001	0.607±0.010	-1.1302	1.292
84	04	002	0.174±0.026	0.283±0.002	0.542±0.016	0.6849	0.501
85	04	003	0.195±0.021	0.195±0.002	0.609±0.016	1.3698	1.844
86	04	004	0.167±0.020	0.260±0.002	0.573±0.013	0.7238	0.519
87	04	005	0.159±0.015	0.273±0.001	0.568±0.010	1.4169	1.977
88	04	006	0.152±0.021	0.276±0.002	0.572±0.014	0.1532	0.025
89	04	007	0.176±0.031	0.260±0.003	0.564±0.021	1.2969	1.640
90	04	008	0.202±0.026	0.211±0.002	0.587±0.019	0.9676	0.921
91	04	009	0.149±0.026	0.222±0.002	0.629±0.019	-2.0655*	4.409*
92	04	010	0.154±0.031	0.283±0.003	0.564±0.020	1.2849	1.602
93	04	011	0.232±0.048	0.362±0.006	0.405±0.023	0.2135	0.045
94	04	012	0.167±0.022	0.209±0.002	0.623±0.016	0.0744	0.006
95	04	013	0.170±0.012	0.262±0.001	0.568±0.008	-0.5974	0.359
96	04	014	0.094±0.030	0.106±0.001	0.800±0.027	-0.0032	0.000
97	04	015	0.130±0.020	0.260±0.002	0.609±0.014	1.2244	1.474
98	04	016	0.145±0.018	0.240±0.002	0.615±0.013	-0.0058	0.000
99	04	017	0.188±0.016	0.264±0.002	0.548±0.011	0.4296	0.188
100	04	018	0.191±0.028	0.263±0.003	0.546±0.019	-0.0906	0.008
101	04	019	0.193±0.020	0.152±0.002	0.655±0.017	0.4600	0.211
102	04	020	0.162±0.022	0.265±0.002	0.573±0.015	0.2594	0.067
103	04	021	0.210±0.046	0.239±0.004	0.551±0.032	-0.2900	0.085
104	04	022	0.169±0.024	0.268±0.002	0.564±0.016	0.1049	0.011
105	04	023	0.177±0.027	0.269±0.003	0.555±0.018	0.2499	0.062
106	04	024	0.307±0.026	0.236±0.003	0.457±0.018	1.0659	1.117
107	04	025	0.159±0.013	0.233±0.001	0.608±0.009	0.3627	0.136
108	04	026	0.149±0.038	0.270±0.003	0.581±0.025	-0.1353	0.018
109	04	027	0.140±0.036	0.239±0.003	0.621±0 026	-1.8204*	3.455
110	04	028	0.209±0.070	0.113±0.005	0.678±0.061	1.1526	1.282
111	04	029	0.159±0.010	0.239±0.001	0.602±0.007	1.7289*	2.821
112	04	030	0.158±0.015	0.281±0.001	0.562±0.010	0.3765	0.148

Table (3 2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
113	04	031	0.248±0.018	0.134±0.001	0.518±0.015	1.0308	1.065
114	04	032	0.181±0.026	0.186±0.002	0.633±0.020	0.5149	0.263
115	04	033	0.262±0.034	0.190±0.003	0.548±0.026	1.2204	1.450
116	04	034	0.146±0.022	0.239±0.002	0.614±0.015	-0.0769	0.006
117	04	035	0.193±0.033	0.277±0.003	0.530±0.021	0.6075	0.366
118	04	036	0.164±0.016	0.246±0.001	0.591±0.011	0.6048	0.363
119	04	037	0.237±0.052	0.290±0.006	0.473±0.032	-0.4567	0.213
120	04	038	0.167±0.024	0.294±0.002	0.538±0.015	0.5861	0.343
121	04	039	0.149±0.023	0.364±0.002	0.487±0.011	-1.2750	1.669
122	04	040	0.200±0.022	0.251±0.002	0.549±0.015	0.3599	0.129
123	04	041	0.177±0.008	0.235±0.001	0.588±0.006	-1.0860	0.997
124	04	042	0.182±0.019	0.217±0.002	0.601±0.014	1.6486*	2.665
125	04	043	0.173±0.004	0.250±0.000	0.577±0.002	4.5051*	20.271*
126	04	044	0.199±0.009	0.243±0.001	0.558±0.006	0.3611	0.130
127	04	045	0.180±0.015	0.244±0.001	0.576±0.011	-0.2000	0.040
128	04	046	0.184±0.015	0.221±0.001	0.594±0.011	-0.8191	0.676
129	04	047	0.223±0.020	0.319±0.002	0.458±0.011	-0.8768	0.781
130	04	048	0.226±0.017	0.302±0.002	0.472±0.010	0.3454	0.119
131	04	049	0.179±0.015	0.239±0.001	0.582±0.010	-1.5820	2.526
132	04	050	0.163±0.023	0.249±0.002	0.588±0.016	-1.0051	1.020
133	04	051	0.235±0.045	0.261±0.005	0.504±0.029	-1.3545	1.924
134	04	052	0.202±0.035	0.304±0.004	0.494±0.021	0.3831	0.145
135	04	053	0.190±0.015	0.236±0.001	0.574±0.011	0.5919	0.348
136	04	054	0.201±0.013	0.223±0.001	0.577±0.009	-0.2888	0.080
137	04	055	0.165±0.018	0.256±0.002	0.579±0.012	-0.5637	0.320
138	04	056	0.195±0.035	0.288±0.004	0.517±0.022	-0.0129	0.000
139	04	057	0.208±0.025	0.212±0.002	0.579±0.018	1.2599	1.556
140	04	058	0.245±0.035	0.201±0.003	0.554±0.026	-0.5835	0.345
141	04	059	0.185±0.018	0.199±0.001	0.616±0.013	0.7738	0.602
142	04	060	0.156±0.020	0.222±0.002	0.622±0.014	0.3481	0.121

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
143	04	061	0.234±0.061	0.546±0.008	0.221±0.000	0.5960	1.610
144	04	062	0.219±0.030	0.279±0.003	0.502±0.019	0.5605	0.310
145	04	063	0.214±0.015	0.197±0.001	0.589±0.011	-1.5602	2.469
146	04	064	0.213±0.017	0.268±0.002	0.519±0.011	1.1382	1.277
147	04	065	0.223±0.018	0.253±0.002	0.524±0.012	-0.5286	0.281
148	04	066	0.248±0.023	0.222±0.002	0.529±0.017	0.0215	0.000
149	04	067	0.231±0.026	0.309±0.003	0.460+0.015	-1.0489	1.127
150	04	068	0.181±0.025	0.251±0.002	0.568±0.017	1.3984	1.907
151	04	069	0.165±0.018	0.260±0.002	0.575±0.012	1.0564	1.101
152	04	070	0.198±0.019	0.244±0.002	0.558±0.013	-0.3393	0.116
153	04	071	0.098±0.020	0.430±0.002	0.472±0.007	-1.1611	1.379
154	04	072	0.237±0.023	0.263±0.002	0.500±0.015	-0.8093	0.665
155	04	073	0.144±0.025	0.297±0.002	0.559±0.015	-0.7453	0.563
156	04	074	0.164±0.019	0.182±0.001	0.654±0.015	0.6816	0.461
157	04	075	0.171±0.026	0.347±0.003	0.482±0.013	-0.1350	0.018
158	05	001	0.445±0.030	0.249±0.004	0.306±0.019	-2.6131*	11.550*
159	05	002	0.244±0.057	0.186±0.005	0.570±0.044	0.7544	0.540
160	05	003	0.249±0.037	0.176±0.003	0.575±0.029	-0.0962	0.009
161	05	004	0.235±0.036	0.135±0.003	0.631±0.030	0.5799	0.333
162	05	005	0.245±0.006	0.190±0.001	0.565±0.005	0.2760	0.076
163	05	006	0.147±0.021	0.212±0.002	0.641±0.016	-0.6609	0.440
164	05	007	0.216±0.022	0.167±0.002	0.617±0.018	0.5776	0.326
165	05	008	0.192±0.025	0.249±0.002	0.559±0.017	-0.3953	0.155
166	05	009	0.192±0.029	0.181±0.002	0.627±0.022	1.9837*	3.807
167	05	010	0.404±0.043	0.121±0.004	0.475±0.036	1.6178	2.510
168	05	011	0.261±0.027	0.209±0.003	0.531±0.020	0.1070	0.011
169	05	012	0.118±0.023	0.229±0.002	0.653±0.017	-0.7287	0.535
170	05	013	0.105±0.033	0.284±0.003	0.610±0.021	-0.2332	0.055
171	05	014	0.155±0.033	0.233±0.003	0.612±0.024	1.5384	2.280
172	05	015	0.089±0.019	0.274±0.001	0.638±0.013	-0.3004	0.091

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
173	05	016	0.112±0.018	0.214±0.001	0.674±0.013	-0.0384	0.001
174	05	017	0.092±0.024	0.274±0.002	0.634±0.016	-0.1777	0.032
175	05	018	0.147±0.015	0.212±0.001	0.640±0.011	0.3294	0.112
176	05	019	0.175±0.036	0.195±0.003	0.630±0.027	-1.0475	1.121
177	05	020	0.131±0.016	0.261±0.001	0.608±0.011	-0.3389	0.118
178	05	021	0.167±0.043	0.508±0.005	0.325±0.000	-1.4878	3.098
179	05	022	0.138±0.045	0.176±0.003	0.686±0.036	-0.4770	0.230
180	05	023	0.244±0.026	0.190±0.002	0.565±0.020	0.1078	0.012
181	05	024	0.323±0.016	0.173±0.002	0.504±0.013	-0.5137	0.217
182	05	025	0.139±0.025	0.193±0.002	0.668±0.020	-0.8487	0.729
183	05	026	0.169±0.043	0.259±0.004	0.572±0.029	-0.2209	0.048
184	05	027	0.133±0.039	0.290±0.003	0.577±0.025	-0.6607	0.445
185	05	028	0.178±0.019	0.241±0.002	0.581±0.013	-0.9214	0.859
186	05	029	0.393±0.025	0.117±0.002	0.490±0.021	-0.0071	0.000
187	05	030	0.161±0.017	0.247±0.001	0.592±0.012	-0.1556	0.026
188	06	001	0.219±0.013	0.281±0.001	0.499±0.008	-0.8730	0.755
189	06	002	0.170±0.018	0.178±0.001	0.652±0.014	0.3849	0.152
190	06	003	0.173±0.015	0.260±0.001	0.567±0.010	-1.2002	2.772
191	06	004	0.107±0.039	0.375±0.003	0.517±0.018	-1.0100	1.052
192	06	005	0.183±0.055	0.183±0.005	0.634±0.043	-0.1721	0.030
193	06	006	0.145±0.019	0.207±0.001	0.647±0.014	-0.6746	0.458
194	06	007	0.240±0.055	0.278±0.006	0.482±0.034	-0.8173	0.691
195	06	008	0.210±0.028	0.205±0.003	0.584±0.021	0.5346	0.283
196	06	009	0.094±0.017	0.225±0.001	0.681±0.012	-0.6573	0.435
197	06	010	0.154±0.043	0.383±0.004	0.464±0.019	0.3834	0.145
198	06	011	0.244±0.055	0.172±0.005	0.584±0.043	-0.0509	0.002
199	06	012	0.275±0.032	0.323±0.004	0.403±0.017	-1.3837	2.100
200	06	013	0.225±0.029	0.265±0.003	0.509±0.019	-0.0882	0.008
201	06	014	0.378±0.085	0.024±0.004	0.598±0.083	-1.2822	1.634
202	06	015	0.281±0.058	0.224±0.006	0.496±0.041	-0.3836	0.150

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
203	06	016	0.105±0.041	0.292±0.003	0.602±0.026	-0.1414	0.020
204	06	017	0.231±0.044	0.390±0.005	0.379±0.018	-0.7930	0.702
205	06	018	0.209±0.022	0.185±0.002	0.606±0.017	1.4563	2.068
206	06	019	0.259±0.033	0.183±0.003	0.558±0.026	-0.1372	0.018
207	06	020	0.196±0.036	0.303±0.004	0.501±0.021	0.0357	0.001
208	06	021	0.191±0.034	0.151±0.003	0.658±0.028	-0.3900	0.153
209	06	022	0.233±0.057	0.328±0.006	0.439±0.031	0.8553	0.771
210	06	023	0.166±0.031	0.241±0.003	0.593±0.022	2.1505*	4.426*
211	06	024	0.154±0.023	0.497±0.003	0.349±0.000	1.8602	3.450
212	06	025	0.263±0.030	0.285±0.003	0.452±0.018	-0.6537	0.[illegible]37
213	06	026	0.280±0.035	0.266±0.004	0.453±0.022	-1.3024	1.767
214	06	027	0.176±0.026	0.233±0.002	0.591±0.018	-0.4210	0.178
215	06	028	0.203±0.027	0.267±0.003	0.530±0.018	1.6412	2.602
216	06	029	0.274±0.043	0.173±0.004	0.553±0.034	-0.5409	0.297
217	06	030	0.223±0.030	0.125±0.002	0.652±0.025	0.0932	0.009
218	06	031	0.298±0.014	0.276±0.002	0.425±0.008	0.3455	0.116
219	06	032	0.373±0.027	0.231±0.003	0.396±0.018	-1.0878	1.214
220	06	033	0.180±0.032	0.273±0.003	0.547±0.021	2.2506*	4.786*
221	06	034	0.165±0.003	0.273±0.000	0.563±0.002	1.6312	2.653
222	06	035	0.164±0.012	0.270±0.001	0.566±0.008	-1.1208	1.268
223	06	036	0.184±0.023	0.277±0.002	0.539±0.015	0.1994	0.040
224	06	037	0.198±0.015	0.294±0.002	0.508±0.009	-0.4811	0.233
225	06	038	0.284±0.026	0.262±0.003	0.454±0.017	-0.4317	0.186
226	06	039	0.180±0.023	0.257±0.002	0.562±0.016	0.6717	0.446
227	06	040	0.2[illegible]4±0.032	0.201±0.003	0.554±0.024	0.1370	0.019
228	06	041	0.236±0.024	0.287±0.003	0.477±0.015	-3.2557*	11.267*
229	06	042	0.184±0.021	0.301±0.002	0.515±0.013	0.1646	0.028
230	06	043	0.180±0.022	0.284±0.002	0.537±0.014	-0.1598	0.026
231	06	044	0.213±0.022	0.286±0.002	0.501±0.013	0.0938	0.009
232	07	001	0.195±0.021	0.237±0.002	0.568±0.015	-1.0269	1.070

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
233	07	002	0.211±0.017	0.262±0.002	0.527±0.012	-3.2501*	11.015*
234	07	003	0.205±0.015	0.252±0.001	0.543±0.010	0.2683	0.072
235	07	004	0.201±0.024	0.213±0.002	0.585±0.018	0.5365	0.289
236	07	005	0.185±0.020	0.173±0.002	0.642±0.016	0.3260	0.109
237	07	006	0.204±0.043	0.179±0.004	0.617±0.033	1.7557*	2.950
238	07	007	0.220±0.031	0.140±0.002	0.640±0.026	0.5800	0.333
239	07	008	0.244±0.024	0.213±0.002	0.543±0.017	0.2753	0.075
240	07	009	0.274±0.034	0.121±0.003	0.605±0.029	0.8527	0.717
241	07	010	0.215±0.028	0.188±0.002	0.597±0.022	0.6184	0.379
242	08	001	0.154±0.024	0.226±0.002	0.621±0.018	0.1351	0.018
243	08	002	0.135±0.022	0.264±0.002	0.600±0.015	1.4166	1.964
244	08	003	0.206±0.030	0.293±0.003	0.501±0.018	0.0358	0.001
245	08	004	0.211±0.026	0.230±0.003	0.559±0.019	-1.0533	1.131
246	08	005	0.202±0.030	0.295±0.003	0.503±0.018	0.7476	0.549
247	08	006	0.163±0.023	0.301±0.002	0.536±0.014	0.1437	0.021
248	08	007	0.201±0.029	0.243±0.003	0.555±0.020	-1.8093*	3.395
249	08	008	0.243±0.032	0.182±0.003	0.575±0.025	1.3620	1.806
250	08	009	0.191±0.029	0.298±0.003	0.511±0.018	0.2732	0.2[illegible]7
251	08	010	0.193±0.027	0.268±0.003	0.539±0.018	-0.5879	0.350
252	08	011	0.287±0.034	0.214±0.003	0.499±0.024	-1.6956*	2.993
253	08	012	0.207±0.026	0.255±0.003	0.538±0.018	-0.6280	0.399
254	08	013	0.174±0.028	0.270±0.003	0.556±0.018	-0.6605	0.442
255	08	014	0.185±0.028	0.220±0.002	0.595±0.020	-1.4165	2.058
256	08	015	0.228±0.031	0.186±0.003	0.586±0.024	0.4466	0.198
257	08	016	0.239±0.031	0.227±0.003	0.534±0.022	-0.9561	0.933
258	08	017	0.261±0.030	0.272±0.003	0.466±0.019	-1.2903	1.719
259	08	018	0.175±0.028	0.251±0.003	0.573±0.019	-0.0797	0.006
260	08	019	0.201±0.016	0.196±0.001	0.603±0.012	-0.8996	0.806
261	08	020	0.179±0.023	0.207±0.002	0.614±0.017	-0.5296	0.283
262	08	021	0.200±0.021	0.169±0.002	0.631±0.017	-0.1591	0.025

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
263	08	022	0.263±0.024	0.119±0.002	0.618±0.020	-1.2115	1.488
264	08	023	0.215±0.022	0.272±0.002	0.513±0.014	1.4922	2.169
265	08	024	0.160±0.019	0.262±0.002	0.578±0.013	2.1157*	4.348*
266	08	025	0.228±0.022	0.166±0.002	0.606±0.018	-0.2677	0.072
267	08	026	0.149±0.019	0.250±0.002	0.601±0.013	0.9533	0.898
268	08	027	0.168±0.019	0.257±0.002	0.576±0.013	0.0952	0.005
269	08	028	0.142±0.026	0.270±0.002	0.587±0.017	2.1841*	4.580*
270	08	029	0.127±0.024	0.277±0.002	0.596±0.016	-0.9214	0.862
271	08	030	0.168±0.019	0.254±0.002	0.578±0.013	0.0151	0.000
272	08	031	0.130±0.019	0.208±0.001	0.662±0.014	-1.3749	1.918
273	08	032	0.199±0.023	0.211±0.002	0.590±0.017	1.1294	1.255
274	08	033	0.284±0.024	0.147±0.002	0.569±0.020	-1.8281*	3.425
275	08	034	0.211±0.024	0.257±0.002	0.532±0.016	-0.6083	0.340
276	08	035	0.184±0.020	0.234±0.002	0.582±0.014	1.3854	1.997
277	08	036	0.263±0.024	0.127±0.002	0.610±0.020	-0.5502	0.305
278	08	037	0.129±0.017	0.237±0.001	0.634±0.012	1.1326	1.267
279	08	038	0.084±0.014	0.208±0.001	0.708±0.011	1.7819*	3.131
280	08	039	0.143±0.018	0.194±0.001	0.663±0.014	0.0221	0.000
281	08	040	0.123±0.022	0.312±0.002	0.566±0.013	-0.7368	0.549
282	08	041	0.102±0.020	0.316±0.002	0.582±0.012	-2.0382*	4.235*
283	08	042	0.069±0.016	0.276±0.001	0.655±0.010	-1.0068	1.024
284	09	001	0.314±0.046	0.205±0.005	0.481±0.034	-0.4811	0.235
285	09	002	0.205±0.021	0.278±0.002	0.516±0.014	1.3581	1.802
286	09	003	0.194±0.007	0.213±0.001	0.593±0.005	0.4877	0.237
287	09	004	0.154±0.016	0.266±0.001	0.580±0.010	1.0547	1.100
288	09	005	0.137±0.014	0.270±0.001	0.592±0.009	-0.5803	0.339
289	09	006	0.197±0.031	0.247±0.003	0.556±0.021	-0.1052	0.011
290	09	007	0.184±0.037	0.330±0.004	0.486±0.020	0.1402	0.020
291	09	008	0.193±0.025	0.220±0.002	0.586±0.018	0.7365	0.536
292	09	009	0.209±0.029	0.249±0.003	0.542±0.019	-0.7975	0.647

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
293	09	010	0.264±0.030	0.232±0.003	0.505±0.021	0.4323	0.185
294	09	011	0.202±0.019	0.258±0.002	0.539±0.013	-0.3786	0.144
295	09	012	0.223±0.032	0.292±0.003	0.485±0.019	0.7235	0.516
296	09	013	0.165±0.026	0.270±0.002	0.565±0.017	-0.1213	0.015
297	09	014	0.205±0.029	0.247±0.003	0.548±0.020	2.4618*	5.751*
298	10	001	0.148±0.021	0.160±0.001	0.692±0.017	0.9983	0.986
299	10	002	0.439±0.038	0.114±0.003	0.448±0.032	0.2776	0.077
300	10	003	0.198±0.035	0.189±0.003	0.614±0.027	1.2537	1.524
301	10	004	0.210±0.014	0.181±0.001	0.608±0.011	1.7632*	3.063
302	10	005	0.170±0.017	0.193±0.001	0.637±0.013	-0.6151	0.381
303	10	006	0.256±0.020	0.203±0.002	0.541±0.015	0.0202	0.000
304	10	007	0.205±0.014	0.239±0.001	0.556±0.010	1.6051	2.536
305	10	008	0.146±0.018	0.165±0.001	0.689±0.014	0.5012	0.250
306	10	009	0.190±0.014	0.235±0.001	0.574±0.010	-0.3606	0.130
307	10	010	0.080±0.017	0.309±0.001	0.611±0.010	-0.2868	0.082
308	11	001	0.471±0.027	0.092±0.002	0.437±0.023	-1.0525	1.125
309	11	002	0.160±0.024	0.090±0.001	0.749±0.021	-1.7383*	3.428
310	11	003	0.196±0.042	0.115±0.003	0.689±0.036	-2.1341*	4.730*
311	11	004	0.193±0.025	0.207±0.002	0.600±0.019	-0.3017	0.091
312	11	005	0.197±0.018	0.120±0.001	0.683±0.016	-1.6295	2.503
313	11	006	0.220±0.028	0.140±0.002	0.640±0.024	1.5553	2.366
314	11	007	0.159±0.031	0.091±0.002	0.750±0.028	-1.4073	2.012
315	11	008	0.000±0.000	0.471±0.000	0.529±0.000	-0.0201	0.000
316	11	009	0.101±0.015	0.167±0.001	0.732±0.012	2.6742*	7.011*
317	11	010	0.134±0.015	0.175±0.001	0.691±0.012	4.0052*	15.604*
318	11	011	0.298±0.038	0.225±0.004	0.477±0.026	2.3192*	4.986*
319	11	012	0.157±0.026	0.163±0.002	0.679±0.021	0.2489	0.064
320	11	013	0.214±0.025	0.137±0.002	0.650±0.021	1.9886*	3.859*
321	11	014	0.134±0.019	0.198±0.001	0.663±0.014	0.5342	0.284
322	11	015	0.118±0.018	0.068±0.001	0.814±0.017	0.4708	0.212

Table (3,2) contd.

(1)	(2) (3)	(4)	(5)	(6)	(7)	(8)
323	11 016	0.419±0.026	0.079±0.002	0.502±0.023	-0.1439	0.021
324	11 017	0.453±0.024	0.070±0.002	0.477±0.021	0.5637	0.316
325	11 018	0.058±0.019	0.141±0.001	0.801±0.016	0.3032	0.092
326	11 019	0.095±0.051	0.532±0.005	0.373±0.000	0.8438	0.678
327	11 020	0.274±0.083	0.030±0.003	0.696±0.080	0.6339	0.397
328	11 021	0.569±0.072	0.111±0.007	0.320±0.060	-0.1455	0.021
329	11 022	0.316±0.034	0.119±0.003	0.565±0.029	-0.5640	0.321
330	11 023	0.166±0.026	0.245±0.002	0.589±0.018	0.4661	0.218
331	11 024	0.265±0.042	0.186±0.004	0.550±0.032	-1.8716	3.670
332	11 025	0.237±0.021	0.187±0.002	0.576±0.016	0.4698	0.223
333	11 026	0.255±0.038	0.197±0.004	0.548±0.028	-0.9926	1.009
334	11 027	0.327±0.046	0.225±0.005	0.448±0.032	2.3943*	5.179*
335	11 028	0.322±0.031	0.266±0.004	0.412±0.019	0.8752	0.751
336	11 029	0.267±0.028	0.244±0.003	0.489±0.019	-0.5074	0.234
337	11 030	0.343±0.042	0.234±0.005	0.423±0.029	0.6223	0.378
338	11 031	0.325±0.061	0.267±0.007	0.408±0.038	1.6765*	2.621
339	11 032	0.163±0.032	0.154±0.002	0.682±0.027	1.6390	2.616
340	11 033	0.177±0.026	0.157±0.002	0.666±0.021	0.3445	0.118
341	11 034	0.109±0.026	0.234±0.002	0.656±0.018	1.2212	1.471
342	11 035	0.192±0.055	0.130±0.004	0.679±0.046	0.4403	0.192
343	11 036	0.129±0.019	0.240±0.001	0.631±0.013	0.5001	0.249
344	11 037	0.121±0.026	0.156±0.002	0.723±0.021	0.7563	0.567
345	11 038	0.208±0.040	0.127±0.003	0.665±0.034	0.0794	0.006
346	11 039	0.085±0.031	0.194±0.002	0.721±0.024	0.4108	0.168
347	11 040	0.122±0.022	0.132±0.001	0.747±0.019	2.2200*	4.824*
348	11 041	0.185±0.029	0.261±0.003	0.554±0.019	0.7614	0.571
349	11 042	0.274±0.065	0.153±0.006	0.568±0.052	1.1970	1.369
350	11 043	0.161±0.057	0.162±0.004	0.677±0.046	1.9102*	3.045*
351	11 044	0.112±0.017	0.170±0.001	0.713±0.013	-0.7834	0.613
352	11 045	0.227±0.050	0.313±0.005	0.459±0.028	0.4049	0.161

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
353	11	046	0.174±0.026	0.138±0.002	0.688±0.022	0.8189	0.664
354	11	047	0.153±0.038	0.178±0.003	0.659±0.030	-3.1498*	10.552*
355	11	048	0.124±0.037	0.252±0.003	0.624±0.025	-0.2404	0.058
356	11	049	0.221±0.027	0.226±0.003	0.553±0.019	-0.2917	0.087
357	11	050	0.110±0.030	0.100±0.001	0.790±0.027	0.2701	0.073
358	12	001	0.228±0.030	0.189±0.003	0.583±0.023	-0.9031	0.824
359	13	001	0.186±0.027	0.297±0.003	0.518±0.016	-0.7257	0.538
360	13	002	0.208±0.027	0.261±0.003	0.530±0.018	-0.2131	0.046
361	13	003	0.224±0.022	0.211±0.002	0.565±0.016	1.1599	1.323
362	13	004	0.214±0.044	0.267±0.004	0.519±0.028	0.3923	0.152
363	13	005	0.204±0.043	0.257±0.004	0.540±0.029	1.2930	1.603
364	13	006	0.208±0.013	0.208±0.001	0.585±0.010	-0.5633	0.319
365	13	007	0.253±0.066	0.176±0.006	0.571±0.052	0.1912	0.036
366	13	008	0.239±0.063	0.214±0.006	0.546±0.046	-0.2633	0.070
367	13	009	0.176±0.022	0.311±0.002	0.513±0.013	-1.9807*	4.062*
368	13	010	0.179±0.024	0.274±0.002	0.547±0.015	1.4027	1.918
369	13	011	0.170±0.019	0.212±0.002	0.618±0.014	-0.7359	0.546
370	13	012	0.256±0.030	0.278±0.003	0.466±0.019	-0.1587	0.025
371	13	013	0.146±0.028	0.229±0.002	0.625±0.020	-1.0651	1.156
372	13	014	0.202±0.038	0.232±0.004	0.565±0.027	1.0648	1.103
373	13	015	0.256±0.027	0.226±0.003	0.518±0.019	0.5239	0.272
374	13	016	0.105±0.024	0.244±0.002	0.651±0.017	-1.9880*	4.422*
375	13	017	0.216±0.025	0.163±0.002	0.621±0.020	0.6962	0.480
376	13	018	0.212±0.032	0.347±0.004	0.441±0.016	1.2609	1.539
377	13	019	0.207±0.027	0.258±0.003	0.535±0.018	-0.0664	0.004
378	13	020	0.200±0.021	0.194±0.002	0.607±0.016	2.3982*	5.576*
379	13	021	0.239±0.023	0.222±0.002	0.5[illegible]±0.016	0.0587	0.003
380	13	022	0.228±0.041	0.273±0.004	0.499±0.026	0.7198	0.506
381	13	023	0.252±0.033	0.300±0.004	0.448±0.019	0.0416	0.002
382	13	024	0.139±0.024	0.325±0.002	0.536±0.014	0.7789	0.597

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
383	13	025	0.137±0.037	0.300±0.003	0.563±0.022	-0.0925	0.008
384	13	026	0.214±0.033	0.229±0.003	0.557±0.023	2.0701*	4.083*
385	13	027	0.205±0.028	0.189±0.002	0.606±0.022	0.0196	0.000
386	13	028	0.197±0.025	0.264±0.002	0.540±0.017	1.4696	2.091
387	13	029	0.156±0.029	0.198±0.002	0.646±0.022	-1.4003	2.007
388	13	030	0.160±0.027	0.236±0.002	0.604±0.019	2.1123*	4.294*
389	13	031	0.225±0.031	0.278±0.003	0.497±0.020	-0.1815	0.033
390	13	032	0.270±0.046	0.221±0.005	0.509±0.033	0.7669	0.573
391	13	033	0.198±0.023	0.239±0.002	0.563±0.016	-0.5132	0.262
392	13	034	0.184±0.034	0.209±0.003	0.607±0.025	-1.1882	1.447
393	13	035	0.168±0.028	0.350±0.003	0.482±0.014	-0.4781	0.231
394	13	036	0.146±0.026	0.322±0.002	0.532±0.015	0.1728	0.030
395	13	037	0.095±0.021	0.361±0.002	0.544±0.011	0.4263	0.180
396	13	038	0.174±0.039	0.271±0.004	0.554±0.025	-0.5639	0.323
397	13	039	0.208±0.025	0.230±0.002	0.562±0.018	-0.0564	0.003
398	13	040	0.142±0.025	0.238±0.002	0.621±0.018	0.4346	0.188
399	13	041	0.252±0.033	0.300±0.004	0.448±0.019	0.0416	0.002
400	13	042	0.197±0.025	0.264±0.002	0.540±0.017	1.4696	2.091
401	13	043	0.176±0.038	0.210±0.003	0.614±0.028	0.0874	0.008
402	13	044	0.178±0.028	0.213±0.002	0.608±0.020	-0.8056	0.658
403	13	045	0.190±0.037	0.242±0.003	0.568±0.026	-0.2148	0.047
404	13	046	0.243±0.021	0.172±0.002	0.584±0.017	1.0092	1.014
405	14	001	0.195±0.012	0.159±0.001	0.646±0.010	-0.3125	0.098
406	14	002	0.187±0.032	0.279±0.003	0.534±0.020	-0.4891	0.242
407	14	003	0.185±0.021	0.127±0.001	0.689±0.018	0.0253	0.001
408	14	004	0.172±0.026	0.220±0.002	0.608±0.019	1.6113	2.528
409	14	005	0.201±0.021	0.132±0.002	0.667±0.018	-0.9164	0.847
410	14	006	0.192±0.021	0.158±0.002	0.650±0.017	1.1002	1.196
411	14	007	0.178±0.020	0.209±0.002	0.612±0.015	-0.0183	0.000
412	14	008	0.157±0.019	0.134±0.001	0.709±0.016	-0.6495	0.424
413	14	009	0.206±0.021	0.206±0.002	0.587±0.016	0.0064	0.000

Table (3.2) contd.

(1)	(2)(3)	(4)	(5)	(6)	(7)	(8)
414	14 010	0.219±0.022	0.185±0.002	0.596±0.017	0.0540	0.003
415	14 011	0.225±0.031	0.298±0.003	0.476±0.019	-0.4725	0.226
416	14 012	0.141±0.049	0.258±0.004	0.600±0.033	0.8788	0.752
417	14 013	0.217±0.042	0.217±0.004	0.565±0.030	1.2529	1.515
418	14 014	0.145±0.037	0.208±0.003	0.647±0.028	1.4011	1.903
419	14 015	0.191±0.058	0.191±0.005	0.618±0.044	-0.0917	0.008
420	14 016	0.362±0.073	0.306±0.009	0.333±0.040	-0.0167	0.000
421	14 017	0.303±0.066	0.090±0.005	0.607±0.059	-0.4182	0.177
422	14 018	0.219±0.052	0.275±0.005	0.506±0.033	0.2141	0.045
423	14 019	0.197±0.046	0.316±0.005	0.487±0.026	-1.7465*	3.253
424	14 020	0.222±0.061	0.251±0.006	0.526±0.041	1.4946	2.066
425	14 021	0.207±0.030	0.132±0.002	0.660±0.025	-1.6428	2.762
426	14 022	0.282±0.056	0.152±0.005	0.566±0.045	-0.4645	0.219
427	14 023	0.180±0.047	0.164±0.004	0.656±0.038	0.9781	0.934
428	14 024	0.093±0.040	0.317±0.003	0.590±0.023	-0.3406	0.116
429	14 025	0.144±0.037	0.233±0.003	0.623±0.026	0.8883	0.777
430	14 026	0.227±0.058	0.185±0.005	0.588±0.045	0.4122	0.168
431	14 027	0.326±0.064	0.283±0.008	0.391±0.038	0.0491	0.002
432	14 028	0.182±0.057	0.447±0.006	0.371±0.015	1.3890	1.911
433	14 029	0.147±0.051	0.218±0.004	0.636±0.038	0.6330	0.391
434	14 030	0.271±0.064	0.247±0.007	0.481±0.043	0.5328	0.277
435	14 031	0.262±0.051	0.247±0.005	0.491±0.034	-3.0576*	10.225*
436	14 032	0.145±0.051	0.145±0.003	0.709±0.042	0.1115	0.012
437	14 033	0.226±0.055	0.188±0.005	0.586±0.042	1.3890	1.344
438	14 034	0.271±0.064	0.247±0.007	0.481±0.043	0.5328	0.277
439	14 035	0.120±0.046	0.120±0.003	0.760±0.040	-2.8927*	8.828*
440	14 036	0.122±0.047	0.239±0.004	0.639±0.033	-0.4774	0.231
441	14 037	0.274±0.063	0.186±0.006	0.540±0.048	0.8024	0.621
442	14 038	0.199±0.055	0.179±0.005	0.621±0.043	-1.5269	2.437
443	14 039	0.280±0.064	0.169±0.006	0.551±0.051	-0.2021	0.041

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
444	14	040	0.186±0.051	0.206±0.004	0.608±0.038	-1.2047	1.510
445	14	041	0.350±0.074	0.168±0.007	0.482±0.058	0.0592	0.003
446	14	042	0.261±0.048	0.207±0.005	0.532±0.035	0.7371	0.533
447	14	043	0.339±0.061	0.210±0.007	0.451±0.044	-0.4427	0.200
448	14	044	0.123±0.048	0.169±0.003	0.708±0.039	-3.2764*	11.534*
449	14	045	0.214±0.055	0.194±0.005	0.592±0.041	1.3039	1.626
450	14	046	0.357±0.072	0.175±0.007	0.468±0.055	-1.8695*	3.745
451	14	047	0.263±0.066	0.166±0.006	0.571±0.053	-0.6073	0.379
452	14	048	0.213±0.060	0.189±0.005	0.599±0.046	-0.7797	0.625
453	14	049	0.261±0.060	0.085±0.004	0.655±0.054	0.3836	0.144
454	14	050	0.249±0.060	0.164±0.005	0.587±0.048	0.3662	0.132
455	14	051	0.164±0.048	0.111±0.003	0.725±0.042	-0.8332	0.706
456	14	052	0.212±0.053	0.212±0.005	0.576±0.039	-0.6847	0.478
457	14	053	0.206±0.054	0.338±0.006	0.455±0.029	2.1935*	4.291*
458	14	054	0.218±0.049	0.130±0.004	0.652±0.041	-0.5423	0.298
459	14	055	0.175±0.053	0.267±0.005	0.558±0.035	-0.3041	0.093
460	14	056	0.350±0.074	0.168±0.007	0.482±0.058	0.0457	0.002
461	14	057	0.241±0.048	0.256±0.005	0.503±0.032	0.3159	0.100
462	14	058	0.163±0.043	0.225±0.004	0.611±0.031	-0.0419	0.002
463	14	059	0.258±0.062	0.213±0.006	0.529±0.045	0.1346	0.018
464	14	060	0.315±0.073	0.155±0.007	0.530±0.058	1.2506	1.478
465	14	061	0.333±0.074	0.083±0.005	0.584±0.067	-0.6718	0.461
466	14	062	0.164±0.043	0.259±0.004	0.577±0.029	0.2794	0.077
467	14	063	0.271±0.061	0.192±0.006	0.537±0.046	-1.9772*	4.176*
468	14	064	0.171±0.017	0.164±0.001	0.665±0.013	0.2502	0.063
469	14	065	0.216±0.056	0.281±0.006	0.503±0.035	-0.1604	0.026
470	14	066	0.175±0.023	0.215±0.002	0.611±0.017	0.2030	0.041
471	14	067	0.213±0.032	0.255±0.003	0.532±0.021	0.5376	0.285
472	14	068	0.172±0.038	0.293±0.004	0.534±0.024	-1.4638	2.237
473	14	069	0.185±0.014	0.246±0.001	0.569±0.010	0.6877	0.470

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
474	14	070	0.242±0.025	0.178±0.002	0.580±0.020	-0.9347	0.886
475	14	071	0.238±0.021	0.215±0.002	0.546±0.016	-0.2060	0.043
476	14	072	0.246±0.019	0.195±0.002	0.558±0.015	0.9404	0.874
477	14	073	0.213±0.022	0.152±0.002	0.635±0.018	0.6745	0.452
478	14	074	0.183±0.005	0.204±0.000	0.613±0.004	-2.7877*	7.834*
479	14	075	0.221±0.023	0.197±0.002	0.581±0.018	-2.0639*	4.388*
480	14	076	0.193±0.023	0.253±0.002	0.553±0.015	-0.7077	0.507
481	14	077	0.222±0.023	0.218±0.002	0.560±0.017	0.7748	0.588
482	14	078	0.238±0.033	0.242±0.003	0.521±0.022	0.9242	0.835
483	14	079	0.216±0.028	0.232±0.003	0.553±0.020	-2.1873*	4.989*
484	14	080	0.104±0.031	0.361±0.003	0.535±0.016	0.5674	0.317
485	14	081	0.168±0.017	0.230±0.001	0.602±0.012	-1.7268*	3.038
486	14	082	0.164±0.019	0.222±0.002	0.614±0.014	-1.3728	1.915
487	14	083	0.176±0.028	0.226±0.002	0.598±0.020	0.4305	0.184
488	14	084	0.152±0.027	0.220±0.002	0.627±0.019	0.8221	0.667
489	14	085	0.136±0.025	0.243±0.002	0.621±0.018	2.2626*	4.929*
490	14	086	0.194±0.030	0.213±0.003	0.593±0.022	0.1119	0.012
491	14	087	0.196±0.030	0.142±0.002	0.662±0.025	1.8420*	3.303
492	14	088	0.233±0.032	0.195±0.003	0.572±0.024	0.4519	0.202
493	14	089	0.173±0.028	0.277±0.003	0.550±0.018	1.9521*	3.853
494	14	090	0.170±0.028	0.106±0.002	0.724±0.025	0.9917	0.973
495	14	091	0.177±0.006	0.221±0.001	0.602±0.004	-0.7132	0.529
496	14	092	0.211±0.022	0.373±0.002	0.416±0.010	-2.3342*	5.890*
497	14	093	0.286±0.030	0.257±0.003	0.457±0.019	-1.1613	1.387
498	14	094	0.136±0.024	0.196±0.002	0.668±0.018	-0.5627	0.315
499	14	095	0.280±0.036	0.220±0.004	0.500±0.026	-0.4343	0.191
500	14	096	0.165±0.016	0.170±0.001	0.665±0.013	2.9867*	8.689*
501	14	097	0.032±0.014	0.266±0.001	0.702±0.009	-0.6642	0.444
502	14	098	0.199±0.023	0.195±0.002	0.606±0.018	0.2056	0.042
503	14	099	0.287±0.030	0.257±0.003	0.457±0.019	-1.1584	1.385

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
504	14	100	0.270±0.024	0.164±0.002	0.566±0.019	-1.4767	2.215
505	14	101	0.183±0.028	0.189±0.002	0.628±0.021	1.1490	1.296
506	14	102	0.232±0.028	0.237±0.003	0.530±0.020	0.3570	0.125
507	14	103	0.121±0.021	0.267±0.002	0.613±0.014	-0.4779	0.230
508	14	104	0.205±0.029	0.188±0.002	0.607±0.022	0.6998	0.484
509	14	105	0.163±0.022	0.129±0.001	0.707±0.019	1.1590	1.328
510	14	106	0.227±0.030	0.132±0.002	0.641±0.026	-0.7001	0.495
511	14	107	0.187±0.020	0.126±0.001	0.686±0.017	-1.3190	1.761
512	14	108	0.127±0.014	0.229±0.001	0.644±0.010	0.9602	0.915
513	14	109	0.230±0.023	0.124±0.002	0.645±0.020	-0.1726	0.030
514	14	110	0.107±0.022	0.374±0.002	0.519±0.010	-0.6088	0.375
515	14	111	0.134±0.024	0.242±0.002	0.624±0.017	0.0066	0.000
516	14	112	0.255±0.034	0.178±0.003	0.567±0.026	-0.8919	0.306
517	14	113	0.232±0.012	0.219±0.001	0.549±0.009	1.6636*	2.751
518	14	114	0.152±0.045	0.240±0.004	0.607±0.031	-1.1011	1.252
519	14	115	0.144±0.027	0.112±0.002	0.745±0.024	-0.0781	0.005
520	14	116	0.213±0.014	0.227±0.001	0.560±0.010	-0.4665	0.218
521	14	117	0.219±0.032	0.213±0.003	0.568±0.023	0.3710	0.138
522	14	118	0.207±0.028	0.266±0.003	0.527±0.018	-0.2338	0.055
523	14	119	0.268±0.026	0.210±0.003	0.522±0.019	-0.2667	0.070
524	14	120	0.146±0.028	0.308±0.003	0.546±0.017	-0.4940	0.244
525	14	121	0.289±0.034	0.520±0.004	0.191±0.000	-1.6422	39.406*
526	14	122	0.146±0.027	0.282±0.002	0.572±0.017	1.6194	2.545
527	14	123	0.235±0.031	0.318±0.003	0.447±0.017	0.4428	0.194
528	14	124	0.175±0.035	0.289±0.003	0.536±0.022	1.8215*	3.158
529	14	125	0.199±0.035	0.297±0.004	0.504±0.021	-1.4375	2.151
530	14	126	0.269±0.010	0.239±0.001	0.492±0.007	-3.4225*	11.989*
531	14	127	0.160±0.031	0.208±0.002	0.632±0.023	0.1022	0.011
532	14	128	0.252±0.028	0.156±0.002	0.592±0.023	0.3580	0.130
533	14	129	0.150±0.026	0.290±0.002	0.561±0.016	1.3737	1.837

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
534	14	130	0.218±0.030	0.206±0.003	0.576±0.023	-0.6484	0.426
535	14	131	0.208±0.029	0.145±0.002	0.647±0.024	-0.7332	0.543
536	14	132	0.205±0.029	0.116±0.002	0.682±0.025	0.0810	0.007
537	14	133	0.149±0.023	0.214±0.002	0.636±0.017	-2.0024*	4.123*
538	14	134	0.158±0.023	0.154±0.002	0.688±0.019	-2.8097*	8.146*
539	14	135	0.197±0.027	0.202±0.002	0.602±0.020	0.5851	0.339
540	14	136	0.198±0.046	0.292±0.005	0.510±0.028	-0.0827	0.007
541	14	137	0.181±0.027	0.315±0.003	0.503±0.016	-0.2067	0.043
542	15	001	0.105±0.015	0.130±0.001	0.765±0.013	0.3220	0.104
543	16	001	0.241±0.025	0.079±0.002	0.680±0.023	0.1335	0.018
544	16	002	0.301±0.030	0.121±0.002	0.578±0.026	0.5203	0.303
545	16	003	0.255±0.029	0.074±0.002	0.674±0.027	-0.1581	0.027
546	16	004	0.278±0.038	0.295±0.004	0.427±0.022	-0.5284	0.284
547	16	005	0.213±0.026	0.143±0.002	0.644±0.022	1.0664	1.122
548	16	006	0.161±0.036	0.161±0.003	0.677±0.029	-0.7104	0.515
549	16	007	0.215±0.032	0.166±0.003	0.609±0.026	1.0185	1.019
550	16	008	0.218±0.018	0.127±0.001	0.654±0.015	1.8638*	3.446
551	16	009	0.250±0.033	0.088±0.002	0.661±0.030	-0.8995	0.819
552	16	010	0.338±0.033	0.150±0.003	0.512±0.027	0.7009	0.484
553	16	011	0.157±0.011	0.107±0.001	0.736±0.010	1.1356	1.284
554	16	012	0.193±0.024	0.102±0.002	0.705±0.021	-0.5402	0.299
555	17	001	0.211±0.025	0.224±0.002	0.564±0.018	1.7946*	3.135
556	17	002	0.160±0.027	0.249±0.002	0.591±0.019	1.7969*	3.121
557	17	003	0.155±0.031	0.155±0.002	0.691±0.025	0.2744	0.075
558	17	004	0.181±0.028	0.284±0.003	0.535±0.018	0.5520	0.304
559	17	005	0.151±0.025	0.228±0.002	0.622±0.018	2.1466*	4.452*
560	17	006	0.176±0.023	0.196±0.002	0.628±0.017	0.2811	0.079
561	17	007	0.218±0.017	0.239±0.002	0.544±0.012	0.4174	0.173
562	17	008	0.184±0.019	0.260±0.002	0.556±0.013	-1.6935*	2.923
563	17	009	0.222±0.036	0.240±0.004	0.539±0.025	1.8701*	3.334

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
564	17	010	0.149±0.021	0.226±0.002	0.625±0.015	0.2828	0.080
565	18	001	0.160±0.035	0.200±0.003	0.639±0.027	-1.9225*	3.841*
566	18	002	0.241±0.027	0.305±0.003	0.455±0.016	0.4655	0.214
567	18	003	0.139±0.053	0.190±0.004	0.671±0.041	-0.8462	0.736
568	18	004	0.194±0.066	0.258±0.006	0.548±0.044	0.0027	0.000
569	18	005	0.168±0.026	0.345±0.003	0.487±0.013	1.2643	1.551
570	18	006	0.255±0.031	0.231±0.003	0.513±0.022	1.9422*	3.602
571	18	007	0.192±0.028	0.181±0.002	0.627±0.022	2.0538*	4.078*
572	18	008	0.169±0.041	0.267±0.004	0.564±0.027	-0.5944	0.360
573	18	009	0.228±0.034	0.315±0.004	0.457±0.019	-0.6389	0.416
574	18	010	0.231±0.021	0.260±0.002	0.509±0.014	-0.2548	0.065
575	18	011	0.202±0.020	0.275±0.002	0.522±0.013	-0.2397	0.058
576	18	012	0.211±0.022	0.214±0.002	0.574±0.016	1.2373	1.504
577	18	013	0.245±0.021	0.242±0.002	0.513±0.014	-0.1299	0.017
578	18	014	0.182±0.019	0.306±0.002	0.511±0.011	1.1064	1.203
579	18	015	0.203±0.017	0.313±0.002	0.483±0.010	0.9315	0.892
580	18	016	0.222±0.017	0.271±0.002	0.507±0.011	0.4601	0.210
581	18	017	0.213±0.024	0.272±0.002	0.515±0.015	0.2322	0.054
582	18	018	0.160±0.018	0.212±0.002	0.628±0.014	1.1560	1.330
583	18	019	0.189±0.028	0.212±0.002	0.599±0.021	-0.1481	0.021
584	18	020	0.147±0.017	0.154±0.001	0.699±0.014	2.7582*	7.435*
585	18	021	0.194±0.021	0.218±0.002	0.588±0.015	4.4649*	19.137*
586	18	022	0.129±0.018	0.261±0.001	0.611±0.012	1.9206	3.603
587	18	023	0.177±0.020	0.260±0.002	0.563±0.013	1.0175	1.020
588	18	024	0.234±0.020	0.226±0.002	0.540±0.014	0.3560	0.126
589	18	025	0.101±0.017	0.294±0.001	0.605±0.011	0.7735	0.607
590	18	026	0.150±0.025	0.260±0.002	0.590±0.017	-0.2542	0.062
591	18	027	0.207±0.033	0.269±0.003	0.523±0.021	-1.0835	1.155
592	18	028	0.222±0.022	0.184±0.002	0.594±0.017	-2.6389*	7.206*
593	18	029	0.201±0.021	0.223±0.002	0.577±0.015	-1.8165*	3.383

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
592	18	030	0.200±0.021	0.170±0.002	0.629±0.017	-2.4196*	6.021*
595	18	031	0.185±0.020	0.179±0.002	0.637±0.016	-2.9206*	8.813*
596	18	032	0.177±0.020	0.156±0.002	0.667±0.016	-1.4056	2.004
597	18	033	0.201±0.021	0.164±0.002	0.634±0.017	1.0926	1.179
598	18	034	0.205±0.021	0.237±0.002	0.559±0.015	-1.0467	1.113
599	18	035	0.198±0.020	0.303±0.002	0.498±0.012	0.4230	0.181
600	18	036	0.209±0.016	0.271±0.002	0.520±0.011	1.4052	1.952
601	18	037	0.193±0.021	0.175±0.002	0.632±0.016	-0.4926	0.244
602	18	038	0.215±0.022	0.271±0.002	0.514±0.014	1.1818	1.369
603	18	039	0.159±0.019	0.235±0.002	0.606±0.014	1.9394*	3.670
604	18	040	0.136±0.028	0.209±0.002	0.655±0.021	-1.6792*	2.872
605	18	041	0.271±0.033	0.262±0.004	0.467±0.021	2.1146*	4.205*
606	18	042	0.244±0.021	0.279±0.002	0.477±0.013	1.4168	1.958
607	18	043	0.247±0.022	0.284±0.002	0.468±0.013	2.6237*	6.404*
608	18	044	0.133±0.021	0.398±0.002	0.469±0.009	3.1998*	9.766*
609	18	045	0.230±0.037	0.205±0.003	0.565±0.027	2.0053*	3.828
610	18	046	0.250±0.033	0.288±0.004	0.462±0.020	1.5619	2.332
611	18	047	0.178±0.026	0.304±0.003	0.519±0.016	-0.4363	0.192
612	18	048	0.194±0.033	0.258±0.003	0.548±0.022	0.0053	0.000
613	18	049	0.221±0.033	0.235±0.003	0.544±0.023	0.9945	0.966
614	18	050	0.232±0.024	0.253±0.002	0.515±0.016	0.9938	0.910
615	18	051	0.084±0.011	0.197±0.001	0.719±0.009	-2.3596*	5.646*
616	19	001	0.160±0.017	0.366±0.002	0.474±0.008	-1.5389	2.425
617	19	002	0.172±0.017	0.242±0.001	0.586±0.012	1.1026	1.240
618	19	003	0.201±0.030	0.233±0.003	0.566±0.021	-0.7158	0.520
619	19	004	0.197±0.006	0.242±0.001	0.562±0.004	-0.2253	0.051
620	19	005	0.181±0.012	0.259±0.001	0.560±0.008	-1.4139	2.022
621	19	006	0.188±0.006	0.221±0.001	0.591±0.004	-1.0830	1.178
622	19	007	0.204±0.019	0.235±0.002	0.[illegible]61±0.013	-0.1643	0.027
623	19	008	0.175±0.006	0.231±0.000	0.594±0.004	1.5065	2.258

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
624	19	009	0.191±0.009	0.257±0.001	0.552±0.006	-0.3566	0.127
625	19	010	0.186±0.006	0.253±0.001	0.561±0.004	2.1153*	4.435*
626	19	011	0.260±0.068	0.260±0.007	0.479±0.045	-0.5512	0.313
627	19	012	0.284±0.036	0.274±0.004	0.443±0.023	1.5128	2.186
628	19	013	0.175±0.046	0.192±0.004	0.633±0.036	-1.1594	1.386
629	19	014	0.180±0.012	0.229±0.001	0.590±0.008	1.0050	1.003
630	19	015	0.167±0.019	0.260±0.002	0.574±0.013	0.4339	0.187
631	19	016	0.128±0.025	0.200±0.002	0.672±0.019	2.0920*	4.262*
632	19	017	0.160±0.007	0.284±0.001	0.555±0.004	2.0244*	4.102*
633	19	018	0.163±0.007	0.292±0.001	0.545±0.004	1.9012*	3.697
634	19	019	0.229±0.038	0.357±0.004	0.414±0.018	-0.5756	0.340
635	19	020	0.240±0.023	0.285±0.002	0.474±0.014	1.2904	1.623
636	19	021	0.206±0.031	0.213±0.003	0.580±0.023	0.5991	0.355
637	19	022	0.201±0.040	0.379±0.004	0.420±0.018	-1.1378	1.507
638	19	023	0.296±0.022	0.248±0.002	0.456±0.014	-0.7920	0.636
639	19	024	0.295±0.034	0.276±0.004	0.428±0.021	0.6504	0.419
640	19	025	0.169±0.004	0.245±0.000	0.586±0.003	2.7876*	7.717*
641	19	026	0.163±0.004	0.294±0.000	0.543±0.002	1.1254	1.263
642	19	027	0.229±0.026	0.260±0.003	0.511±0.017	1.1203	1.233
643	19	028	0.140±0.024	0.234±0.002	0.625±0.017	1.0825	1.153
644	19	029	0.234±0.033	0.290±0.004	0.476±0.020	-0.7284	0.544
645	19	030	0.270±0.069	0.241±0.007	0.489±0.047	0.8745	0.730
646	19	031	0.162±0.034	0.241±0.003	0.597±0.024	-1.1556	1.376
647	19	032	0.309±0.062	0.229±0.007	0.462±0.043	-0.7265	0.546
648	19	033	0.126±0.045	0.166±0.003	0.708±0.036	-1.8564	3.584
649	19	034	0.214±0.032	0.256±0.003	0.530±0.021	0.9902	0.958
650	19	035	0.290±0.026	0.249±0.003	0.461±0.017	-0.2277	0.053
651	19	036	0.168±0.034	0.287±0.003	0.546±0.021	1.2238	1.455
652	19	037	0.151±0.031	0.217±0.002	0.632±0.022	-0.0437	0.002
653	19	038	0.208±0.030	0.252±0.003	0.540±0.020	-0.1295	0.016

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
654	19	039	0.213±0.047	0.243±0.005	0.544±0.032	1.5457	2.264
655	19	040	0.166±0.021	0.238±0.002	0.596±0.015	0.7872	0.613
656	19	041	0.172±0.019	0.233±0.002	0.595±0.013	0.3428	0.117
657	19	042	0.189±0.020	0.306±0.002	0.504±0.012	-0.9464	0.910
658	19	043	0.258±0.019	0.162±0.002	0.580±0.015	0.7371	0.539
659	19	044	0.237±0.023	0.263±0.002	0.500±0.015	-0.8093	0.665
660	19	045	0.176±0.027	0.250±0.002	0.573±0.018	1.2087	1.428
661	19	046	0.209±0.047	0.568±0.006	0.223±0.000	-0.9304	4.875*
662	19	047	0.195±0.039	0.314±0.004	0.491±0.022	-1.9800*	4.160*
663	19	048	0.177±0.025	0.341±0.003	0.482±0.013	-3.4278*	12.618*
664	19	049	0.161±0.015	0.304±0.001	0.535±0.009	0.3281	0.107
665	19	050	0.166±0.012	0.280±0.001	0.554±0.008	0.9578	0.910
666	19	051	0.195±0.015	0.275±0.001	0.529±0.009	1.0530	1.096
667	19	052	0.247±0.042	0.292±0.005	0.461±0.025	-0.1673	0.028
668	19	053	0.228±0.035	0.270±0.004	0.503±0.023	0.7823	0.598
669	19	054	0.280±0.025	0.314±0.003	0.406±0.014	-1.0910	1.223
670	19	055	0.129±0.018	0.299±0.001	0.572±0.010	0.1678	0.028
671	19	056	0.217±0.030	0.242±0.003	0.540±0.021	0.7678	0.587
672	19	057	0.265±0.035	0.243±0.004	0.493±0.024	-0.5179	0.272
673	19	058	0.215±0.034	0.255±0.003	0.530±0.023	1.3157	1.690
674	19	059	0.172±0.009	0.265±0.001	0.564±0.006	1.3073	1.717
675	19	060	0.171±0.017	0.262±0.002	0.567±0.011	0.0599	0.004
676	19	061	0.172±0.012	0.272±0.001	0.556±0.008	0.7739	0.595
677	19	062	0.187±0.010	0.252±0.001	0.561±0.007	-0.0787	0.006
678	19	063	0.184±0.008	0.280±0.001	0.536±0.005	0.8030	0.642
679	19	064	0.173±0.008	0.263±0.001	0.564±0.005	1.1492	1.313
680	19	065	0.166±0.014	0.243±0.001	0.592±0.010	0.9217	0.843
681	19	066	0.182±0.027	0.329±0.003	0.489±0.015	-1.5107	2.693
682	19	067	0.250±0.019	0.316±0.002	0.434±0.010	2.3802*	5.454*
683	19	068	0.161±0.013	0.293±0.001	0.546±0.008	0.1843	0.034

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
684	19	069	0.173±0.015	0.293±0.001	0.533±0.009	0.1303	0.017
685	19	070	0.175±0.013	0.302±0.001	0.522±0.008	0.1395	0.019
686	19	071	0.165±0.013	0.287±0.001	0.548±0.008	0.7550	0.566
687	19	072	0.168±0.010	0.291±0.001	0.541±0.006	0.3958	0.156
688	19	073	0.166±0.014	0.315±0.001	0.519±0.008	0.6943	0.478
689	19	074	0.178±0.020	0.290±0.002	0.532±0.012	0.1869	0.035
690	19	075	0.164±0.015	0.292±0.001	0.544±0.009	0.0190	0.000
691	19	076	0.319±0.033	0.271±0.004	0.410±0.021	0.4472	0.197
692	19	077	0.322±0.039	0.203±0.004	0.475±0.029	0.9127	0.814
693	19	078	0.302±0.035	0.209±0.004	0.489±0.026	-0.4733	0.225
694	19	079	0.111±0.033	0.225±0.002	0.663±0.024	1.1066	1.198
695	19	080	0.238±0.032	0.225±0.003	0.537±0.023	-0.1100	0.012
696	19	081	0.118±0.023	0.360±0.002	0.522±0.011	-0.3677	0.136
697	19	082	0.151±0.019	0.335±0.002	0.515±0.010	0.1675	0.028
698	19	083	0.290±0.048	0.304±0.006	0.407±0.027	0.6253	0.379
699	19	084	0.313±0.044	0.144±0.004	0.540±0.036	0.6245	0.384
700	19	085	0.202±0.046	0.231±0.004	0.567±0.032	-1.8541*	3.635
701	19	086	0.238±0.034	0.275±0.004	0.487±0.021	0.3539	0.124
702	19	087	0.313±0.056	0.309±0.007	0.378±0.031	-0.7013	0.569
703	19	088	0.305±0.019	0.214±0.002	0.481±0.014	0.3751	0.143
704	19	089	0.146±0.026	0.252±0.002	0.602±0.018	0.1610	0.026
705	19	090	0.261±0.033	0.241±0.003	0.498±0.023	1.7944*	3.072
706	19	091	0.159±0.027	0.258±0.002	0.582±0.018	-0.2563	0.066
707	19	092	0.201±0.030	0.233±0.003	0.567±0.021	1.4429	2.020
708	19	093	0.208±0.030	0.190±0.003	0.601±0.023	0.5728	0.325
709	20	001	0.214±0.028	0.247±0.003	0.539±0.019	0.1610	0.026
710	20	002	0.172±0.027	0.258±0.002	0.571±0.018	-0.4762	0.229
711	20	003	0.174±0.011	0.246±0.001	0.579±0.008	1.5176	2.276
712	20	004	0.175±0.010	0.269±0.001	0.557±0.007	0.0331	0.001
713	20	005	0.174±0.060	0.230±0.005	0.596±0.043	-0.2271	0.052

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
714	20	006	0.167±0.032	0.246±0.003	0.588±0.022	1.5668	2.362
715	20	007	0.155±0.047	0.233±0.004	0.612±0.034	1.0878	1.140
716	20	008	0.120±0.021	0.170±0.001	0.710±0.017	-1.4286	2.072
717	20	009	0.166±0.004	0.243±0.000	0.590±0.003	2.3936*	5.689*
718	20	010	0.154±0.027	0.330±0.003	0.516±0.015	-0.6976	0.485
719	21	001	0.144±0.006	0.230±0.000	0.626±0.004	-1.3247	1.763
720	21	002	0.096±0.018	0.195±0.001	0.709±0.014	-0.4572	0.210
721	21	003	0.170±0.052	0.235±0.005	0.594±0.037	0.2684	0.071
722	21	004	0.161±0.035	0.077±0.002	0.762±0.032	0.4717	0.221
723	21	005	0.154±0.010	0.145±0.001	0.701±0.008	3.7455*	13.782*
724	21	006	0.133±0.014	0.154±0.001	0.713±0.011	1.8558	3.434
725	21	007	0.146±0.004	0.168±0.000	0.685±0.003	2.1755*	4.816*
726	21	008	0.131±0.010	0.197±0.001	0.672±0.008	-1.3302	1.783
727	21	009	0.123±0.021	0.226±0.002	0.651±0.015	0.0932	0.010
728	21	010	0.185±0.017	0.133±0.001	0.682±0.014	-0.1562	0.024
729	21	011	0.151±0.022	0.187±0.002	0.662±0.017	-0.2938	0.087
730	21	012	0.164±0.024	0.227±0.002	0.609±0.017	-1.3545	1.873
731	21	013	0.187±0.023	0.165±0.002	0.648±0.018	1.5467	2.347
732	21	014	0.061±0.024	0.247±0.001	0.693±0.017	0.5358	0.285
733	21	015	0.122±0.037	0.163±0.002	0.715±0.030	-1.1041	1.243
734	21	016	0.169±0.043	0.127±0.003	0.704±0.037	-0.1747	0.031
735	21	017	0.136±0.028	0.212±0.002	0.652±0.021	1.4865	2.155
736	21	018	0.196±0.019	0.241±0.002	0.563±0.013	-0.0500	0.002
737	21	019	0.119±0.007	0.192±0.000	0.689±0.006	-1.7609*	3.078
738	21	020	0.155±0.010	0.218±0.001	0.627±0.008	-0.6206	0.387
739	21	021	0.051±0.010	0.276±0.001	0.673±0.007	0.0462	0.001
740	21	022	0.133±0.020	0.167±0.001	0.700±0.016	0.4583	0.209
741	22	001	0.176±0.020	0.297±0.002	0.527±0.012	-1.4335	2.102
742	22	002	0.233±0.045	0.114±0.003	0.653±0.039	-2.4332*	6.210*
743	22	003	0.188±0.041	0.163±0.003	0.649±0.033	0.0465	0.002

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
744	22	004	0.150±0.006	0.182±0.000	0.668±0.005	4.2051*	17.432*
745	22	005	0.202±0.025	0.266±0.002	0.532±0.016	0.8322	0.682
746	22	006	0.156±0.008	0.182±0.001	0.662±0.006	1.7417*	3.011
747	22	007	0.170±0.023	0.234±0.002	0.596±0.017	3.1545*	9.438*
748	22	008	0.149±0.027	0.200±0.002	0.651±0.020	0.8470	0.708
749	22	009	0.102±0.032	0.138±0.002	0.760±0.027	1.3195	1.709
750	22	010	0.140±0.021	0.219±0.002	0.641±0.015	1.2376	1.508
751	22	011	0.130±0.021	0.194±0.002	0.676±0.017	0.8168	0.590
752	22	012	0.197±0.028	0.118±0.002	0.685±0.024	0.6471	0.421
753	22	013	0.150±0.027	0.181±0.002	0.669±0.021	1.6876	2.765
754	22	014	0.140±0.049	0.208±0.004	0.651±0.037	0.5613	0.312
755	22	015	0.212±0.051	0.085±0.003	0.703±0.046	0.3456	0.117
756	22	016	0.129±0.019	0.123±0.001	0.748±0.017	0.1368	0.005
757	22	017	0.131±0.020	0.192±0.001	0.676±0.015	-0.0358	0.001
758	22	018	0.131±0.022	0.258±0.002	0.611±0.015	-0.0727	0.005
759	22	019	0.107±0.027	0.297±0.002	0.596±0.017	1.4694	2.097
760	22	020	0.167±0.036	0.338±0.004	0.495±0.019	1.4330	1.961
761	22	021	0.152±0.035	0.067±0.002	0.781±0.032	-0.3451	0.119
762	22	022	0.176±0.038	0.244±0.003	0.580±0.026	-0.1135	0.013
763	22	023	0.173±0.037	0.253±0.003	0.575±0.025	0.8030	0.631
764	22	024	0.199±0.041	0.037±0.002	0.764±0.039	1.0132	1.027
765	22	025	0.149±0.043	0.217±0.003	0.633±0.032	1.9485*	3.601
766	22	026	0.162±0.048	0.162±0.004	0.676±0.039	-0.6689	0.081
767	22	027	0.071±0.034	0.148±0.002	0.780±0.029	-0.5739	0.332
768	22	028	0.122±0.047	0.265±0.004	0.613±0.031	-0.3012	0.092
769	22	029	0.085±0.040	0.284±0.003	0.631±0.026	1.3850	1.844
770	22	030	0.187±0.015	0.236±0.001	0.577±0.010	1.6083	2.545
771	22	031	0.000±0.000	0.222±0.000	0.778±0.000	-0.0296	0.000
772	22	032	0.158±0.014	0.195±0.001	0.647±0.010	-0.6639	0.443
773	22	033	0.192±0.024	0.180±0.002	0.628±0.019	-2.7449*	7.812*

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
774	22	034	0.136±0.019	0.279±0.002	0.534±0.012	0.9844	0.956
775	22	035	0.215±0.026	0.166±0.002	0.619±0.021	0.0251	0.001
776	22	036	0.144±0.012	0.233±0.001	0.624±0.009	0.5863	0.351
777	22	037	0.152±0.011	0.178±0.001	0.670±0.008	0.5408	0.409
778	22	038	0.160±0.016	0.244±0.001	0.597±0.011	1.1061	1.198
779	22	039	0.121±0.013	0.197±0.001	0.682±0.010	-1.0581	1.172
780	22	040	0.182±0.039	0.160±0.003	0.657±0.031	1 5145	2.224
781	22	041	0.136±0.011	0.242±0.001	0.621±0.008	-0.3193	0.726
782	22	042	0.137±0.039	0.034±0.002	0.729±0.035	-0.2153	0.046
783	22	043	0.157±0.006	0.231±0.000	0.612±0.004	-0.3322	0.694
784	22	044	0.163±0.030	0.222±0.002	0.615±0.022	0.5364	0.288
785	22	045	0.150±0.034	0.310±0.003	0.540±0.020	-0.1742	0.030
786	22	046	0.201±0.028	0.140±0.002	0.659±0.023	-0.1475	0.022
787	22	047	0.114±0.015	0.217±0.001	0.669±0.011	-0.3921	0.802
788	22	048	0.217±0.032	0.170±0.003	0.613±0.026	-0.0593	0.004
789	22	049	0.152±0.023	0.194±0 002	0.654±0.018	-0.6471	0.422
790	22	050	0.168±0.014	0.150±0.001	0.603±0.011	2.1510*	1.564*
791	22	051	0.125±0.013	0.252±0.001	0.624±0.009	-0.0180	0.000
792	22	052	0.000±0.000	0.293±0.000	0.707±0.000	0.0000	0.000
793	22	053	0.175±0.025	0.194±0.002	0.630±0.019	-0.1319	0.009
794	22	054	0.149±0.031	0.226±0.003	0.625±0.022	-0.6605	0.409
795	22	055	0.112±0.032	0.134±0.002	0.754±0.027	0.5305	0.326
796	22	056	0.198±0.032	0.378±0.003	0.424±0.014	-0.6529	0.414
797	22	057	0.007±0.003	0.229±0.000	0.764±0.002	-3.5253	12.485*
798	22	058	0.147±0.036	0.158±0.003	0.695±0.030	-1.2400	1.574
799	22	059	0.159±0.034	0.199±0.003	0.641±0.026	1.2056	1.412
800	22	060	0.153±0.036	0.310±0.002	0.538±0.016	1.9626*	3.702
801	22	061	0.281±0.064	0.129±0.005	0.590±0.054	0.0931	0.009
802	22	062	0.173±0.030	0.375±0.003	0.452±0.014	1.3410	1.739
803	22	063	0.011±0.003	0.236±0.000	0.753±0.002	-0.0958	0.009

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
804	23	001	0.197±0.030	0.210±0.003	0.593±0.022	-1.6102	2.671
805	23	002	0.157±0.040	0.455±0.004	0.388±0.009	-1.0527	1.189
806	23	003	0.218±0.031	0.111±0.002	0.671±0.027	-0.6367	0.409
807	23	004	0.319±0.030	0.210±0.003	0.471±0.021	0.6296	0.394
808	23	005	0.230±0.026	0.298±0.003	0.472±0.015	0.1753	0.031
809	23	006	0.248±0.027	0.333±0.003	0.420±0.014	1.0025	0.982
810	23	007	0.215±0.014	0.331±0.001	0.454±0.007	1.0374	1.062
811	24	001	0.148±0.026	0.371±0.002	0.481±0.012	0.5213	0.271
812	24	002	0.180±0.006	0.262±0.001	0.558±0.004	2.7122*	7.272*
813	24	003	0.191±0.010	0.239±0.001	0.569±0.007	2.1657*	4.586*
814	24	004	0.180±0.027	0.262±0.003	0.559±0.018	-1.0935	1.222
815	24	005	0.170±0.027	0.249±0.002	0.581±0.018	-1.3714	1.928
816	24	006	0.191±0.026	0.249±0.002	0.559±0.018	-0.4496	0.204
817	24	007	0.131±0.020	0.259±0.002	0.609±0.014	0.6505	0.420
818	24	008	0.150±0.020	0.255±0.002	0.595±0.013	1.9904*	3.856*
819	24	009	0.163±0.024	0.250±0.002	0.587±0.017	-1.0059	1.029
820	24	010	0.191±0.019	0.332±0.002	0.477±0.010	-3.4184*	12.355*
821	24	011	0.181±0.027	0.280±0.003	0.539±0.017	1.0062	0.992
822	24	012	0.185±0.023	0.304±0.002	0.511±0.014	0.1742	0.030
823	24	013	0.275±0.028	0.178±0.003	0.547±0.022	-1.2480	1.592
824	24	014	0.167±0.027	0.218±0.002	0.615±0.020	1.2226	1.464
825	24	015	0.166±0.019	0.265±0.002	0.569±0.012	-0.1568	0.025
826	24	016	0.145±0.018	0.251±0.002	0.603±0.013	1.5600	2.380
827	24	017	0.233±0.020	0.220±0.002	0.547±0.015	-0.7055	0.503
828	24	018	0.189±0.028	0.299±0.003	0.512±0.017	0.4533	0.206
829	24	019	0.203±0.015	0.241±0.001	0.556±0.010	0.1358	0.018
830	24	020	0.208±0.021	0.224±0.002	0.568±0.015	0.7905	0.618
831	24	021	0.205±0.022	0.247±0.002	0.548±0.015	1.7597*	3.009
832	24	022	0.170±0.027	0.260±0.002	0.570±0.018	-1.0826	1.197
833	24	023	0.167±0.011	0.258±0.001	0.575±0.008	0.4543	0.206

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
834	24	024	0.179±0.024	0.289±0.002	0.532±0.015	-1.7072*	3.007
835	24	025	0.241±0.065	0.357±0.007	0.403±0.031	-1.4166	2.419
836	24	026	0.227±0.039	0.228±0.004	0.545±0.027	-0.0482	0.002
837	24	027	0.236±0.046	0.211±0.004	0.553±0.033	-0.5810	0.343
838	24	028	0.169±0.023	0.419±0.002	0.412±0.008	-0.8154	0.679
839	24	029	0.287±0.033	0.208±0.003	0.505±0.024	0.0420	0.002
840	24	030	0.271±0.055	0.236±0.006	0.493±0.038	-0.6842	0.483
841	24	031	0.242±0.064	0.268±0.007	0.490±0.041	0.2731	0.074
842	24	032	0.223±0.027	0.288±0.003	0.489±0.017	1.7882*	3.069
843	24	033	0.359±0.054	0.126±0.005	0.515±0.045	-1.5326	2.455
844	24	034	0.197±0.035	0.288±0.003	0.515±0.021	1.1118	1.198
845	24	035	0.205±0.027	0.268±0.003	0.526±0.018	-0.8280	0.693
846	24	036	0.240±0.031	0.265±0.003	0.495±0.020	-0.8130	0.674
847	24	037	0.163±0.016	0.249±0.001	0.589±0.011	0.1244	0.017
848	24	038	0.193±0.013	0.259±0.001	0.548±0.009	-0.4577	0.210
849	24	039	0.233±0.030	0.282±0.003	0.485±0.019	-0.4907	0.242
850	24	040	0.238±0.028	0.228±0.003	0.533±0.020	0.3586	0.128
851	24	041	0.233±0.049	0.189±0.004	0.578±0.037	-1.4135	2.082
852	24	042	0.299±0.025	0.236±0.003	0.465±0.017	0.9675	0.918
853	24	043	0.151±0.037	0.265±0.003	0.583±0.025	0.0110	0.000
854	24	044	0.267±0.038	0.358±0.005	0.375±0.018	-2.2680*	7.033*
855	24	045	0.267±0.024	0.243±0.003	0.490±0.016	-0.7941	0.640
856	24	046	0.149±0.038	0.285±0.003	0.565±0.024	0.0074	0.000
857	24	047	0.146±0.025	0.254±0.002	0.600±0.017	-0.8042	0.651
858	24	048	0.230±0.031	0.255±0.003	0.514±0.021	0.8559	0.718
859	24	049	0.211±0.025	0.199±0.002	0.590±0.019	-0.8467	0.726
860	24	050	0.143±0.019	0.346±0.002	0.511±0.010	1.2924	1.635
861	24	051	0.150±0.032	0.355±0.003	0.495±0.016	0.6800	0.451
862	24	052	0.246±0.026	0.350±0.003	0.403±0.013	0.3442	0.117
863	24	053	0.171±0.020	0.386±0.002	0.443±0.009	1.5432	2.320

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
864	24	054	0.220±0.025	0.320±0.003	0.460±0.014	-0.5663	0.325
865	24	055	0.156±0.019	0.340±0.002	0.504±0.010	1.2325	1.488
866	24	056	0.199±0.021	0.259±0.002	0.542±0.014	0.8872	0.783
867	24	057	0.150±0.019	0.271±0.002	0.579±0.012	1.3460	1.780
868	24	058	0.108±0.016	0.336±0.001	0.556±0.009	-0.5091	0.261
869	24	059	0.198±0.030	0.297±0.003	0.505±0.018	-0.8588	0.753
870	24	060	0.186±0.054	0.186±0.004	0.628±0.042	-1.6916*	3.011
871	24	061	0.155±0.053	0.416±0.005	0.429±0.020	0.9611	0.879
872	24	062	0.206±0.021	0.330±0.002	0.464±0.012	-0.1124	0.012
873	24	063	0.184±0.018	0.320±0.002	0.496±0.010	0.2511	0.065
874	24	064	0.303±0.027	0.244±0.003	0.453±0.018	-0.0355	0.001
875	24	065	0.256±0.030	0.209±0.003	0.535±0.022	-0.5858	0.347
876	24	066	0.210±0.031	0.243±0.003	0.547±0.021	1.7295*	2.877
877	24	067	0.198±0.036	0.198±0.003	0.603±0.027	1.2813	1.595
878	24	068	0.223±0.031	0.217±0.003	0.560±0.023	-0.9440	0.909
879	24	069	0.285±0.043	0.209±0.004	0.507±0.031	-1.9726*	4.097*
880	24	070	0.152±0.039	0.218±0.003	0.630±0.029	-0.6662	0.451
881	24	071	0.161±0.017	0.257±0.002	0.582±0.012	0.6197	0.381
882	24	072	0.164±0.016	0.260±0.001	0.576±0.010	0.3433	0.117
883	24	073	0.176±0.015	0.287±0.001	0.538±0.009	0.9329	0.861
884	24	074	0.184±0.017	0.285±0.002	0.532±0.011	0.1959	0.038
885	24	075	0.180±0.022	0.249±0.002	0.571±0.015	-0.0754	0.006
886	24	076	0.170±0.013	0.287±0.001	0.544±0.008	-0.8263	0.689
887	24	077	0.178±0.016	0.279±0.002	0.543±0.010	-1.2157	1.500
888	24	078	0.191±0.016	0.256±0.002	0.553±0.011	0.8051	0.642
889	24	079	0.192±0.018	0.275±0.002	0.533±0.012	-0.1121	0.013
890	24	080	0.178±0.024	0.250±0.002	0.571±0.016	-1.6017	2.634
891	24	081	0.271±0.023	0.227±0.002	0.502±0.016	-0.0857	0.007

Table (3.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
892	24	082	0.283±0.032	0.271±0.004	0.446±0.020	0.4501	0.207
893	24	083	0.264±0.028	0.308±0.003	0.428±0.016	-1.6262	2.799
894	24	084	0.239±0.038	0.226±0.003	0.535±0.024	0.1068	0.011
895	24	085	0.181±0.017	0.273±0.002	0.546±0.011	-0 5540	0.309
896	24	086	0.231±0.023	0.272±0.002	0.496±0.015	-0.3850	0.149
897	24	087	0.276±0.036	0.276±0.004	0.447±0.022	-0.3498	0.122
898	24	088	0.270±0.034	0.183±0.003	0.547±0.026	1.9935	3.800
899	24	089	0.261±0.034	0.254±0.004	0.485±0.022	0.8518	0.709

Table 3.3 Zonal classification of the Indian sub-continent

sl. no.	zone	'areas' covered
(1)	(2)	(3)
1.	Northern (N)	Jammu and Kashmir, Himachal Pradesh, Delhi, Haryana, Punjab, Rajasthan, North-West Pakistan, Haryana
2.	Eastern (E)	Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Tripura, Sikkim, West Bengal, Bihar, Orissa, Andaman and Nicobar Islands, Bangladesh
3.	Southern (S)	Andhra Pradesh, Tamilnadu, Kerala, Lakshadweep, Maldives, Sri Lanka
4.	Western (W)	Gujarat, Maharashtra, Goa, Karnataka
5.	Central (C)	Uttar Pradesh, Madhya Pradesh
6.	Himalayan(H)	Bhutan, Tibet, Nepal

Table 3.4 Distribution of data sets by geographical zones

sl. no.	geographical zone	no of data sets	identification nos. of data sets
(1)	(2)	(3)	(4)
1	Northern Zone (N)	87	09001, 09004, 09005, 09007, 09009 to 09013, 17001 to 17004, 17006, 17007, 19002 to 19004, 19007, 19012, 19013, 19018, 19019, 19020, 19023, 19024, 19027 to 19031, 19034 to 19037, 19039, 19043 to 19045, 19049 to 19054, 19056 to 19066, 19068, 19069, 19071 to 19087, 19089 to 19093, 20001, 20004 to 20008.
2	Eastern Zone (E)	180	01001, 01003 to 01008, 01010, 01011, 03002, 03004 to 03012, 03014 to 03024, 03026, 04002 to 04004, 04006, 04008, 04011, 04014 to 04019, 04024, 04026 to 04028, 04031, 04033 to 04040, 04042, 04044 to 04049, 04051 to 04056, 04058 to 04075, 06002 to 06005, 06007 to 06022, 06024, 06027 to 06032, 06035 to 06040, 06042 to 06044, 16001 to 16004, 16006 to 16012, 18002 to 18006, 18008 to 18017, 18019, 18022 to 18027, 18029, 18032 to 18040, 18042, 18045 to 18050, 23001 to 23007.

... contd.

Table 3.4 (contd.)

(1)	(2)	(3)	(4)
3	Southern Zone (S)	115	02002 to 02005, 02007, 02008, 02010 to 02013, 02016 to 02023, 02028, 02030 to 02035, 02037 to 02044, 11001, 11002, 11004, 11006 to 11008, 11012, 11014 to 11026, 11028 to 11032, 11034 to 11039, 11041, 11042, 11044 to 11046, 11049, 11050, 12001, 22001, 22008 to 22014, 22016 to 22020, 22022 to 22029, 22031, 22034 to 22041, 22045, 22048, 22049, 22051, 22052, 22054 to 22056, 22058, 22059, 22061 to 22063.
4	Western Zone (W)	175	07003, 07005, 07007 to 07010, 08001 to 08017, 08019 to 08023, 08025 to 08027, 08029 to 08040, 08042, 10002 to 10010, 14001 to 14030, 14032 to 14034, 14036 to 14043, 14045 to 14052, 14054 to 14062, 14064 to 14073, 14076 to 14078, 14080 to 14084, 14086 to 14091, 14093 to 14095, 14097 to 14120, 14122 to 14125, 14127 to 14132, 14135 to 14137.
5	Central Zone (C)	115	13002 to 13008, 13010 to 13015, 13017 to 13019, 13021 to 13025, 13028, 13031 to 13042, 13044 to 13046, 24004 to 24007, 24009, 24011 to 24015, 24017 to 24022, 24024 to 24041, 24043, 24046 to 24068, 24070 to 24089.
6	Himalayan Zone (H)	26	05002, 05004 to 05008, 05010 to 05030.
	TOTAL	698	

Table 3.5 Distribution of data sets by socio-religious categories

sl. no.	socio-religious category	no. of data sets	identification nos. ofdata sets
(1)	(2)	(3)	(4)
1	Upper Caste (UC)	70	02039, 03021, 04003, 04016, 04027, 04033, 04046, 04055, 04060, 04070, 08007, 08015, 08025, 08039, 09005, 09013, 10004, 10005, 10006 to 10009, 11045, 13028, 13042, 14006 to 14008, 14020 to 14023, 14064, 14066, 14083, 14084, 14086 to 14090, 14105 to 14107, 14131, 14132, 18023, 18032, 19013, 19019, 19024, 19027, 19051, 19057, 19058, 19069, 19083, 22011, 22017, 22040, 22048, 22049, 24020, 24021, 24030, 24036, 24049, 24065, 24080, 24087.
2	Middle Caste (MC)	229	02028, 02032 to 02035, 03019, 03020, 04004, 04014, 04015, 04024, 04026, 04028, 04034, 04051 to 04053, 04058, 04059, 04068, 04069, 05011, 05024, 06015, 06016, 06043, 07003, 07007 to 07010, 08004 to 08006, 08011, 08012, 08016, 08022, 08026, 08029, 08037, 08038, 08040, 08042, 09001, 11002, 11006, 11037, 11039, 11046, 13008, 13023, 13034 to 13036, 13038, 13041, 13044, 13045, 14001 to 14005, 14009,

... contd.

Table 3.5 (contd)

(1)	(2)	(3)	(4)
			14010, 14024, 14026 to 14028, 14030, 14032 to 14034, 14036, 14039 to 14043, 14046 to 14052, 14054 to 14061, 14067, 14070 to 14072, 14077, 14078, 14097, 14108 to 14120, 14122 to 14125, 14127, 14128, 14130, 18022, 18029, 18033, 18034, 18047, 18048, 19002, 19003, 19012, 19018, 19020, 19023, 19028, 19030, 19031, 19034 to 19037, 19039, 19044, 19045, 19049, 19050, 19052 to 19054, 19056, 19059 to 19066, 19068, 19071 to 19075, 19079, 19080, 19082, 19086, 19089, 19091 to 19093, 20001, 20004 to 20008, 20010, 22010, 22020, 22022, 22023, 22026 to 22029, 22034 to 22039, 24005, 24006, 24019, 24022, 24025, 24029, 24031 to 24033, 24035, 24040, 24041, 24043, 24047, 24048, 24055 to 24060, 24064, 24067, 24068, 24071 to 24079, 24085, 24088.
3	Lower Caste (LC)	48	03022, 04006, 04011, 04018, 04035 to 04037, 04039, 04047 to 04049, 04063, 04065 to 04067, 04071 to 04073, 08017, 08023, 10010, 13007, 13024, 13039, 14011 to 14016, 14025, 14038, 14045, 14068, 14069, 14076, 14081, 14129, 18050, 19090, 24007, 24009, 24034, 24050, 24081 to 24084.

... contd.

Table 3.5 (contd.)

(1)	(2)	(3)	(4)
4	Muslim (MU)	34	02007, 02031, 03023, 03024, 04002, 04008, 04017, 04038, 04040, 04044, 04045, 04054, 06035, 08009, 08010, 09004, 09007, 13040, 17001 to 17004, 17006, 17007, 18017, 19004, 19007, 22013, 22016, 22051, 24004, 24014, 24015, 24046.
5	Christian/Anglo-Indian (CH)	16	02008, 02030, 04019, 04031, 06036, 07005, 11004, 11032, 11038, 11049, 14073, 18019, 22008, 22009, 22014, 22018.
6	Parsee (PA)	3	14082, 14091, 14098.
7	Australoid Tribe (AT)	167	01004, 02002, 02004, 02005, 02013, 02016 to 02021, 02023, 02037, 02038, 02041 to 02044, 04061, 04062, 04064, 04075, 06002 to 06005, 06007 to 06014, 06017 to 06022, 06027 to 06032, 06037 to 06040, 06042, 06044, 08008, 08013, 08019 to 08021, 08027, 08030 to 08036, 10002, 10003, 11001, 11007, 11008, 11012, 11015 to 11026, 11028 to 11031, 11034, 11036, 11041, 11044, 11050, 12001, 13002 to 13006, 13010, 13011, 13013 to 13015, 13017 to 13019, 13021, 13022, 13025, 13031 to 13033, 14017 to 14019, 14029,

... contd.

Table 3.5 (contd.)

(1)	(2)	(3)	(4)
			14037, 14062, 14065, 14080, 14093 to 14095, 14099 to 14104, 14135 to 14137, 18002 to 18006, 18008 to 18016, 18024 to 18027, 18035 to 18039, 18042, 18045, 18046, 22054, 22055, 22058, 22059, 22061, 24013, 24086, 24089.
8	Mongoloid Tribe (MT)	71	01003, 01006 to 01008, 01010, 01011, 03002, 03004 to 03012, 03014 to 03018, 03026, 04074, 05002, 05004 to 05008, 05010, 05012 to 05020, 05023, 05025 to 05030, 16001 to 16004, 16006 to 16012, 23001 to 23007, 24011, 24028, 24051 to 24054, 24062, 24063.
9	Caucasoid Tribe (CT)	11	02003, 02010 to 02012, 02022, 22001, 22031, 22052, 22056, 22062, 22063.
10	Negrito Tribe (NT)	2	01001, 01005.
	TOTAL	651	

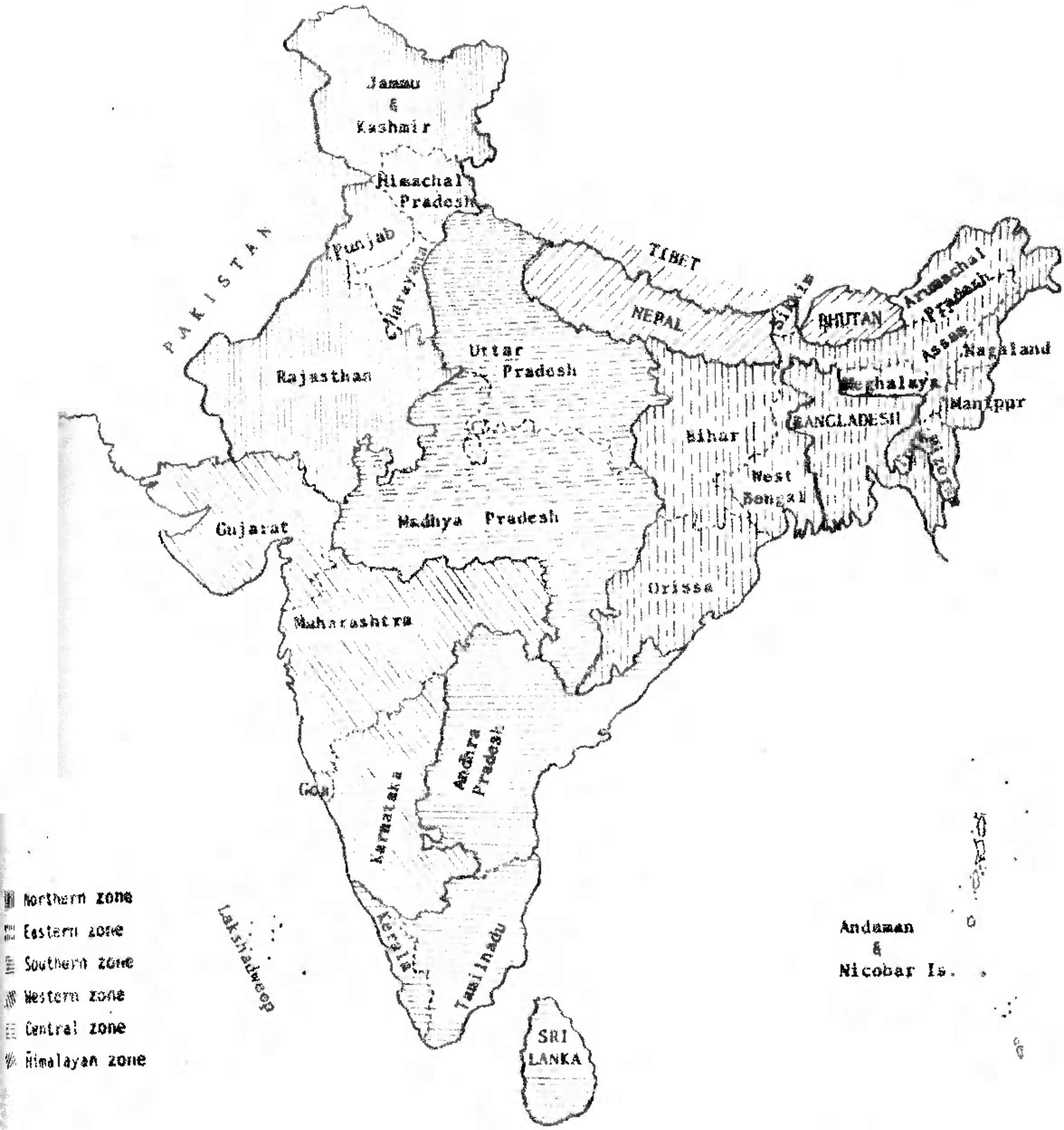


Figure 3.1 The Indian sub-continent and its zonal divisions

CHAPTER IV

STATISTICAL METHODS USED

4.1 Estimation of gene frequencies and standard errors

Suppose in a random sample of size n, the frequencies of blood groups O, A, B and AB are n_1, n_2, n_3 and n_4, respectively. Let p, q and r be the A, B and O gene frequencies in the population from which the samples are drawn. Assuming that the population is panmictic, the relative expected frequencies of the four blood groups in the population are as given below :

phenotype	relative frequency
O	$\pi_1 = r^2$
A	$\pi_2 = p^2 + 2pr$
B	$\pi_3 = q^2 + 2qr$
AB	$\pi_4 = 2pq$

(4.1.1)

Under this set-up, the likelihood, L, of the sample is :

$$L = \frac{n!}{n_1!\, n_2!\, n_3!\, n_4!} \pi_1^{n_1} \pi_2^{n_2} \pi_3^{n_3} \pi_4^{n_4} . \quad (4.1.2)$$

For the purpose of obtaining the maximum likelihood estimates of the parameters p, q and r, the scoring method (Rao, 1952) was used, which is described below.

In this iterative procedure, an iteration is started with an approximation p^*, q^* and r^* $(= 1 - p^* - q^*)$ for the parameters. The initial approximations are :

$$\left.\begin{aligned} p^* &= \left(1 - \sqrt{\frac{n_1+n_3}{n}}\right)(1 + D/2) \\ q^* &= \left(1 - \sqrt{\frac{n_1+n_2}{n}}\right)(1 + D/2) \\ r^* &= 1 - p^* - q^* , \end{aligned}\right\} \quad (4.1.3)$$

where $D = \sqrt{\frac{n_1+n_3}{n}} + \sqrt{\frac{n_1+n_2}{n}} - \sqrt{\frac{n_1}{n}} - 1$

Each cycle of iteration then consists of the following steps :

First, the 'scores' are calculated at $p = p^*$, $q = q^*$, $r = r^*$, which are defined as :

$$\phi_p = \frac{\partial \log L}{\partial p} = \sum_{i=1}^{4} \frac{n_i}{\pi_i} \left(\frac{\partial \pi_i}{\partial p}\right), \quad (4.1.4)$$

and

$$\phi_q = \frac{\partial \log L}{\partial q} = \sum_{i=1}^{4} \frac{n_i}{\pi_i} \left(\frac{\partial \pi_i}{\partial q}\right)$$

4.3

where the partial derivatives are :

$$\left.\begin{array}{ll} \partial\pi_1/\partial p = -2r, & \partial\pi_2/\partial p = 2r, \\ \partial\pi_3/\partial p = -2q, & \partial\pi_4/\partial p = 2q, \\ \partial\pi_1/\partial q = -2r, & \partial\pi_2/\partial q = -2p, \\ \partial\pi_3/\partial q = 2r, & \partial\pi_4/\partial q = 2p. \end{array}\right\} \quad (4.1.5)$$

The maximum likelihood estimates are required to satisfy the equations $\phi_p = \phi_q = 0$. Consequently, no further iterations are required if simultaneously $|\phi_p| < \varepsilon$ and $|\phi_q| < \varepsilon$, where ε is a preassigned small positive number, and $p = p^*$ and $q = q^*$ are accepted as the maximum likelihood estimates of p and q, respectively.

Asymptotically as $n \to \infty$, $\sqrt{n}\,\{(\hat{p}-p), (\hat{q}-q)\}$ follows a bivariate normal distribution with expectations zero and dispersion matrix $\mathcal{I}^{-1} = \begin{bmatrix} I^{pp} & I^{pq} \\ I^{qp} & I^{qq} \end{bmatrix}$,

where the elements of the information matrix (per unit observation) $\mathcal{I} = \begin{bmatrix} I_{pp} & I_{pq} \\ I_{qp} & I_{qq} \end{bmatrix}$ are given by :

$$\left.\begin{array}{l} I_{pp} = \sum_{i=1}^{4} \frac{1}{\pi_i} (\partial\pi_i/\partial p)^2 = \sum_{i=1}^{4} (\partial\pi_i/\partial p)\left(\frac{1}{\pi_i} \cdot \frac{\partial\pi_i}{\partial p}\right) \\ I_{pq} = I_{qp} = \sum_{i=1}^{4} \frac{1}{\pi_i} (\partial\pi_i/\partial p)(\partial\pi_i/\partial q), \text{ and} \\ I_{qq} = \sum_{i=1}^{4} (\partial\pi_i/\partial q)\left(\frac{1}{\pi_i} \cdot \frac{\partial\pi_i}{\partial q}\right). \end{array}\right\} \quad (4.1.6)$$

Obviously,

$$\left.\begin{aligned} I^{pp} &= I_{qq}/D, \\ I^{pq} &= I^{qp} = -\, I_{pq}/D, \text{ and} \\ I^{qq} &= I_{pp}/D, \end{aligned}\right\} \quad (4.1.7)$$

where $D = I_{pp}\ I_{qq} - I^2_{pq}$.

The variances of the maximum likelihood estimates are :

$$\left.\begin{aligned} V(\hat{p}) &= I^{\hat{p}\hat{p}}/n, \\ V(\hat{q}) &= I^{\hat{q}\hat{q}}/n, \text{ and} \\ V(\hat{r}) &= [I^{\hat{p}\hat{p}} + 2\, I^{\hat{p}\hat{q}} + I^{\hat{q}\hat{q}}]/n \end{aligned}\right\} \quad (4.1.8)$$

If the conditions $|\phi_p| < \varepsilon$ and $|\phi_q| < \varepsilon$ are not simultaneously satisfied, the additive corrections at $p = p^*$, $q = q^*$ and $r = r^*$ are computed. These are given as :

$$\left.\begin{aligned} \delta p &= \frac{I^{pp}.\phi_p + I^{pq}.\phi_q}{n}, \\ \text{and,} \quad \delta q &= \frac{I^{pq}.\phi_p + I^{qq}.\phi_q}{n}. \end{aligned}\right\} \quad (4.1.9)$$

The improved approximations are :

$$p^{**} = p^* + \delta p, \quad q^{**} = q^* + \delta q, \text{ and } r^{**} = 1 - p^{**} - q^{**}.$$

The cycle of iteration is repeated until the 'scores' (ignoring their sign) are less than ε.

4.2 Tests for detecting excess/deficiency of blood group AB in a given sample

To examine whether there is an excess/deficiency of blood group AB in a sample of size n over that expected under Hardy-Weinberg equilibrium, one can use the statistic (Kopeć, 1970) :

$$D = \sqrt{\frac{n_1+n_2}{n}} + \sqrt{\frac{n_1+n_3}{n}} - \sqrt{\frac{n_1}{n}} - 1 \qquad (4.2.1)$$

The sign of D is positive or negative according as whether there is a deficiency or an excess of AB blood group individuals in the sample. The significance of the deviation of the observed frequency of AB blood group individuals over that expected under Hardy-Weinberg equilibrium can be tested by carrying out a normal deviate test.

Asymptotically as $n \rightarrow \infty$, $D/\sigma^2(D)$ follows (under the Hardy-Weinberg equilibrium) a normal distribution with expectation zero and variance unity. The asymptotic variance of D is :

$$\sigma^2(D) = pq/\left[2n(1-p)(1-q)\right], \qquad (4.2.2)$$

where, $p = (1 - \sqrt{(n_1+n_3)/n})\ (1 + \frac{1}{2} D)$,

and $q = (1 - \sqrt{(n_1+n_2)/n})\ (1 + \frac{1}{2} D)$.

4.3 Testing Hardy-Weinberg equilibrium

To test the hypothesis of Hardy-Weinberg equilibrium, namely,

$$H_0 : E(n_i) = n\,\pi_i \quad (i = 1,2,3,4),$$

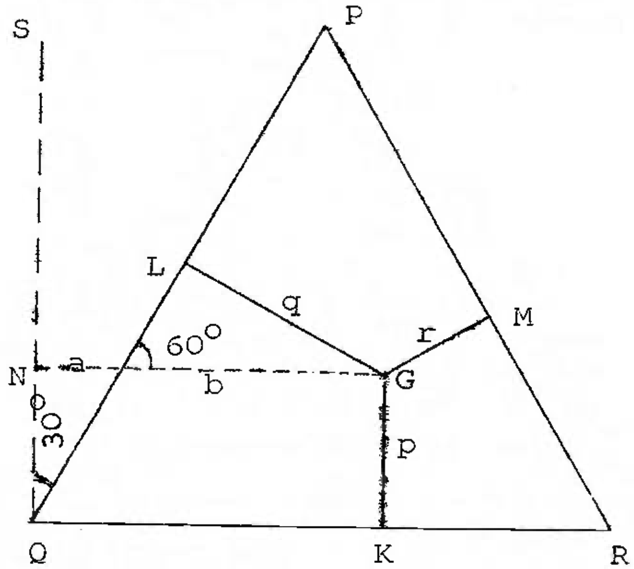
where π_i's are given by (4.1.1), we use the test statistic :

$$\chi^2_{HW} = \sum_{i=1}^{4} \frac{(n_i - e_i)^2}{e_i}, \qquad (4.3.1)$$

where, $e_i = n\hat{\pi}_i$ and $\hat{\pi}_i = \pi_i$, computed at the values $\hat{p}, \hat{q}, \hat{r}$ $(i = 1,2,3,4)$. Under H_0, χ^2_{HW} follows asymptotically a chi-square distribution with 1 d.f. The hypothesis H_0 is rejected at the 5% level of significance if $\chi^2_{HW} > 3.84$, and at the 1% level of significance if $\chi^2_{HW} > 6.63$.

4.4 Graphical representation of gene frequencies

As is well known (Li, 1955) the gene frequencies p, q and r of the ABO blood group system can be represented by a point inside an equilateral triangle of unit altitude such that the lengths of the perpendiculars drawn to the sides represent the gene frequencies. For plotting the gene frequencies one needs a graph paper indicating trilinear co-ordinates. However, this may not always be available. It is, therefore, desirable to transform the gene frequencies to rectangular co-ordinates. This can easily be done as follows:



In the figure given above, PQR is an equilateral triangle of unit length. G is a point such that the heights of the perpendiculars GK, GL and GM are p, q and r, respectively. Let QS be perpendicular to QR, and let NG be perpendicular to QS. Let the rectangular co-ordinates of the point G with respect to QR as the X-axis and QS as the Y-axis be (p^*, q^*). Then,

$$p^* = a+b = p.\tan 30^o + q/\sin 60^o = \frac{1}{\sqrt{3}} (p+2q),$$

$$\text{and} \quad q^* = p \qquad (4.4.1)$$

Hence, given gene frequencies p, q and r, the transformation given in (4.4.1) can be used and (p^*, q^*) can be drawn on a rectangular co-ordinate graph, on which the equilaterial triangle can be drawn.

4.5 Confidence set for gene frequencies

Having plotted the gene frequencies of data sets on a triangular chart, it is useful to indicate the margin of error associated with the location of a point on the chart, since two points on the chart may appear to be distant merely because of sampling fluctuations.

In this section, a statistical procedure for obtaining the confidence set for gene frequencies will be described.

Let $(\hat{p}, \hat{q})$ be the maximum likelihood estimates of A and B gene frequencies (p, q) based on a large sample of size n. Then, it is well-known that asymptotically as $n \to \infty$, $\sqrt{n}\,\{(p-\hat{p}),\ (q-\hat{q})\}$ follows a bivariate normal distribution with expectations zero and dispersion-matrix $\mathcal{I}^{-1} = \begin{pmatrix} I^{pp} & I^{pq} \\ I^{qp} & I^{qq} \end{pmatrix}$, which is the inverse of the information matrix (per unit observation) $\mathcal{I} = \begin{pmatrix} I_{pp} & I_{pq} \\ I_{qp} & I_{qq} \end{pmatrix}$, where the elements I_{pq}, etc., are given by (4.1.6).

Consequently,

$$T = n\left[I_{pp}(p-\hat{p})^2 + 2I_{pq}(p-\hat{p})(q-\hat{q}) + I_{qq}(q-\hat{q})^2\right], \qquad \text{....(4.5.1)}$$

follows, asymptotically as $n \to \infty$, a chi-square distribution with 2 degrees of freedom.

Thus, if $C = -2 \log_e(1-\alpha)$, then

$$\text{Prob}\left(T \leq C\right) = \alpha. \qquad (4.5.2)$$

Hence, given $(\hat{p},\hat{q})$, the set of points (p,q) satisfying $T \leq C$, provides a confidence region with confidence coefficient α. The confidence region corresponding to a point on the triangular chart can also be shown on the chart.

Since for a large sample size the information matrix computed at the estimated values $(\hat{p},\hat{q})$ tends to the information matrix computed at the true values (p,q), in practice, the confidence region obtained by (4.5.2) can be replaced by an elliptical confidence region as the set of points satisfying .

$$\left\{ \hat{I}_{pp}(p-\hat{p})^2 + 2\hat{I}_{pq}(p-\hat{p})(q-\hat{q}) + \hat{I}_{qq}(q-\hat{q})^2 \right\} \leq \frac{C}{n}, \qquad (4.5.3)$$

where, $\hat{I}_{pp}$, etc., denote the values of I_{pp}, etc., computed at $(\hat{p},\hat{q})$.

For practical purposes, however, it is almost impossible to indicate the confidence region associated with every point on the triangular chart. In the present study, therefore, on each triangular chart the confidence ellipses around the pooled gene frequencies have been presented for n = 100, 200 and 400.

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In order to illustrate this procedure, the data sets belonging to the Nortnern zone are considered. There are 87 data sets in this zone. The serial numbers of these 87 data sets have been presented in Table 3.4. Let n_i, $n_i^{(1)}$, $n_i^{(2)}$, $n_i^{(3)}$ and $n_i^{(4)}$, denote the sample size and the absolute frequencies of blood groups O, A, B and AB, respectively, for the i-th data set, $i = 1,2,\ldots,87$. Let the A, B and O gene frequencies for the i-th data set be denoted as p_i, q_i and r_i $(= 1 - p_i - q_i)$, respectively. For this zone, the pooled sample size and the absolute frequencies of the 4 blood groups are :

$$n_o = \Sigma\, n_i = 22495,$$

$$n_o^{(1)} = \Sigma\, n_i^{(1)} = 6661,$$

$$n_o^{(2)} = \Sigma\, n_i^{(2)} = 5536,$$

$$n_o^{(3)} = \Sigma\, n_i^{(3)} = 8179,$$

and, $$n_o^{(4)} = \Sigma\, n_i^{(4)} = 2119.$$

The pooled A, B and O gene frequencies, denoted as p_o, q_o and r_o, respectively, which were computed by the maximum likelihood method from the pooled blood group frequencies are :

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$p_o = 0.188 \pm 0.002,$

$q_o = 0.264 \pm 0.000,$

and, $r_o = 0.548 \pm 0.001.$

Having computed the pooled gene frequencies, the information matrix of p and q at $p = p_o$ qnd $q = q_o$ was then computed. The formulae for computing the information matrix have been presented in equations (4.1.6). For this zone, the information matrix at p_o and q_o, $I_{(p_o, q_o)}$ turned out to be :

$$I_{(p_o,q_o)} = \begin{pmatrix} \sigma^{11} & \sigma^{12} \\ \sigma^{21} & \sigma^{22} \end{pmatrix} = \begin{pmatrix} 12.561 & 2.681 \\ 2.681 & 9.356 \end{pmatrix}.$$

For a fixed sample size n, in order to find the boundary of the 95% confidence ellipse around (p_o, q_o), one has to calculate sets of values of p and q satisfying the equation :

$$n\left[(p-p_o)^2\ \sigma^{11} + 2(p-p_o)(q-q_o)\sigma^{12} + (q-q_o)^2\ \sigma^{22}\right] = \alpha, \tag{4.5.4}$$

where $\alpha = 5.99$, is the upper 95% point of the chi-square distribution with 2 degrees of freedom.

To solve equation (4.5.4) it is rewritten as :

$$x_1^2\ \sigma^{11} + 2x_1x_2\ \sigma^{12} + x_2^2\ \sigma^{22} = \alpha, \tag{4.5.5}$$

where $x_1 = p-p_o$ and $x_2 = q-q_o$.

Now, for a fixed $x_2 = t$, equation (4.5.5) can be written as :

$$Ax_1^2 + 2Bx_1 + C = 0, \tag{4.5.6}$$

where $A = \sigma^{11}$, $B = t\,\sigma^{22}$ and $C = t^2\,\sigma^{22} - \alpha$.

The solutions of equation (4.5.6) are :

$$x_1 = (-B \pm \sqrt{B^2 - AC})/A \tag{4.5.7}$$

Thus,

$$x_1^{(1)} = (-B + \sqrt{B^2 - AC})/A \text{ and } x_2 = t,$$

and, $$x_1^{(2)} = (-B - \sqrt{B^2 - AC})/A \text{ and } x_2 = t,$$

will satisfy equation (4.5.6).

Hence, the two sets of values :

$$p_1 = (x_1^{(1)}/\sqrt{n}) + p_o \text{ and } q = (x_2/\sqrt{n}) + q_o,$$

and, $$p_2 = (x_1^{(2)}/\sqrt{n}) + p_o \text{ and } q = (x_2/\sqrt{n}) + q_o, \tag{4.5.8}$$

will both satisfy equation (4.5.4).

The values of p_1, p_2 and q for $n = 100$, 200 and 400 have been given in Table 4.1. In Figure 5.1 the 87 (p_i, q_i) values (p_o, q_o) and the confidence ellipses for $n = 100$, 200 and 400 have also been plotted.

4.6 Test for homogeneity of gene frequencies

The chi-square test used for testing the homogeneity of gene frequencies is described below :

Suppose there are k population groups. Let, for the i-th group, n_i, p_i and q_i denote the sample size, and the estimated A and B gene frequencies, respectively, $i = 1,2,\ldots,k$. Let $\underset{\sim}{x}_i = (\hat{p}_i, \hat{q}_i)$. Let the true values of A and B gene frequencies for the i-th group be $\underset{\sim}{\theta}_i = (p_i, q_i)$.

To test : H_o $(\underset{\sim}{\theta}_1 = \underset{\sim}{\theta}_2 = \ldots = \underset{\sim}{\theta}_k = \underset{\sim}{\theta})$

Under H_o, the statistic $T_i = \sqrt{n_i}\,(\underset{\sim}{x}_i - \underset{\sim}{\theta}) \sim N(0, \mathcal{J}^{-1})$, where $\mathcal{J}$ is the information matrix, $i = 1,2,\ldots,k$, and '$\sim$' denotes 'asymptotically distributed as'.

Therefore, $T = \sum_{i=1}^{k} n_i\,(\underset{\sim}{x}_i - \underset{\sim}{\theta})\,\mathcal{J}\,(\underset{\sim}{x}_i - \underset{\sim}{\theta})' \sim \chi^2_{2k}$.

Since $\underset{\sim}{\theta}$ is unknown, we estimate $\underset{\sim}{\theta}$ as :

$$\hat{\underset{\sim}{\theta}} = \sum_{i=1}^{k} n_i\,\underset{\sim}{x}_i \Big/ \sum_{i=1}^{k} n_i\,.$$

Then, $\hat{T} = \sum_{i=1}^{k} n_i\,(\underset{\sim}{x}_i - \hat{\underset{\sim}{\theta}})\,I\,(\underset{\sim}{x}_i - \hat{\underset{\sim}{\theta}})' \sim \chi^2_{2k-2}$, where $I = \begin{pmatrix} I_{pp} & I_{pq} \\ I_{pq} & I_{qq} \end{pmatrix}$

is the information matrix evaluated at $\underset{\sim}{\theta} = \hat{\underset{\sim}{\theta}} = (\hat{p}, \hat{q})$.

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The statistic $\hat{T}$ reduces to

$$\hat{T} = \sum_{i=1}^{k} n_i \left[(\hat{p}_i-\hat{p})^2 \hat{I}_{pp} + 2(\hat{p}_i-\hat{p})(\hat{q}_i-\hat{q}) \hat{I}_{pq} + (\hat{q}_i-\hat{q})^2 \hat{I}_{qq}\right]$$

$$= \left[\hat{I}_{pp} \sum_{i=1}^{k} n_i \hat{p}_i^2 + 2 \hat{I}_{pq} \sum_{i=1}^{k} n_i \hat{p}_i \hat{q}_i + \hat{I}_{qq} \sum_{i=1}^{k} n_i \hat{q}_i^2\right]$$

$$- n \left[\hat{I}_{pp} \hat{p}^2 + 2 \hat{I}_{pq} \hat{p}\hat{q} + \hat{I}_{qq} \hat{q}^2\right], \text{ where } n = \sum_{i=1}^{k} n_i .$$

$$\sim \chi^2_{2k-2} ,$$

4.7 Cluster analysis and linear representation of dendrograms

Cluster analysis is a technique of arranging a given finite collection of 'entities' or 'points' into subsets called 'clusters', such that points belonging to a cluster are in some sense 'closer' together than those belonging to different clusters. For this purpose a measure of 'distance' between every pair of points is required. In this study the entities or points are the population groups and the distance between any two of them is to be measured in terms of their ABO gene frequencies. The particular measure adopted in this paper for finding the distance, D, between two population groups with ABO gene frequencies (p_1, q_1, r_1) and (p_2, q_2, r_2) is

$$D = \text{arc cos } (\sqrt{p_1 p_2} + \sqrt{q_1 q_2} + \sqrt{r_1 r_2}), \qquad (4.7.1)$$

after Bhattacharyya (1946). Though there are various other measures of distance available (Rao, 1977), there seems to be no single rational criterion for choice amongst them. The Bhattacharyya distance is based on a geometrical representation of the two population groups as points with co-ordinates $(\sqrt{p_1}, \sqrt{q_1}, \sqrt{r_1})$ and $(\sqrt{p_2}, \sqrt{q_2}, \sqrt{r_2})$ on the unit sphere and the distance is defined as the angle subtended by these two points at the centre of the unit sphere.

The particular algorithm adopted in this study for formation of clusters is known as the method of single linkage. In this method one starts with N points 1,2,...,N, and distances $d(i,j)$ between the i-th and the j-th points, $i \neq j = 1,\ldots,N$. At the initial, or the 0-th step, each point is considered as a single point cluster, so that there are N clusters, $C_i^{(0)} \equiv i$, $i = 1,\ldots,N$. At each of the succeeding stages, two of the clusters of the previous stage which are 'nearest' to each other are merged to form one cluster, while the other clusters of the previous stage are retained as separate clusters, thereby reducing the total number of clusters by unity at each stage. For this purpose, the distance between two clusters is defined as the minimum distance between two points one belonging to each cluster. Thus at the k-th step one gets a total of N-k clusters which may be denoted as $C_j^{(k)}$, $j = 1,\ldots,N-k$, with a possible maximum of (k+1) points in one of the clusters, $k = 0,1,..,N-1$.

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The single linkage method is illustrated here by considering 21 population groups - the Upper Caste Hindus of the Western region forming the subset W-UC, which were found to be internally heterogeneous. The matrix of pair-wise distances amongst these was first computed. For example, the ABO gene frequencies for the data sets 08007 and 08039 are, respectively, ($p_1 = 0.143$, $q_1 = 0.194$, $r_1 = 0.663$) and ($p_2 = 0.201$, $q_2 = 0.243$, $r_2 = 0.556$), and the Bhattacharyya distance between them was computed as

$$D_{12} = \text{arc cos } (\sqrt{p_1 p_2} + \sqrt{q_1 q_2} + \sqrt{r_1 r_2})$$

$$= \text{arc cos } (0.99381) = 6.38$$

The distances between other pairs of population groups were similarly computed.

At the initial or the 0-th step, the single-point clusters are the individual data sets, and are denoted as

$$C_i^{(0)}, \quad i = 1, \ldots, 21.$$

At the 1-st step, in the matrix of pair-wise distances amongst the 21 points, the distance 0.35 between the data sets 08007 and 10007 was the smallest. These two were combined to form the 2-point cluster .

$$C^{(1)} \equiv C_1^{(1)} = \{08007, \ 10007\}$$

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and the remaining 19 single-point clusters were retained as separate clusters, and renamed $C_i^{(1)}$, $i = 2, \ldots, 20$. The pair-wise distances amongst these 20 new clusters were re-named.

At the 2-nd step, it was found that the distance 0.44 between two single-point clusters 14007 and 14066 was the smallest and these were combined together to form another new two-point cluster :

$$C^{(2)} \equiv C_{(1)}^{(2)} = \{14007,\ 14066\}.$$

The other two-point cluster at this stage was $C_2^{(2)} = C^{(1)}$, and the remaining 17 single-point clusters were retained as separate clusters and renamed $C_i^{(2)}$, $i = 3, \ldots, 19$. The pair-wise distances amongst these 19 clusters were recomputed.

Proceeding in this way, at the 20-th step, all the 21 points were combined into a single cluster. The positions at the intermediate steps have been presented in columns (1)-(4) of Table 4.2, where for each step the composition of the new cluster formed at that stage has been shown, together with the distance between the two clusters of the previous stage forming the new cluster.

A geometrical representation showing how the points and clusters are combined at each stage, indicating at the same time the distance between the two clusters combined at

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each stage to form a new cluster, as in Figure 4.1 for the Western Upper Castes is called a dendrogram. It is convenient to represent a dendrogram as a linear list as shown below.

From Table 4.2, as well as Figure 4.1, it is seen that the last cluster $c^{(20)}$ comprises the cluster $c^{(19)}$ and the point 10006, and the distance between the last two is 2.61. This may be represented as

$$c^{(20)} \rightarrow (c^{(19)},\ 10006 : 2.61)$$

Similarly, the cluster $c^{(19)}$ is formed of $c^{(18)}$ and $c^{(11)}$ at a distance 2.46, so that

$$c^{(19)} \rightarrow (c^{(18)},\ c^{(11)} : 2.46)$$

and combining the two, we get

$$c^{(20)} \rightarrow ((c^{(18)},\ c^{(11)} : 2.46),\ 10006 : 2.61)$$

Again,

$$c^{(18)} \rightarrow (c^{(17)},\ c^{(15)} : 2.17)$$

and

$$c^{(11)} \rightarrow (c^{(9)},\ 08025 : 1.52)$$

so that

$$c^{(20)} \rightarrow (((c^{(17)},\ c^{(15)} : 2.17),$$
$$(c^{(19)},\ 08025 : 1.52) : 2.46),$$
$$10006 : 2.61).$$

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Proceeding in the same manner, ultimately the entire dendrogram can be linearly represented as :

(((((((08007, 10007 : 0.35), 10009 : 1.12), ((14007, 14066 : 0.44) , 10005 : 1.45) : 2.04), 08039 : 2.17), (((14008, 14105 : 0.57), (((((14021, 14131 : 1.12), 14006 : 1.40), 14106 : 1.42), (14107, 14132 : 1.29) : 1.53), 14064 : 1.57) : 1.81), 10008 : 1.98) : 2.17), ((08015, 10004 : 1.44), 08025 : 1.52) : 2.46), 10006 : 2.61).

Having obtained the dendrogram, in order to determine clusters of points which do not differ significantly among themselves, the chi-square test of homogeneity of gene frequencies may be performed within the clusters formed at the different steps of agglomeration, starting with the penultimate cluster, $C^{(N-1)}$, corresponding to the (N-1)-th step. If for any cluster $C^{(i)}$, the chi-square value turns out to be insignificant at the 1% level, the cluster can be taken to be homogeneous.

For the example under consideration, the ultimate cluster $C^{(20)}$ consists of $C^{(19)}$ and 10006. There is no question of heterogeneity of 10006 which is a single population group. The cluster $C^{(19)}$, however, consists of 20 population groups and the value of the chi-square statistic for testing for testing homogeneity turned out to be 113.21 which with 38 degrees of freedom is highly significant (see columns (5) and (6) of Table 4.2). Consequently, $C^{(19)}$ cannot be considered to be homogeneous. But $C^{(19)}$ consists of $C^{(11)}$ and $C^{(18)}$. The cluster $C^{(11)}$ consists of three data sets 08105, 10004 and 08025 and the chi-square value 1.02 with 4 degrees of freedom is not significant at the 1% level. Thus $C^{(11)}$ may be regarded as internally homogeneous. $C^{(18)}$, on the other hand, consists of 17 population groups and the chi-square value of 103.02 with 32 degrees of freedom is highly significant. The break-up of $C^{(18)}$ is in terms of $C^{(15)}$ and $C^{(17)}$, consisting of 10 and 7 population groups, respectively. The corresponding chi-square values were 17.70 with 18 degrees of freedom and 18.78 with 12 degrees of freedom; neither of them is significant. Thus the clusters $C^{(17)}$ with 7 data sets, $C^{(15)}$ with 10 data sets, $C^{(11)}$ with 3 data sets and 10007 are four mutually exclusive and exhaustive internally homogeneous subsets of the Western Upper Caste Hindus. These 'rational homogeneous clusters' (RHC's) have been designated as follows :

W-UC*1 = $C^{(17)}$

W-UC*2 = $C^{(15)}$

W-UC*3 = $C^{(11)}$

W-UC*4 = 10007

4.8 Estimation and testing in some linear models

In Chapter VII, an analysis has been performed on the variation in ABO gene frequencies within geographical x socio-religious subsets in terms of micro-geographical variation. For the purpose of this analysis, the following model has been considered.

$$p_{ij} = p_i + \delta_{pT} . T_{ij} + \delta_{pt} . t_{ij}$$
$$q_{ij} = q_i + \delta_{qT} . T_{ij} + \delta_{qt} . t_{ij} \, , \qquad (4.8.0)$$

where, within a socio-religious category, p_{ij} and q_{ij} denote the A and B gene frequencies, respectively, of the j-th data set ($j = 1,2,\ldots,n_i$) within the i-th geographical zone ($i = 1,2,\ldots,k$), and T_{ij} and t_{ij} are the corresponding latitude and longitude, respectively, of the location of sampling.

In this section the least-squares estimates of the parameters p_i, q_i, δ_{pT}, δ_{pt}, δ_{qT} and δ_{qt}, of the model, and also a procedure for testing the significance of the δ-values have been derived.

4.8.1 Notations

Let the dispersion matrix $\mathcal{D}(p_{ij}, q_{ij})$ of (p_{ij}, q_{ij}) be denoted as

$$\mathcal{D}^{-1}(p_{ij}, q_{ij}) = n_{ij} \begin{bmatrix} \alpha_{ij} & \beta_{ij} \\ \beta_{ij} & \eta_{ij} \end{bmatrix}, \text{ where } n_{ij} \text{ is the}$$

sample size corresponding to the (i,j)-th data set.

Also let

$$\alpha(1) = \sum_i \sum_j n_{ij}\,\alpha_{ij}, \quad \alpha(p) = \sum_i \sum_j n_{ij}\,\alpha_{ij}\,p_{ij},$$

$$\alpha_i(1) = \sum_j n_{ij}\,\alpha_{ij}, \quad \alpha_i(p) = \sum_j n_{ij}\,\alpha_{ij}\,p_{ij}, \quad \alpha_i(T) = \sum_j n_{ij}\alpha_{ij}T_{ij},$$

$$\alpha_i(t) = \sum_j n_{ij}\,\alpha_{ij}\,t_{ij}, \quad \alpha(pT) = \sum_i \sum_j n_{ij}\,\alpha_{ij}\,p_{ij}\,T_{ij},$$

$$\alpha(Tt) = \sum_i \sum_j n_{ij}\,\alpha_{ij}\,T_{ij}\,t_{ij},$$

$$\alpha(pt) = \sum_i \sum_j n_{ij}\,\alpha_{ij}\,p_{ij}\,t_{ij}, \quad \alpha(T^2) = \sum_i \sum_j n_{ij}\,\alpha_{ij}\,T^2_{ij},$$

$$\alpha(t^2) = \sum_i \sum_j n_{ij}\,\alpha_{ij}\,t^2_{ij}.$$

In a similar manner, terms like $\beta(1)$, $\beta_i(1)$, $\beta(q)$, $\beta_i(q)$, $\beta(qT)$, $\beta(T^2)$ or $\eta(1)$, $\eta_i(1)$, $\eta(q)$, $\eta_i(T)$, $\eta(Tt)$, $\eta(t^2)$, etc. are also defined.

4.8.2 Estimation of parameters

In order to obtain least-squares estimates of the parameters of the model, one has to minimize the quadratic form:

$$Q = \sum_{i=1}^{k} \sum_{j=1}^{n_i} Q_{ij},$$ with respect to the parameters,

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where

$$Q_{ij} = n_{ij}[\alpha_{ij} (p_{ij} - p_i - \delta_{pT}T_{ij} - \delta_{pt}t_{ij}) +$$

$$+ 2\beta_{ij} (p_{ij} - p_i - \delta_{pT}T_{ij} - \delta_{pt}t_{ij}).$$

$$(q_{ij} - q_i - \delta_{qT}T_{ij} - \delta_{qt}t_{ij})$$

$$+ \eta_{ij} (q_{ij} - q_i - \delta_{qT}T_{ij} - \delta_{qt}t_{ij})^2] \qquad (4.8.1)$$

The normal equations are :

$$\frac{\partial Q}{\partial p_i} = 0 , \qquad \frac{\partial Q}{\partial q_i} = 0 ,$$

$$\frac{\partial Q}{\partial \delta_{pT}} = 0 , \qquad \frac{\partial Q}{\partial \delta_{pt}} = 0 , \qquad (4.8.2)$$

$$\frac{\partial Q}{\partial \delta_{qT}} = 0 , \qquad \frac{\partial Q}{\partial \delta_{qt}} = 0 .$$

In terms of the notations defined above, the Normal equations can be written as:

$$\alpha_i(p) + \beta_i(q) = p_i\alpha_i(1) + q_i\beta_i(1) + \delta_{pT}\alpha_i(T) + \delta_{qT}\beta_i(T) + \delta_{pt}\alpha_i(t) + \delta_{qt}\beta_i(t) \quad (4.8.3)$$

$$\beta_i(p) + \eta_i(q) = p_i\beta_i(1) + q_i\eta_i(1) + \delta_{pT}\beta_i(T) + \delta_{qT}\eta_i(T) + \delta_{pt}\beta_i(t) + \delta_{qt}\eta_i(t) \quad (4.8.4)$$

$$\alpha(pT) + \beta(qT) = \sum_i p_i\alpha_i(T) + \sum_i q_i\beta_i(T) + \delta_{pT}\alpha(T^2) + \delta_{qT}\beta(T^2) + \delta_{pt}\alpha(Tt) + \delta_{qt}\beta(Tt) \quad (4.8.5)$$

$$\alpha(pt) + \beta(qt) = \sum_i p_i\alpha_i(t) + \sum_i q_i\beta_i(t) + \delta_{pT}\alpha(Tt) + \delta_{qT}\beta(Tt) + \delta_{pt}\alpha(t^2) + \delta_{qt}\beta(t^2) \quad (4.8.6)$$

$$\beta(pT) + \eta(qT) = \sum_i p_i\beta_i(T) + \sum_i q_i\eta_i(T) + \delta_{pT}\beta(T^2) + \delta_{qT}\eta(T^2) + \delta_{pt}\beta(Tt) + \delta_{qt}\eta(Tt) \quad (4.8.7)$$

$$\beta(pt) + \eta(qt) = \sum_i p_i\beta_i(t) + \sum_i q_i\eta_i(t) + \delta_{pT}\beta(Tt) + \delta_{qT}\eta(Tt) + \delta_{pt}\beta(t^2) + \delta_{qt}\eta(t^2) \quad (4.8.8)$$

Solving equations (4.8.3) and (4.8.4), one gets :

$$\hat{p}_i = \frac{1}{\alpha_i(1)\eta_i(1) - \beta_i^2(1)}\Big[\eta_i(1)\{\alpha_i(p) + \beta_i(q)\} - \beta_i(1)\{\beta_i(p) + \eta_i(q)\} - \delta_{pT}\{\alpha_i(T)\eta_i(1) - \beta_i(T)\beta_i(1)\} - \delta_{qT}\{\beta_i(T)\eta_i(1) - \eta_i(T)\beta_i(1)\} - \delta_{pt}\{\alpha_i(t)\eta_i(1) - \beta_i(t)\beta_i(1)\} - \delta_{qt}\{\beta_i(t)\eta_i(1) - \eta_i(t)\beta_i(1)\}\Big],$$

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and

$$\hat{q}_i = \frac{1}{\beta^2(1) - \alpha_i(1)\eta_i(1)} [\beta_i(1)\{\alpha_i(p) + \beta_i(q)\} - \alpha_i(1)\{\beta_i(p) + \eta_i(q)\}$$

$$- \delta_{pT}\{\alpha_i(T)\beta_i(1) - \beta_i(T)\alpha_i(1)\} - \delta_{qT}\{\beta_i(T)\beta_i(1) - \eta_i(T)\alpha_i(1)\}$$

$$- \delta_{pt}\{\alpha_i(t)\beta_i(1) - \beta_i(t)\alpha_i(1)\} - \delta_{qt}\{\beta_i(t)\beta_i(1) - \eta_i(t)\alpha_i(1)\}] \quad \ldots \quad (4.8.9)$$

Now, substituting the values of p_i and q_i, equations (4.8.3)-(4.8.6) can be written as:

$$\begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \cdot \begin{bmatrix} \delta_{pT} \\ \delta_{pt} \\ \delta_{qT} \\ \delta_{qt} \end{bmatrix}$$

where,

$$\lambda_1 = \alpha(pT) + \beta(qT) - \sum_i \frac{1}{|\Lambda_i|} [\{\alpha_i(T)\eta_i(1) - \beta_i(T)\beta_i(1)\}$$

$$\{\alpha_i(p) + \beta_i(q)\} + \{\alpha_i(1)\beta_i(T) - \alpha_i(T)\beta_i(1)\}$$

$$\{\beta_i(p) + \eta_i(q)\}]$$

$$\lambda_2 = \alpha(pt) + \beta(qt) - \sum_i \frac{1}{|\Lambda_i|} [\{\alpha_i(t)\eta_i(1) - \beta_i(t)\beta_i(1)\}$$

$$\{\alpha_i(p) + \beta_i(q)\} + \{\alpha_i(1)\beta_i(t) - \alpha_i(t)\beta_i(1)\}$$

$$\{\beta_i(p) + \eta_i(q)\}]$$

$$\lambda_3 = \beta(pT) + \eta(qT) - \sum_i \frac{1}{|\Lambda_i|}[\{\beta_i(T)\eta_i(1) - \eta_i(T)\beta_i(1)\}$$

$$\{\alpha_i(p) + \beta_i(q)\} + \{\alpha_i(1)\eta_i(T) - \beta_i(T)\beta_i(1)\}$$

$$\{\beta_i(p) + \eta_i(q)\}]$$

$$\lambda_4 = \beta(pt) + \eta(qt) - \sum_i \frac{1}{|\Lambda_i|}[\{\beta_i(t)\eta_i(1) - \eta_i(t)\beta_i(1)\}$$

$$\{\alpha_i(p) + \beta_i(q)\} + \{\alpha_i(1)\eta_i(t) - \beta_i(t)\beta_i(1)\}$$

$$\{\beta_i(p) + \eta_i(q)\}] \qquad (4.8.10)$$

where,

$$\Lambda_i = \begin{bmatrix} \alpha_i(1) & \beta_i(1) \\ \beta_i(1) & \eta_i(1) \end{bmatrix}$$

and

$$a_{11} = \alpha(T^2) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i^2(T) - 2\alpha_i(T)\beta_i(T)\beta_i(1)$$

$$+ \alpha_i(1)\beta_i^2(T)]$$

$$a_{21} = \alpha(Tt) - \sum_i \frac{1}{|\Lambda_i|}[\alpha_i(T)\alpha_i(t)\eta_i(1) - \beta_i(1)$$

$$\{\alpha_i(t)\beta_i(T) + \beta_i(t)\alpha_i(T)\} + \alpha_i(1)\beta_i(T)\beta_i(t)]$$

$$a_{31} = \beta(T^2) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i(T)\beta_i(T) - \beta_i(1)$$

$$\{\beta_i^2(T) + \alpha_i(T)\eta_i(T)\} + \alpha_i(1)\beta_i(T)\eta_i(T)]$$

$$a_{41} = \beta(Tt) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i(T)\beta_i(t) - \beta_i(1)$$

$$\{\beta_i(T)\beta_i(t) + \alpha_i(T)\eta_i(t)\} + \alpha_i(1)\beta_i(T)\eta_i(t)]$$

$$a_{12} = \alpha(Tt) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i(T)\alpha_i(t) - \beta_i(1)\{\alpha_i(T)\beta_i(t) + \beta_i(T)\alpha_i(t)\} + \alpha_i(1)\beta_i(T)\beta_i(t)]$$

$$a_{22} = \alpha(t^2) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i^2(t) - 2\beta_i(1)\alpha_i(t)\beta_i(t) + \alpha_i(1)\beta_i^2(t)]$$

$$a_{32} = \beta(Tt) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\beta_i(T)\alpha_i(t) - \beta_i(1)\{\beta_i(T)\beta_i(t) + \alpha_i(t)\eta_i(T)\} + \alpha_i(1)\beta_i(t)\eta_i(T)]$$

$$a_{42} = \beta(t^2) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i(t)\beta_i(t) - \beta_i(1)\{\beta_i^2(t) + \alpha_i(t)\eta_i(t)\} + \alpha_i(1)\beta_i(t)\eta_i(t)]$$

$$a_{13} = \beta(T^2) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i(T)\beta_i(T) - \beta_i(1)\{\beta_i^2(T) + \alpha_i(T)\eta_i(T)\} + \alpha_i(1)\beta_i(T)\eta_i(T)]$$

$$a_{23} = \beta(Tt) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i(t)\beta_i(T) - \beta_i(1)\{\alpha_i(t)\eta_i(T) + \beta_i(T)\beta_i(t)\} + \alpha_i(1)\beta_i(t)\eta_i(T)]$$

$$a_{33} = \eta(T^2) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\beta_i^2(T) - 2\beta_i(1)\beta_i(T)\eta_i(T) + \alpha_i(1)\eta_i^2(T)]$$

$$a_{43} = \eta(Tt) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\beta_i(T)\beta_i(t) - \beta_i(1)\{\beta_i(t)\eta_i(T) + \beta_i(T)\eta_i(t)\} + \alpha_i(1)\eta_i(T)\eta_i(t)]$$

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$$a_{14} = \beta(Tt) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i(T)\beta_i(t) - \beta_i(1)\{\alpha_i(T)\eta_i(t) + \beta_i(T)\beta_i(t)\} + \alpha_i(1)\beta_i(T)\eta_i(t)]$$

$$a_{24} = \beta(t^2) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\alpha_i(t)\beta_i(t) - \beta_i(1)\{\alpha_i(t)\eta_i(t) + \beta_i^2(t)\} + \alpha_i(1)\beta_i(t)\eta_i(t)]$$

$$a_{34} = \eta(Tt) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\beta_i(T)\beta_i(t) - \beta_i(1)\{\beta_i(T)\eta_i(t) + \eta_i(T)\beta_i(t)\} + \alpha_i(1)\eta_i(T)\eta_i(t)]$$

$$a_{44} = \eta(s^2) - \sum_i \frac{1}{|\Lambda_i|}[\eta_i(1)\beta_i^2(t) - 2\beta_i(1)\beta_i(t)\eta_i(t) + \alpha_i(1)\eta_i^2(t)] .$$

The estimates of the δ-values are obtained as:

$$\underset{4\times 1}{\underset{\sim}{\delta}} = \begin{bmatrix} \delta_{pT} \\ \delta_{pt} \\ \delta_{qT} \\ \delta_{qt} \end{bmatrix} = \underset{4\times 4}{A^{-1}} . \underset{4\times 1}{\underset{\sim}{\lambda}} \qquad (4.8.11)$$

The model described by equations (4.8.0) have been studied in conjunction with two other models, which are:

(i) $p_{ij} = p$, $q_{ij} = q$; and (ii) $p_{ij} = p_i$, $q_{ij} = q_i$,

4.29

the estimates ($\bar{p}$, $\bar{q}$, $\bar{p}_i$ and $\bar{q}_i$) of the parameters (p, q, p_i and q_i) are similarly obtained by solving the corresponding normal equations. These are:

$$\left.\begin{aligned} \bar{p} &= \frac{1}{|\Lambda|}[\eta(1)\{\alpha(p) + \beta(q)\} - \beta(1)\{\beta(p) + \eta(q)\}], \\ \bar{q} &= -\frac{1}{|\Lambda|}[\beta(1)\{\alpha(p) + \beta(q)\} - \alpha(1)\{\beta(p) + \eta(q)\}], \end{aligned}\right\} \quad (4.8.12)$$

$$\left.\begin{aligned} \bar{p}_i &= \frac{1}{|\Lambda_i|}[\eta_i(1)\{\alpha_i(p) + \beta_i(q)\} - \beta_i(1)\{\beta_i(p) + \eta_i(q)\}] \\ \text{and} \\ \bar{q}_i &= -\frac{1}{|\Lambda_i|}[\beta_i(1)\{\alpha_i(p) + \beta_i(q)\} - \alpha_i(1)\{\beta_i(p) + \eta_i(q)\}], \end{aligned}\right\}$$

... (4.8.13)

where $|\Lambda| = \alpha(1)\eta(1) - \beta^2(1)$,

and $|\Lambda_i| = \alpha_i(1)\eta_i(1) - \beta_i^{\,2}(1)$.

Since, $\underset{\sim}{\lambda} = A\,\underset{\sim}{\delta}$ and $\mathcal{D}(\underset{\sim}{\lambda}) = A$,

hence, $\mathcal{D}(\hat{\underset{\sim}{\delta}}) = A$.

Therefore, to test the significance of the δ-values, one can use the statistic:

$X = \underset{\sim}{\delta}'\,A\,\underset{\sim}{\delta}$, which follows asymptotically a chi-square distribution with 4 d.f. under the hypothesis that all δ-values are zero.

4.30

It is to be noted that in this estimation procedure we have used the information matrix evaluated at (p_{ij}, q_{ij}), which means that we have ignored the sampling fluctuations in the estimate of the sampling error of the gene frequencies. In order to maintain uniformity and comparability, this has been done also for the other two models considered in Chapter VII.

4.9 Directions of maximum and minimum variation

In Chapter VIII, the problem of representing the scatter of ABO gene frequencies unidimensionally has been considered. The variation in the gene frequencies p and q can easily be represented two-dimensionally. It is also of interest to find out an axis along which the variation in p and q is the maximum and another along which the variation is the minimum. A statistical procedure of finding the directions of maximum and minimum variability has been described in this section.

Suppose there are k populations, 1,2,...,k. Let the A and B gene frequencies in the i-th population be p_i and q_i, respectively, $i = 1,2,...,k$. For the i-th population, we define a new one-dimensional random variable $\lambda_i = ap_i + bq_i$, where a and b are constants.

4.31

Suppose we wish to test the hypothesis: $H_0 : \lambda_1 = \lambda_2 = \ldots = \lambda_k = \lambda$ (say). Let $\hat{p}_i$ and $\hat{q}_i$ be the maximum likelihood estimates pf p_i and q_i, respectively. Then, $(\hat{p}_i, \hat{q}_i) \sim N(p_i, q_i, \mathcal{I}_i^{-1})$, where $\mathcal{I}_i^{-1}$ is the information matrix of (p_i, q_i). We estimate λ_i as:

$$\hat{\lambda}_i = a\hat{p}_i + b\hat{q}_i.$$

Then, $E(\hat{\lambda}_i) = \lambda_i$.

Also, λ being unknown, we estimate λ as:

$$\hat{\lambda} = a\hat{p} + b\hat{q}, \text{ where } \hat{p} = \sum_{i=1}^{k} n_i \hat{p}_i / \sum_{i=1}^{k} n_i, \text{ and}$$

$$\hat{q} = \sum_{i=1}^{k} n_i \hat{q}_i / \sum_{i=1}^{k} n_i,$$

n_i being the sample size from the i-th population.

Then, in order to test the hypothesis H_0, we use the statistic:

$$T = \sum_{i=1}^{k} \left[n_i(\hat{\lambda}_i - \hat{\lambda})^2\right] / \left[a^2\, I^{\hat{p}\hat{p}} + 2ab\, I^{\hat{p}\hat{q}} + b^2\, I^{\hat{q}\hat{q}}\right],$$

which follows, asymptotically as $n \to \infty$, a chi-square distribution with (k-1) d.f. under H_0, where $\begin{bmatrix} I^{pp} & I^{pq} \\ I^{pq} & I^{qq} \end{bmatrix}$ is the inverse of the information matrix of (p, q) evaluated at $(\hat{p}, \hat{q})$.

Note that T can be written as:

$$T = \frac{a^2 S_{\hat{p}\hat{p}} + 2ab\, S_{\hat{p}\hat{q}} + b^2 S_{\hat{q}\hat{q}}}{a^2 I^{\hat{p}\hat{p}} + 2ab\, I^{\hat{p}\hat{q}} + b^2 I^{\hat{q}\hat{q}}},$$

where

$$S_{\hat{p}\hat{p}} = \sum_{i=1}^{k} n_i \left[\hat{p}_i^{\,2} + \frac{(\Sigma n_i \hat{p}_i)^2}{(\Sigma n_i)^2} - \frac{2\hat{p}_i\,(\Sigma n_i \hat{p}_i)}{\Sigma n_i}\right]$$

$$S_{\hat{p}\hat{q}} = \sum_{i=1}^{k} n_i \left[\hat{p}_i \hat{q}_i + \frac{(\Sigma n_i \hat{p}_i)(\Sigma n_i \hat{q}_i)}{(\Sigma n_i)^2} - \frac{\hat{q}_i(\Sigma n_i \hat{p}_i)}{\Sigma n_i} - \frac{\hat{p}_i(\Sigma n_i \hat{q}_i)}{\Sigma n_i}\right]$$

$$S_{\hat{q}\hat{q}} = \sum_{i=1}^{k} n_i \left[\hat{q}_i^{\,2} + \frac{(\Sigma n_i \hat{q}_i)^2}{(\Sigma n_i)^2} - \frac{2q_i(\Sigma n_i \hat{q}_i)}{\Sigma n_i}\right]$$

We now wish to find the sets of values of a and b, which will maximise and minimise T.

$$\text{Let } \underset{\sim}{\alpha} = \begin{bmatrix} a \\ b \end{bmatrix}, \quad S = \begin{bmatrix} S_{pp} & S_{pq} \\ S_{pq} & S_{qq} \end{bmatrix} \text{ and } D = \begin{bmatrix} I^{pp} & I^{pq} \\ I^{pq} & I^{qq} \end{bmatrix}.$$

Then, T can be written as:

$$T = \frac{\underset{\sim}{\alpha}'\, S\, \underset{\sim}{\alpha}}{\underset{\sim}{\alpha}'\, D\, \underset{\sim}{\alpha}},$$ where D is a positive definite matrix.

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Since D is positive definite, there exists a non-singular matrix C such that $D = C'C$.

Hence, $\underset{\sim}{\alpha}' D \underset{\sim}{\alpha} = \underset{\sim}{\alpha}' C' C \underset{\sim}{\alpha} = \underset{\sim}{y}'\underset{\sim}{y}$, where $\underset{\sim}{y} = C \underset{\sim}{\alpha}$,

and, $\underset{\sim}{\alpha}' S \underset{\sim}{\alpha} = \underset{\sim}{y}' C'^{-1} S C^{-1} \underset{\sim}{y}$.

Our problem is, therefore, to maximise (minimise) $\dfrac{\underset{\sim}{y}' C'^{-1} S C^{-1} \underset{\sim}{y}}{\underset{\sim}{y}'\underset{\sim}{y}}$.

By using standard results in matrix theory, it can be shown that the [largest (smallest)] eigen-vector corresponding to the largest (smallest) eigen-value of $C'^{-1} S C^{-1}$ maximises (minimises) the above quantity. Again, since similar matrices have the same eigen-values, the eigen-values of $C'^{-1} S C^{-1}$ will be the same as those of $C^{-1} C'^{-1} S C^{-1} C = D^{-1} S$. Hence, the eigen-vector corresponding to the largest (smallest) eigen value of $D^{-1}S$ will maximise (minimise) T. It is to be noted that in the above procedure, we have ignored the sampling fluctuations in the estimate of the sampling error of gene frequencies, since the estimated dispersion matrix tends, asymptotically, to the actual dispersion matrix.

Table 4.1 The boundary values of 95% confidence ellipses around the pooled gene frequencies for sample sizes 100, 200 and 400 for the Northern zone.

n = 100			n = 200			n = 400		
p_1	p_2	q	p_1	p_2	q	p_1	p_2	q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0.222	0.188	0.184	0.212	0.188	0.207	0.205	0.188	0.224
0.233	0.175	0.189	0.220	0.179	0.211	0.210	0.182	0.227
0.248	0.153	0.204	0.231	0.164	0.222	0.218	0.171	0.234
0.256	0.140	0.219	0.236	0.154	0.232	0.222	0.164	0.242
0.259	0.130	0.234	0.238	0.147	0.243	0.223	0.159	0.249
0.259	0.123	0.249	0.238	0.142	0.253	0.224	0.156	0.257
0.257	0.119	0.264	0.237	0.139	0.264	0.223	0.153	0.264
0.253	0.117	0.279	0.234	0.138	0.275	0.220	0.152	0.272
0.246	0.117	0.294	0.229	0.138	0.285	0.217	0.153	0.279
0.236	0.120	0.309	0.222	0.140	0.296	0.212	0.154	0.287
0.223	0.128	0.324	0.213	0.145	0.306	0.205	0.158	0.294
0.210	0.136	0.334	0.203	0.152	0.314	0.199	0.162	0.299
0.188	0.154	0.344	0.188	0.164	0.321	0.188	0.171	0.304

Table 4.2 Composition and distances of clusters formed at the 20 steps of single-linkage agglomeration for the Western Upper Castes

step	new cluster formed at this step	composition of the new cluster	distance between the two clusters forming the new cluster	chi-square value	chi-square d.f.
(1)	(2)	(3)	(4)	(5)	(6)
1	$C^{(1)}$	08007, 10007	0.35	-	-
2	$C^{(2)}$	14007, 14066	0.44	-	-
3	$C^{(3)}$	14008, 14105	0.57	-	-
4	$C^{(4)}$	10009, $C^{(1)}$	1.12	-	-
5	$C^{(5)}$	14021, 14131	1.12	-	-
6	$C^{(6)}$	14107, 14132	1.29	-	-
7	$C^{(7)}$	14006, $C^{(5)}$	1.40	-	-
8	$C^{(8)}$	14106, $C^{(7)}$	1.42	-	-
9	$C^{(9)}$	08015, 10004	1.44	-	-
10	$C^{(10)}$	10005, $C^{(2)}$	1.45	-	-
11	$C^{(11)}$	08025, $C^{(9)}$	1.52	1.02	4
12	$C^{(12)}$	$C^{(6)}$, $C^{(8)}$	1.53	-	-
13	$C^{(13)}$	14064, $C^{(12)}$	1.57	-	-
14	$C^{(14)}$	$C^{(3)}$, $C^{(13)}$	1.81	-	-
15	$C^{(15)}$	10008, $C^{(14)}$	1.98	17.70	18
16	$C^{(16)}$	$C^{(4)}$, $C^{(10)}$	2.04	-	-
17	$C^{(17)}$	08039, $C^{(16)}$	2.17	18.78	12
18	$C^{(18)}$	$C^{(15)}$, $C^{(17)}$	2.17	103.02**	32
19	$C^{(19)}$	$C^{(11)}$, $C^{(18)}$	2.46	113.21**	38
20	$C^{(20)}$	10006, $C^{(19)}$	2.61	-	-

** significant at the 1% level

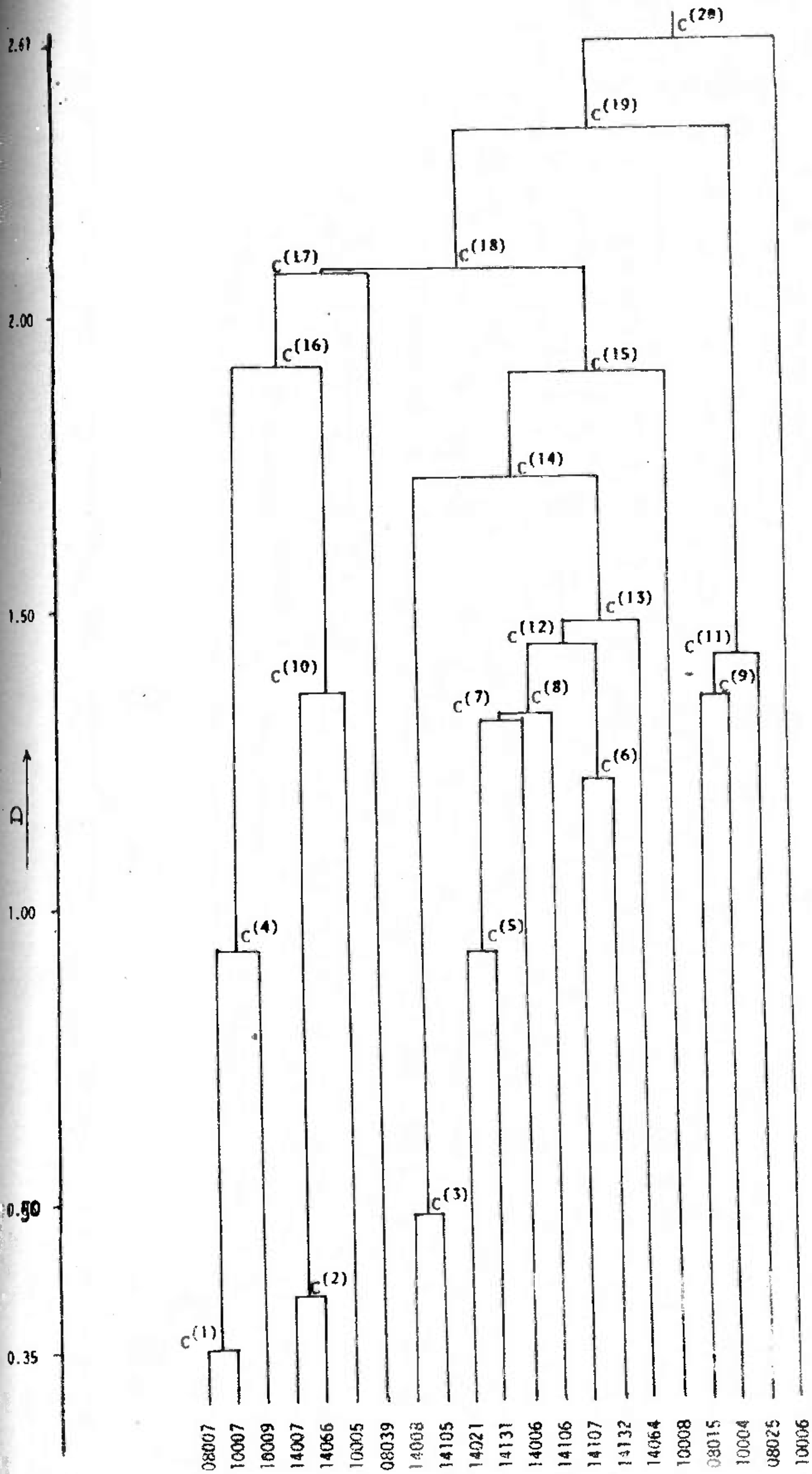

Figure 4.1 Dendrogram depicting resemblances among Western Upper Castes

CHAPTER V

PRELIMINARY ANALYSIS

5.1 Checking quality of the data : Distribution of D/σ and χ^2_{HW} values

Before embarking upon an analysis of the data, it is important to investigate the quality of the data - to search for systematic serological typing errors in the data. The main source of error in blood grouping is the failure of the anti-sera to detect the presence of A antigen in AB blood group phenotypes, which results in a shortage of AB (Mourant, 1954). As early as in 1940, Fisher and Taylor observed : 'Systematic errors not all of which are yet understood, do undoubtedly affect the frequency of the rarest of the four blood groups (AB)'. As has been mentioned in section 4.2, the sign of D/σ is an indicator of the deficiency (+) or excess (-) of group AB. An examination of the distribution of D/σ values might, therefore, provide clues to the presence of systematic serological typing errors in the data. In the absence of any grouping error, for large samples from a random-mating population, D/σ follows a standard normal distribution. Hence, the observed and expected frequency distributions of D/σ can be compared to detect the presence of systematic blood grouping errors in the data.

For this purpose, the entire body of data was divided into four groups depending upon the year of publication - (i) data published upto 1950, (ii) data published between 1951 and 1960, (iii) data published between 1961 and 1970, and, (iv) data published after 1970. The idea behind this grouping was that even if we were able to detect systematic serological typing errors in the data, they should mostly be present in the data published in the earlier decades, since blood grouping techniques have been perfected over the years. The observed and expected frequency distributions of D/σ values along with the goodness-of-fit chi-square values have been presented in Table 5.1, separately for the 4 groups of data. Contrary to expectations, the goodness-of-fit chi-square values turned out to be significant at the 5% level only for the latter two groups of data. Although chance factors cannot be ruled out, even for the groups of data published upto 1950, and those published between 1951 and 1960, the observed frequency of $D/\sigma > 1.645$ is higher than the expected indicating the possibility of some amount of deficiency of blood group AB. A closer examination of D/σ values indicated the possibility of the existence of some laboratories in India where the error in serological classification may still be quite large. For example, of the 31 studies reported after 1970 from the anthropological laboratory of Utkal University in Orissa (identification numbers 18020 to 18050), 13 showed significant D/σ values in comparison with the expected figure of only 3.1. When all these 31 data sets were excluded, then for the group of data published after 1970, the observed and expected frequency distributions of D/σ values were modified to those presented in Table 5.2. The overall goodness-of-fit chi-square value of 10.0725 turned out to be insignificant at the 5% level with 10 d.f. Of course, it is not always possible to attribute the excess of observed D/σ values over the expected solely to typing errors. In fact, for populations practising inbreeding or other forms of non-random mating, Hardy-Weinberg proportions may not be met. In an inbred population one would actually expect a decreased frequency of the heterozygotes as compared with a random mating population. It may, however, be mentioned that the rates of inbreeding among the populations of Orissa are not so high (Roychoudhury, 1977) to cause such an extreme departure of the observed frequency of D/σ values from the expected. This analysis, therefore, suggests the existence of some laboratories in India where the blood group data generated may not be very reliable.

We also looked into the observed frequency distribution of χ^2_{HW} values for the entire body of data under consideration and compared it with the expected. It is known that the existence of inbreeding, differential mortality, inclusion of related individuals in the sample and other such factors tend to enhance the χ^2_{HW} value (Rao, 1958, Workman and Niswander, 1970). The detection of an excess frequency of large χ^2_{HW} values is, therefore, not of much interest. The detection of an excess frequency of small χ^2_{HW} values may, however, indicate the possibility of data being 'smoothed' to a certain extent to bring them in closer agreement with Hardy-Weinberg proportions (Rao, 1958).

The observed and expected frequency distributions of χ^2_{HW} values, and the chi-square values for testing the goodness-of-fit of these two distributions have been presented in Table 5.3. The observed and expected frequency distributions of χ^2_{HW} values were found to differ significantly at the 5% level. There was indeed a great excess of large χ^2_{HW} values, but not much of an excess of small χ^2_{HW} values.

It may also be mentioned that, in most cases, for the data sets for which the D/σ values turned out to be significant, the χ^2_{HW} values also turned out to significant.

5.2 Graphical analysis

Triangular charts were prepared to describe the scatter of gene frequencies within the geographical zones and socio-religious categories, by the method described in section 4.4. A method of indicating the margin of error associated with the location of a point on a triangular chart has been described in section 4.5. Since the computation of the confidence ellipses and plotting them for all the points on the charts turned out to be practically infeasible, for each chart confidence ellipses for n = 100, 200 and 400, were plotted only around the pooled values of gene frequencies. The Negrito tribals and Parsees being represented by only 2 and 3 data sets, respectively, triangular charts were not prepared for these two categories.

The triangular charts for the geographical zones and the socio-religious categories have been presented in Figures 5.1 through 5.14. The broad patterns of variation as are evident from these figures have been discussed below in some detail.

5.2.1 Variation within geographical zones

(i) Northern zone . As can be seen from figure 5.1, the scatter of gene frequencies of data sets belonging to the Northern zone is rather small, most fall in the range :

p = (0.15 - 0.20) and q = (0.25 - 0.35). There are 8 data sets with sample sizes greater than 100 which fall outside the confidence ellipse for n = 100. These data sets cannot be treated as homogeneous. Of these 8, two deserve special mention. They are Rajputs of Kulu and Katrain (19023) and Kinnar Kanets of Chini Valley (19043) with sample sizes 268 and 310, respectively. These two populations fall aside significantly from the rest. There are also 14 other data sets which fall outside the confidence ellipse corresponding to n = 100, but all these sets have sample sizes smaller than 100. The remaining 65 data sets included in this zone fall within the confidence ellipses corresponding to their sample sizes, and can, therefore, be treated as homogeneous. Thus, by and large, there is considerable homogeneity among the data sets of this zone.

(ii) Eastern zone. In contrast to the Northern zone, the gene frequencies of the data sets belonging to the Eastern zone are very much scattered (figure 5.2). At the one extreme are some populations of Nicobar islands (01003, 01007, 01008, 01011) with low A and B gene frequencies, at another extreme are the Onges of Andaman islands (01001), Asuras of Palamau (06014), Northern Pahiras (06032), with high A gene frequency, and at yet another extreme are the Poundra Kshatriyas of Bengal (04071), Birjias of Palamau (06024), with high B gene frequency. The pooled A and B gene frequencies would have been higher but for the presence of the Nicobarese samples in the pooled data. Although several data sets are outside the confidence ellipse for n = 100, there appears to be one large cluster consisting of several data sets lying in the gene frequency ranges : p = (0.14 - 0.21) and q = (0.23 - 0.32). The samples of Nicobar islands also form a cluster.

(iii) Southern zone . The gene frequencies of the data sets of Southern zone are also very scattered (figure 5.3). At the one extreme, we have the Kotas of Nilgiri Hills in Tamilnadu (22031, 22052, 22063) who possess almost no A gene, and at the other we have the Paniyans of Malabar Wynaad in Kerala (11001, 11016, 11017) with about 45% of A gene. The Adiyans of Kerala (11021) also seem to lie close to the Paniyans, but the size of the Adiyan sample is rather small (= 38). Similarly, the Nayadis of Kerala (11008) are found to possess no A gene, but, again, their sample size is small (= 38). Of the three Indian Indian States - Andhra Pradesh, Kerala and Tamilnadu - included in the Southern zone, Kerala has the maximum variation in gene frequencies. Although a majority of the data sets of this zone fall within the confidence ellipse corresponding to n = 100, there are also several data sets lying outside it.

Actually, only 46 samples out of a total of 115 lie within their corresponding confidence ellipses. However, because of the inclusion of the sets of data on Paniyans and Adiyans, the pooled p value of this zone has become somewhat higher. There appears to be a cluster of data sets falling in the ranges : p = (0.10 - 0.17) and q = (0.07 - 0.17), which includes diverse caste, religious and tribal groups from Andhra Pradesh (e.g., Yenadi, Erukula), Kerala (e.g., Izhavan, Nair) and Tamilnadu (e.g., Muslim, Kurumba).

(iv) <u>Western zone</u> . In this zone, as is evident from figure 5.4, although there is a central cluster of data sets that fall within the confidence ellipse for n = 400, and although most data sets fall within the confidence ellipse for n = 100, there are several sets whose gene frequencies are very much deviated from the pooled gene frequencies of this zone. For instance, there are several populations of Maharashtra, e.g., Bhavasar (14016), Kunbi Mana (14041), Lewa (14043), Nhavi (14046), Vaishya Wani (14060), Wadwal (14061), etc. who possess a high A gene frequency (29-36%), and some populations, e.g. Nandivallah of Maharashtra (14097), Sindhi Lohana (08040) and Visa Oswal Jain (08038) of Gujarat, Sanagar of Karnataka (10010), etc., who possess rather low A gene frequency (3-9%). It may, however, be noted that for no data set possessing the A gene frequency higher than 0.287, the sample size is greater than 50. Out of a total of 175 data sets included in this zone, 30 fall outside the confidence ellipse for n = 100, although each them has a sample size greater than 100. Four sets falling within the confidence ellipse for n = 100, are also not rightly placed, that is, they do not fall within their corresponding confidence ellipses. In any case, although nothing can be said about the variation in gene frequencies of data sets with sample sizes less than 100, there appears to be a good degree of homogeneity among populations of this zone.

(v) Central zone . As can be seen from figure 5.5, the populations of Uttar Pradesh and Madhya Pradesh are very similar in respect of ABO gene frequencies. A small proportion (22 out of 115) of data sets fall outside the confidence ellipse for n = 100, of which only 12 are of sample size greater than 100. Five other sets (13006, 13011, 24062, 24063 and 24081) do not fall in their corresponding confidence ellipses. There is a significant clustering of data sets within the confidence ellipse for n = 400.

(vi) Himalayan zone . Of the 27 data sets included in this zone, four - Kiranti (05010), Rai Nepalese (05029), Newar (05024) and Lunana (05021) - stand apart significantly from the rest (figure 5.6). Of these four, Kiranti and Rai Nepalese possess a very high A gene frequency (about 40%), Newars also possess a relatively high A gene frequency (about 32%) and the Lunanas possess a very high B gene frequency (about 51%). Of course, the sample size of the Lunanas is rather small (= 41). Although only a few data sets fall within their respective confidence ellipses, there appears to exist one large cluster consisting of 17 sets with gene frequencies in the ranges : p = (0.089 - 0.132) and q = (0.176 - 0.290). It must be mentioned that because of the presence of the 4 sets with high A and B gene frequencies as mentioned above, the pooled gene frequencies have shifted upwards. If these were excluded out of pooling, then most of the data sets would, perhaps, have fallen within the confidence ellipses around the pooled gene frequencies.

5.2.2 Variation within socio-religious categories

(i) Upper caste . Among the Upper castes, as is evident from figure 5.7, there appears to be a good deal of uniformity. Only a few Brahmin groups of Kannamangalam in Kerala (11045), Simla Hills (19019), Kulu (19024 and 19083) and Jaunsar-Bawar (24087), are distinctly away from the rest with relatively high A and B gene frequencies. Of the 70 data sets of upper castes, 20 lie outside the confidence ellipse for n = 100, of which 11 are of sample size greater than 100. Two populations - Pandits of Kashmir (09005) and Deshastha Brahmins of Hanbar in Karnataka (10008), with sample sizes 320 and 215, respectively, lie outside the confidence ellipse for n = 200. Also, three Brahmin samples from Karnataka and Punjab (10004, 10007, 19031) with sample sizes larger than 400 fall outside the confidence ellipse for n = 400. There appears to be a distinct cluster of 15 data sets which possess relatively low B gene frequency. Of these 15 sets, 12 are Brahmin groups of Maharashtra. In fact, most of the upper caste samples of Maharashtra fall in this cluster.

(ii) Middle caste . Although there is a rather large dispersal of gene frequencies among the Middle caste samples of India, as is evident from figure 5.8, if we ignore the populations with sample size less than 100, the amount of dispersal is vastly reduced. It, therefore, seems that the large deviations of gene frequencies of several sets from the pooled values may be due mainly to sampling fluctuations. Of course, it must be mentioned that out of a total of 45 data sets with sample sizes larger than 100, 16 do not fall within their corresponding confidence ellipses. One conspicuous departure are the Newars of Nepal (05024), with very high A gene frequency and rather low B gene frequency. In any case, the middle castes appear to be less homogeneous in comparison with the upper castes.

(iii) Lower caste . The owor castes are not homogeneous in respect of ABO gene frequencies (figure 5.9). Out of a total of 48 data sets of lower castes, 12 fall outside the confidence ellipse for n = 100. Three population groups - Bagdi (04011) and Poundra Kshatriya (04071) from West Bengal, and Bhavasar (14016) from Maharashtra - are pretty distant from the rest. Four other sets (04047, 04048, 04063, 24081) also do not fall within their corresponding confidence ellipses. Thus, a total of 12 out of 48 data sets are misplaced, which indicates that there is a good deal of variation among ower castes.

(iv) Muslim . It can be seen from figure 5.10 that the confidence ellipse for n = 100 envelopes all but 3 data sets of Muslims out of a total of 34. These three Muslim samples are from Jammu and Kashmir (09007), North-West Pakistan (17003) and Tamilnadu (22016) with sample sizes 60, 74 and 161, respectively. Since, of these three, the sample sizes for the sets from Jammu and Kashmir and North-West Pakistan are smaller than 100, there is no cause for concern regarding their not being included within the confidence ellipse for n = 100. However, the data sets of Muslims from Tamilnadu (22016) with a sample size greater than 100 and lying outside the confidence ellipses is clearly noticeable. This set

5.13

possesses a particularly low B gene frequency (0.123). It is also to be noticed that all but two data sets - one from Andhra Pradesh (02007) and another from Tamilnadu (22051), with sample sizes larger than 200, fall within the confidence ellipse for n = 200. The five data sets with sample size greater than 400 are all included in the confidence ellipse for n = 400. Therefore, it is clear that there is little heterogeneity among the Muslim samples.

(v) Christian/Anglo-Indian . As can be seen from figure 5.11, among the 16 data sets of Christians/Anglo-Indians of eastern and southern zones there is no clear-cut cluster. Four sets fall outside the confidence ellipse for n = 100. Of these four, the data set of Anglo-Indians from Calcutta (04031) with a sample size of 346 is remarkably deviated from the rest.

(vi) Parsee . There are 3 independent data sets of Parsees with sample sizes 214, 2282 and 162, respectively. These three sets have more or less similar gene frequencies, the O gene frequency being about 61%, B - about 20-22% and A - about 17-20%.

(vii) Australoid tribe . As is evident from figure 5.12, there is a great deal of heterogeneity among the Australoid population groups. The A gene frequency of the Australoids varies from

5.14

0.00 among the Nayadis of Kerala (11008) to 0.569 among the Adiyans of Malabar Wynaad (11021). Similarly, the B gene frequency also varies widely from 0.024 among the Asuras of Palamau (06014) to 0.546 among the Mundas of Bihar (04061). A number of population groups from Andhra Pradesh - e.g., Yenadi (02020), Erukula (02021), etc., Kerala - e.g., Iluva (11007), Kanikkar (11015), Mullu Kuruma (11018), Malayaran (11050), etc., and Tamilnadu - e.g., Kurumba (22055), Paliyan (22058), etc., possess low A and B gene frequencies. At the same time, the Paniyans of Kerala (11001, 11016, 11017) possess a low B gene frequency but a very high A gene frequency. Several data sets fall outside the confidence ellipse for n = 100. However, there appears to be a very close clustering of many data sets from different States, - e.g., Chenchu (02023) of Andhra Pradesh; Santal (04062) of Bengal; Oraon (06013), Ho (06044), etc., of Bihar; Maria Gond (13002), Northern Dhurwa (13065), etc., of Madhya Pradesh; Tadvi Bhil (14018), Katkari (14065), etc., of Maharashtra; and Bado Gabada (18010), Konda Paroja (18016), etc., of Orissa. The A and B gene frequencies of this cluster are about 22% and 32%, respectively.

(viii) Mongoloid tribe. There is a rather large dispersion of gene frequencies of the Mongoloid tribal groups (figure 5.13). At the one extreme are the Mongoloid groups of Nicobar Is.

with very low (about 5%) A and B gene frequencies, and at the other extreme are some populations of Tripura - e.g., Noatia (23006), Riang (23007), etc., and some populations of Uttar Pradesh - e.g., Bhotia (24028), Tharu (24053, 24062), etc., with very high A (20-25%) and B (30-40%) gene frequencies. There also are certain populations of Nepal, e.g., Kiranti (05010) and Rai (05029), with about 40% of A gene and only about 12% of B gene.

In the case of the Mongoloid tribal groups, there is no central clustering of points, as is clear from figure 5.13. Very few data sets fall even within the confidence ellipse for n = 100. The tribal groups of Nicobar Is., appear to form a distinct cluster. There also appears to be another relatively distinct cluster comprising some populations of Tripura (23005, 23006, 23007) and Uttar Pradesh (24054, 24062, 24063), with rather high A and B gene frequencies. In any case, it is clear that the Mongoloid tribal samples are very dissimilar in respect of A and B gene frequencies.

(viii) Caucasoid tribe. There is a great deal of variation in ABO gene frequencies of Caucasoid tribes (figure 5.14). The A gene frequency varies from about 0.00 among Kotas (23031, 22052, 22063) to about 0.20 - Lambadi (02011), Toda (22056). The pooled gene frequencies cannot be representative, and only two data sets out of a total of 11 fall within the confidence ellipse for n = 100.

(ix) Negrito tribe . There are only two Negrito tribal samples - Onge and Bhantu - from the Andaman islands, with sample sizes 34 and 122, respectively. Since the total number of Negrito tribal groups is small no scattergram of gene frequencies has been presented. In respect of ABO gene frequencies, these two populations are very much distant from each other. Whereas the A, B, O gene frequencies among the Onges are 0.540, 0.091 and 0.368, respectively, these are, among the Bhantus, 0.123, 0.261 and 0.615, respectively.

5.2.3 Broad patterns of variation . On the whole, it appears from this graphical analysis that in almost all the geographical zones there is considerable heterogeneity in ABO gene frequencies. In none of the zones, the heterogeneity seems to be explainable by sampling errors alone, although the extent of heterogeneity seems to vary from one zone to another. Among the six geographical zones, the Eastern, Southern and Western zones seem to exhibit a great deal of heterogeneity. Of course, it must be mentioned that in these three zones the different socio-religious categories, are more well-represented in comparison with the remaining zones.

Among most socio-religious categories also, the extent of variation in gene frequencies seems to be unaccountable solely by sampling errors. To a good degree, the Upper castes, Muslims and Parsees, seem to be homogeneous. Both the Middle and Lower caste groups seem to exhibit a good deal of heterogeneity. The Christians/Anglo-Indians also show considerable heterogeneity in gene frequencies. All the tribal groups also seem to be largely heterogeneous.

5.3 Chi-square analysis

As is evident from the graphical analysis, within all geographical zones and socio-religious categories there is a lot of variation in ABO gene frequencies. In order to test the homogeneity of gene frequencies, chi-square tests were performed within the geographical zones and the socio-religious categories. The test statistic used for this purpose has been given in section 4.6. Moreover, since the same socio-religious category is spread over more than one geographical zone, and since no geographical zone is homogeneous with respect to the socio-religious type, the data were cross-classified in two ways on the basis of both geographical and socio-religious considerations. Cross-classification of the data thus gave rise to 6x10 = 60 subsets, of which are many as 28 turned out to be empty. It is to be noted that since the test statistic given in section 4.6 follows a chi-square distribution only for large values of n, data sets for which n is $\leq$ 100 have been excluded from this analysis. The frequency distribution of the data sets among the geographical x socio-religious subsets have been presented in Table 5.4 (see also Table 6.1).

The results of the tests of homogeneity for the marginal classifications separately in terms of geographical and socio-religious considerations, and also for the cross-classified subsets have been presented in Tables 5.5, 5.6 and 5.7, respectively.

From these tables it was seen that within all geographical zones there exists a great deal of heterogeneity. Almost all the socio-religious categories also exhibit significant heterogeneity. The Parsees, all of whom live in the Western zone, are homogeneous, and the Negrito tribals are represented by only one population group from the Eastern zone, and of course there was no question of heterogeneity there. Of the 32 non-empty two-way cross-classified subsets, only the following 13 subsets accounting for 76 population groups, turned out to be homogeneous :

Northern Muslims (N-MU), Northern Australoid Tribes (N-AT), Eastern Upper Castes (E-UC), Eastern Muslims (E-MU), Eastern Negrito Tribes (E-NT), Southern Upper Castes (S-UC), Western Muslims (W-MU), Western Parsees (W-PA), Central Upper Castes (C-UC), Central Muslims (C-MU), Central Australoid Tribes (C-AT), Central Mongoloid Tribes (C-MT) and Himalayan Middle Castes (H-MC).

5.19

Thus it is seen that though the Muslims when considered all over the sub-continent are highly heterogeneous, when they are subdivided into geographical zones, are homogeneous in the Northern, Eastern, Western and Central zones, though not in the Southern zone. The Upper Caste Hindus are homogeneous in the Eastern, Southern and Central zones, but not in the Northern and Western zones. Australoid Tribes are homogeneous in the Southern and Central zones, but not elsewhere. Mongoloid tribes are homogeneous in the Central zone, but not anywhere else. Middle caste Hindus are homogeneous only in the Himalayan zone.

The remaining 19 subsets containing 329 population groups were found to be internally heterogeneous. The method of cluster analysis has been used in this paper to split up each of these 19 subsets into two or more subsets to achieve homogeneity within the subsets.

Table 5.1 Observed and expected frequency distributions of D/σ values by year of publication of data, and goodness-of-fit chi-square values

value of D/σ		< -1.645	-1.037	-0.675	-0.385	-0.126	0.126
probability		0.05	0.10	0.10	0.10	0.10	0.10
data published upto 1950	observed freq.	12	21	13	15	17	21
	expected freq.	9.70	19.40	19.40	19.40	19.40	19.40
	contribution to χ^2	0.5454	0.1320	2.1113	0.9979	0.2969	0.1320
data published between 1951-1960	observed freq.	16	21	28	31	21	24
	expected freq.	13.80	27.60	27.60	27.60	27.60	27.60
	contribution to χ^2	0.3507	1.5783	0.0058	0.4188	1.5783	0.4696
data published between 1961-1970	observed freq.	10	17	12	22	18	27
	expected freq.	10.45	20.90	20.90	20.90	20.90	20.90
	contribution to χ^2	0.0194	0.7278	3.7900	0.0579	0.4024	1.7804
data published after 1970	observed freq.	19	14	16	19	20	23
	expected freq.	11.00	22.00	22.00	22.00	22.00	22.00
	contribution to χ^2	5.8182	2.9091	1.6364	0.4091	0.1818	0.0454

* Significant at the 5% level with 10 d.f.

...contd.

Table 5.1 contd.

value of D/σ		0.385	0.675	1.037	1.645	> 1.645	total
probability		0.10	0.10	0.10	0.10	0.05	1.00
data published upto 1950	observed freq.	20	17	15	26	17	194
	expected freq.	19.40	19.40	19.40	19.40	9.70	194
	contribution to χ^2	0.0186	0.2969	0.9979	2.2454	5.4938	13.2681
data published between 1951-1960	observed freq.	25	31	25	30	24	276
	expected freq.	27.60	27.60	27.60	27.60	13.80	276
	contribution to χ^2	0.2449	0.4188	0.2449	0.2087	7.5391	13.0579
data published between 1961-1970	observed freq.	12	16	25	35	15	209
	expected freq.	20.90	20.90	20.90	20.90	10.45	209
	contribution to χ^2	3.7900	1.1488	0.8043	9.5124	1.9811	24.0145*
data published after 1970	observed freq.	23	22	22	22	20	220
	expected freq.	22.00	22.00	22.00	22.00	11.00	220
	contribution to χ^2	0.0454	0.0000	0.0000	0.0000	7.3636	18.4090*

* Significant at the 5% level with 10 d.f.

Table 5.2 Modified observed and expected frequency distributions of D/σ values for data published after 1970, and goodness-of-fit chi-square values

value of D/σ		< -1.645	-1.037	-0.675	-0.385	-0.126	0.126
data published after 1970	observed freq.	14	11	16	17	19	22
	expected freq.	9.45	18.90	18.90	18.90	18.90	18.90
	contribution to χ^2	2.132	3.302	0.445	0.191	0.0005	0.508

Table (5.2) contd.

value of D/σ		0.385	0.675	1.037	1.645	>1.645	total
data published after 1970	observed freq.	22	21	18	17	12	189
	expected freq.	18.90	18.90	18.90	18.90	9.45	189
	contribution to χ^2	0.508	0.233	0.043	0.191	2.519	10.072

Table 5.3 Observed and expected frequency distributions of χ^2_{HW} values and goodness-of-fit chi-square values

value of χ^2_{HW}	< .004	.016	.036	.065	.102	.148	.206	.276	.358	456
probability	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
observed freq.	53	44	47	35	30	42	31	41	55	43
expected freq.	44.95	44.95	44.95	44.95	44.95	44.95	44.95	44.95	44.95	44.95
contribution to χ^2	1.442	.020	.093	2.203	4.972	.194	4.329	.347	2.247	.085

Table (5.3) contd.

value of χ^2_{HW}	.572	.709	.874	1.075	1.323	1.641	2.070	2.706	3.84	> 3.84	total
probability	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	1.0
observed freq.	43	44	32	38	51	44	41	47	55	83	899
expected freq.	44.95	44.95	44.95	44.95	44.95	44.95	44.95	44.95	44.95	44.95	899
contribution to χ^2	.085	.020	3.731	1.075	.814	.020	.347	.093	2.247	32.209	56.573*

* significant at the 5% level with 19 d.f.

Table 5.4 Number of data sets included in different two-way classified subsets

socio-religious category		geographical zone						
		Northern (N)	Eastern (E)	Southern (S)	Western (W)	Central (C)	Himalayan (M)	total
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hindus -								
Upper Caste	(UC)	6	9	3	21	8	-	47
Middle Caste	(MC)	34	16	14	36	26	2	128
Lower Caste	(LC)	-	16	-	8	8	-	32
Muslims	(MU)	7	12	4	2	4	-	29
Christians/ Anglo-Indians	(CH)	-	5	4	-	-	-	9
Parsees	(PA)	-	-	-	3	-	-	3
Tribals -								
Australoid	(AT)	3	39	25	23	10	-	100
Mongoloid	(MT)	-	31	-	-	7	13	51
Caucasoid	(CT)	-	-	5	-	-	-	5
Negrito	(NT)	-	1	-	-	-	-	1
total		50	129	55	93	63	15	405

Table 5.5 Chi-square test for homogeneity of data sets within geographical zones

geographical zone	no. of data sets in zone	degrees of freedom	chi-square
(1)	(2)	(3)	(4)
Northern	50	98	334.69 **
Eastern	129	256	2441.74 **
Southern	55	108	1375.73 **
Western	93	184	885.23 **
Central	63	124	371.65 **
Himalayan	15	28	275.28 **

** significant at the 1% level

Table 5.6 Chi-square test for homogeneity of data sets within socio-religious categories

socio-religious category	no. of data sets in category	degrees of freedom	chi-square
(1)	(2)	(3)	(4)
Hindu Upper Caste	47	92	341.19 **
Middle Caste	128	254	1367.00 **
Lower Caste	32	62	263.29 **
Muslim	29	56	136.87 **
Christian/Anglo Indian	9	16	68.69 **
Parsee	3	4	2.07
Australoid Tribe	100	198	1431.82 **
Mongoloid Tribe	51	100	1835.96 **
Caucasoid Tribe	5	8	205.07 **
Negrito Tribe	1	-	-

** significant at the 1% level

Table 5.7 Chi-square test for homogeneity of data sets within two-way cross-classified subsets

geographical x socio-religious subset (1)		no. of data sets in subset (2)	degrees of freedom (3)	chi-square (4)
1. Northern Upper Caste	(N-UC)	6	10	32.69 **
2. Northern Middle Caste	(N-MC)	34	66	223.12 **
3. Northern Muslim	(N-MU)	7	12	15.77
4. Northern Australoid Tribe	(N-AT)	3	4	8.10
5. Eastern Upper Caste	(E-UC)	9	16	26.22
6. Eastern Middle Caste	(E-MC)	16	30	101.33 **
7. Eastern Lower Caste	(E-LC)	16	30	148.79 **
8. Eastern Muslim	(E-MU)	12	22	30.72
9. Eastern Christian/ Anglo-Indian	(E-CH)	5	8	36.89 **
10. Eastern Australoid Tribe	(E-AT)	39	76	349.23 **
11. Eastern Mongoloid Tribe	(E-MT)	31	60	1273.81 **
12. Eastern Negrito Tribe	(E-NT)	1	-	-
13. Southern Upper Caste	(S-UC)	3	4	0.63
14. Southern Middle Caste	(S-MC)	14	26	90.48 **
15. Southern Muslim	(S-MU)	4	6	30.48 **
16. Southern Christian/ Anglo-Indian	(S-CH)	4	6	20.60 **
17. Southern Australoid Tribe	(S-AT)	25	48	648.99 **
18. Southern Caucasoid Tribe	(S-CT)	5	8	205.07 **
19. Western Upper Caste	(W-UC)	21	40	129.57 **
20. Western Middle Caste	(W-MC)	36	70	364.69 **

** significant at the 1% level

... contd.

Table (5.7) contd.

(1)		(2)	(3)		
21. Western Lower Caste	(W-LC)	8	14	42.05	**
22. Western Muslim	(W-MU)	2	2	0.42	
23. Western Parsee	(W-PA)	3	4	2.07	
24. Western Australoid Tribe	(W-AT)	23	44	220.39	**
25. Central Upper Caste	(C-UC)	8	14	11.84	
26. Central Middle Caste	(C-MC)	26	50	108.07	**
27. Central Lower Caste	(C-LC)	8	14	66.07	**
28. Central Muslim	(C-MU)	4	6	3.19	
29. Central Australoid Tribe	(C-AT)	10	18	26.71	
30. Central Mongoloid Tribe	(C-MT)	7	12	22.30	
31. Himalayan Middle Caste	(C-MC)	2	2	4.19	
32. Himalayan Mongoloid Tribe	(H-MT)	13	24	230.98	**

** significant at the 1% level

FIGURES 5.1 - 5.14

NOTE: (1) In the figures 5.1 - 5.14, the triangular-chart representations of the scatter of ABO gene frequencies have been presented for data sets belonging to the 6 geographical zones (figures 5.1 - 5.6) and for data sets belonging to 8 socio-religious categories - excluding the Parsees and Negrito tribals (figures 5.7 - 5.14).

(2) For each point in a triangular chart, the identification number (as in Appendix 1) of the corresponding data set has been given alongwith. In order to save space, an identification number, say 04008, has been written as 4/8.

(3) Different symbols have been used to indicate the sample-size class in which the data set belongs. These symbols are as given below:

sample size class	symbol
≤ 50	Δ
51 - 100	◻
101 - 200	○
201 - 300	▲
301 - 400	■
> 400	●

Thus, if a point in the triangular chart is represented by a Δ, then it means that the sample size of the data set corresponding to that point is less than 51.

(4) The pooled gene frequencies of all the data sets belonging to a particular category have been represented by a "X" in the triangular chart.

(5) The confidence ellipses around the pooled gene frequencies have also been presented for n=100, 200 and 400. These sample sizes are indicated alongside the ellipses.

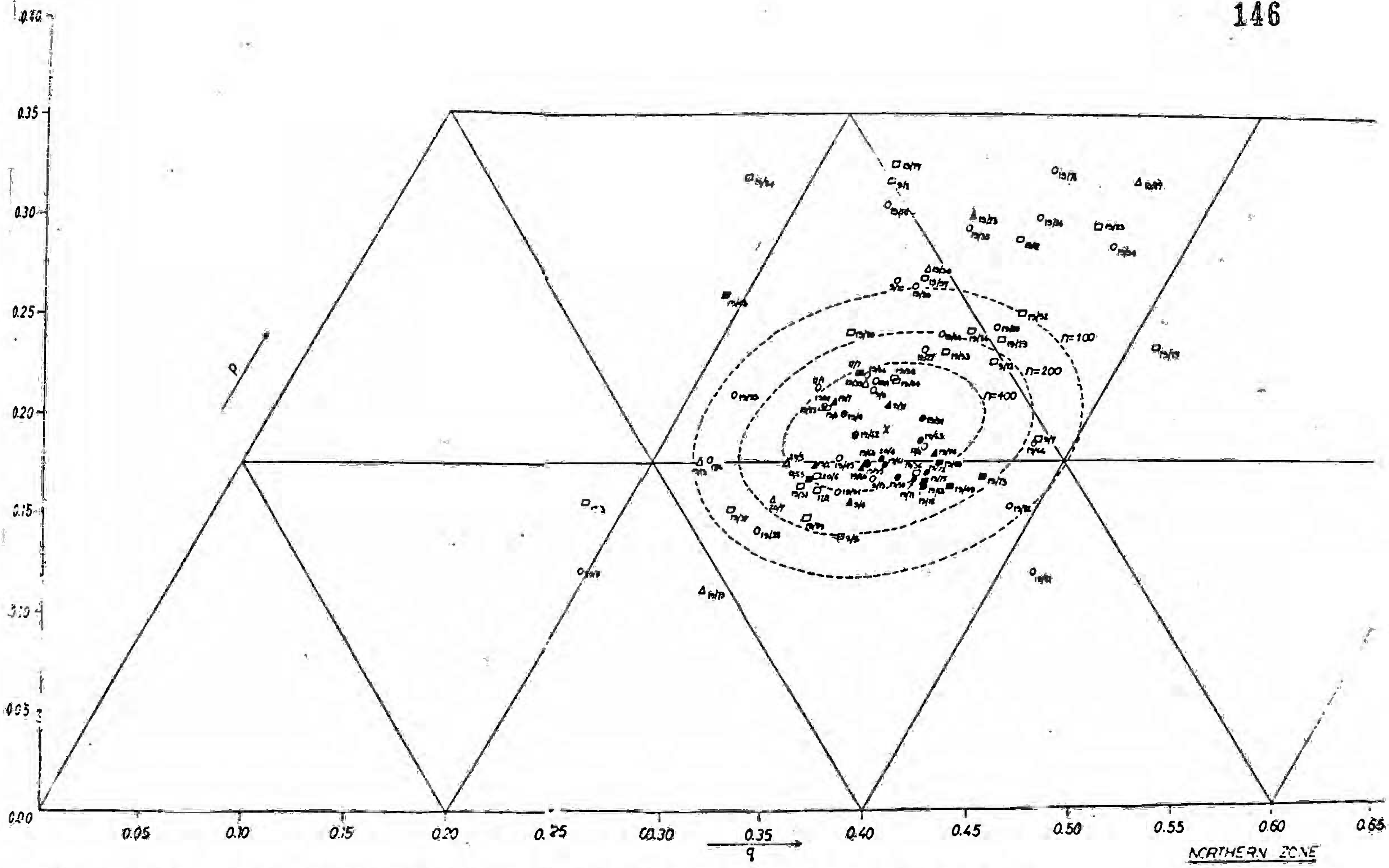

Figure 5.1 Scatter diagram of ABO gene frequencies of population groups belonging to the NORTHERN ZONE

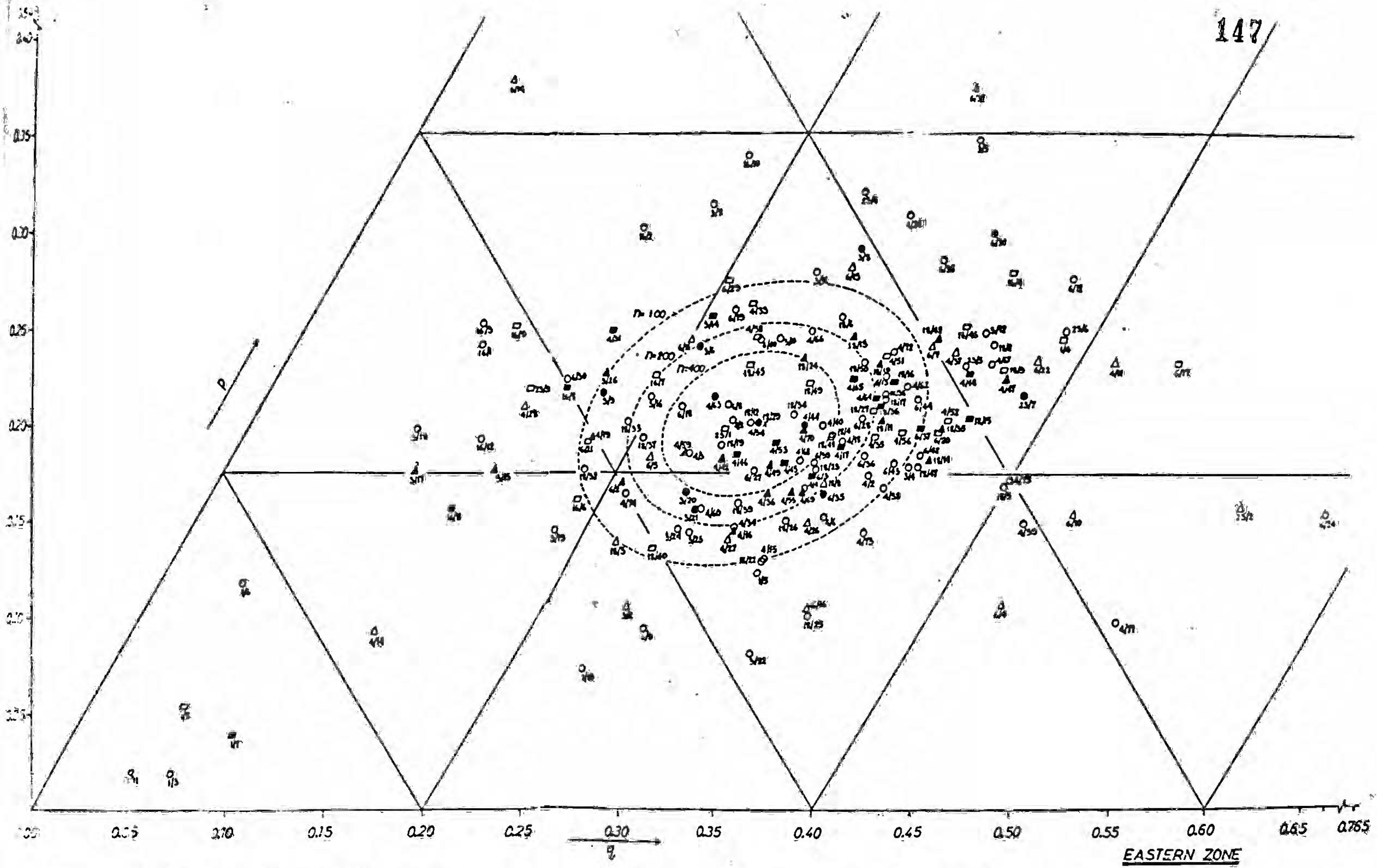

Figure 5.2 Scatter diagram of ABO gene frequencies of population groups belonging to the EASTERN ZONE

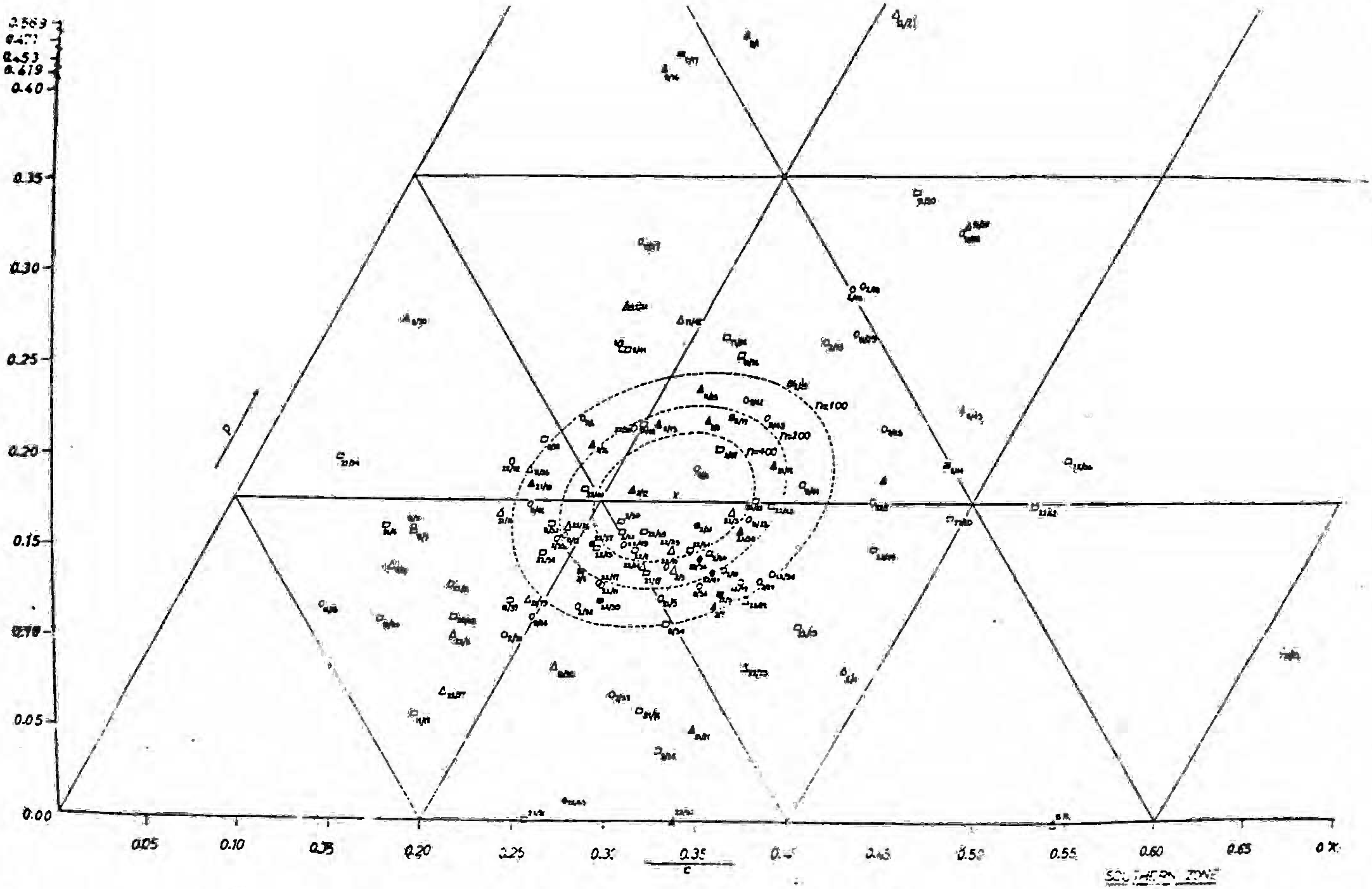

Figure 5.3 Scatter diagram of ABO gene frequencies of population groups belonging to the SOUTHERN ZONE

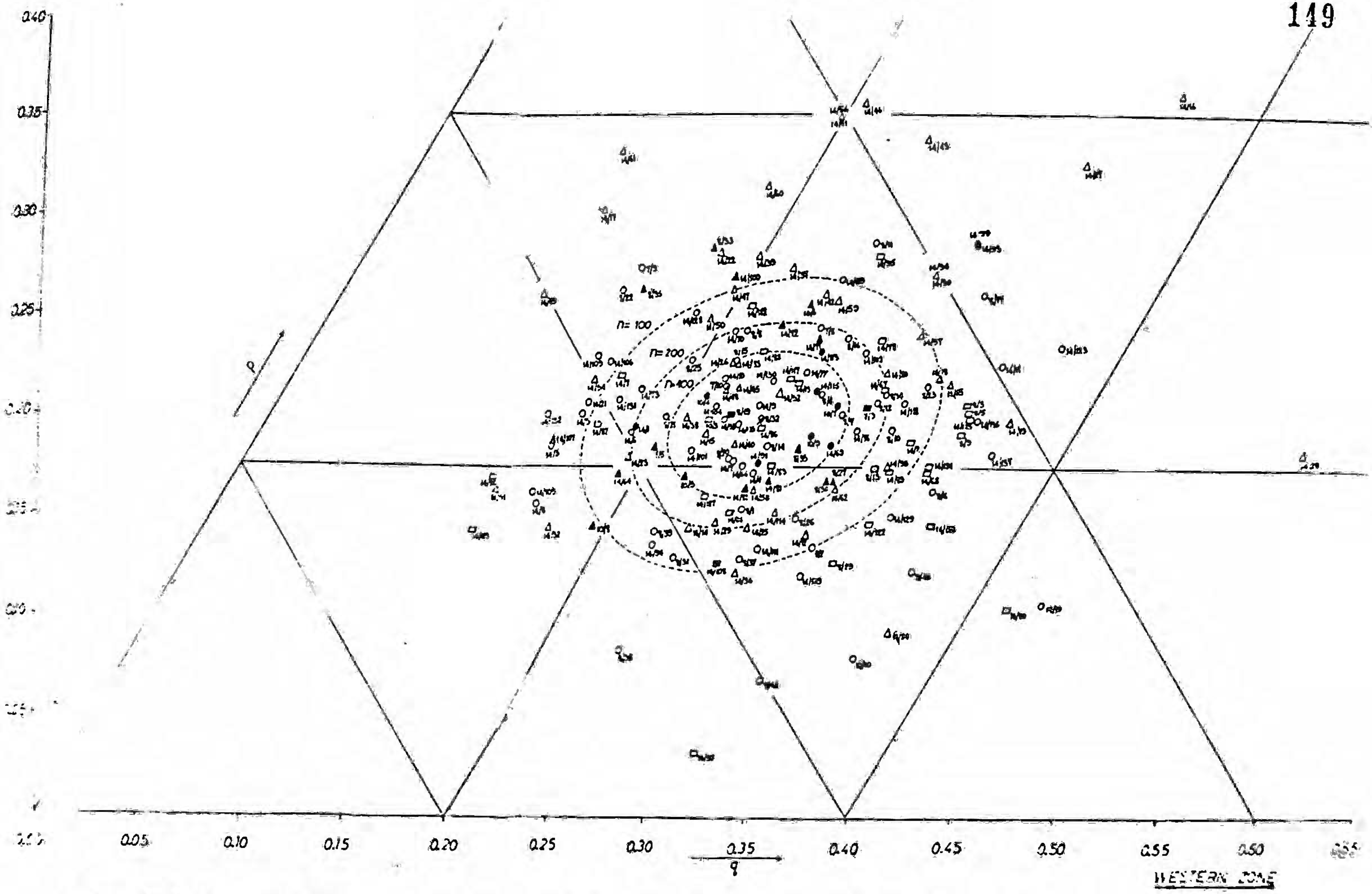

Figure 5.4 Scatter diagram of ABO gene frequencies of population groups belonging to the WESTERN ZONE

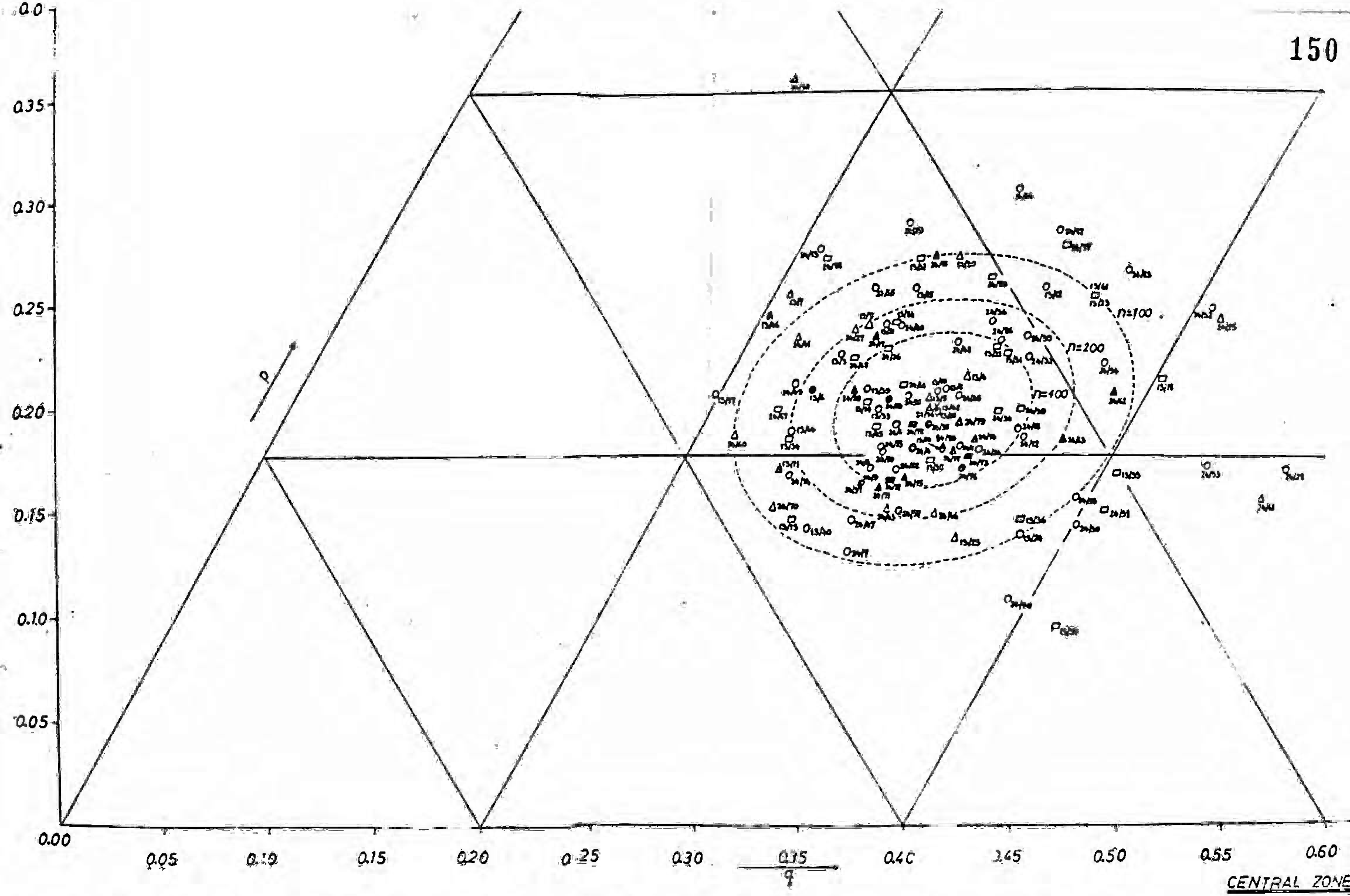

Figure 5.5 Scatter diagram of ABO gene frequencies of population groups belonging to the CENTRAL ZONE

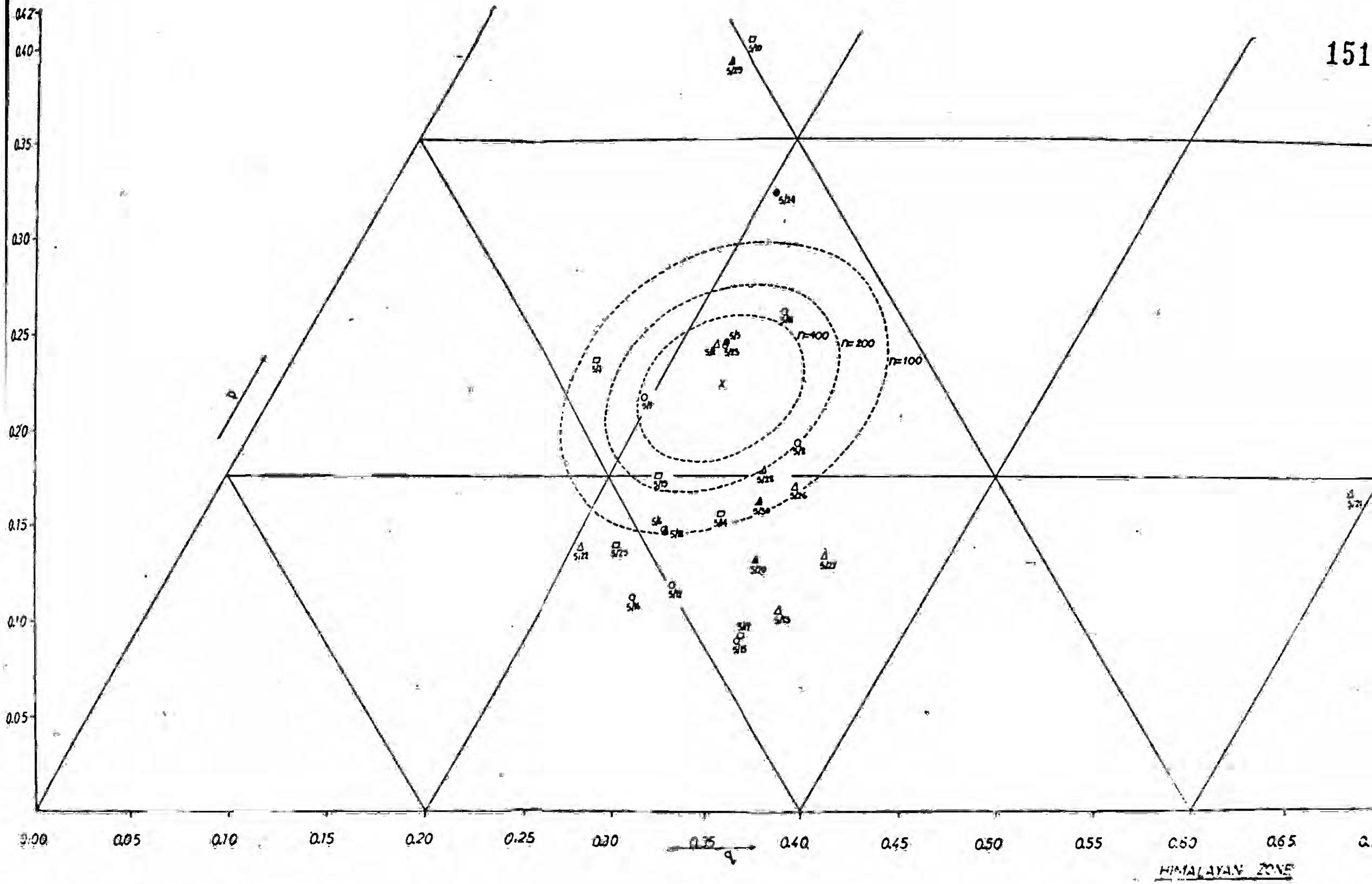

Figure 5.6 [illegible] gene frequencies of [illegible] HIMALAYAN ZONE

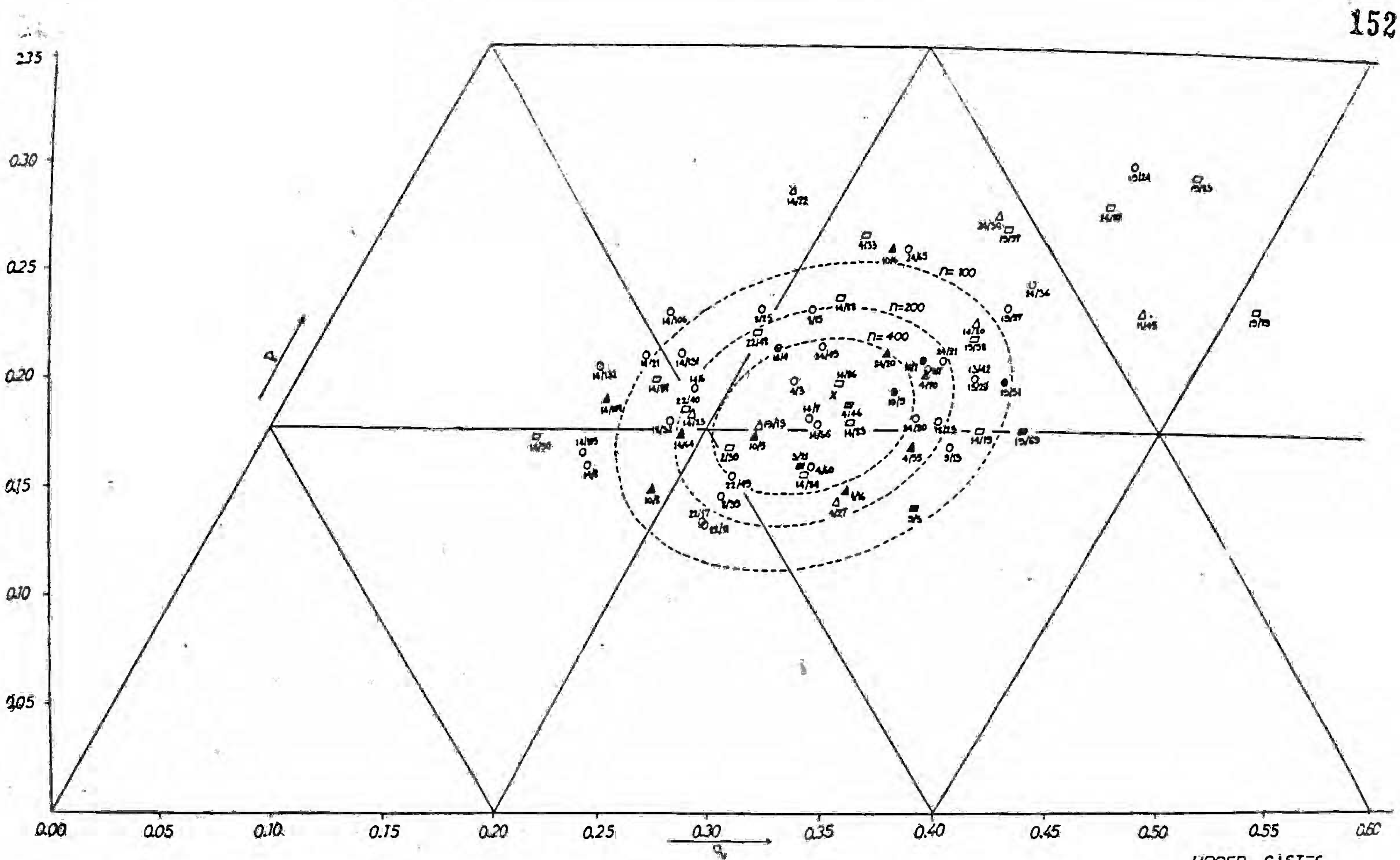

Figure 5.7 Scatter diagram of ABO gene frequencies of UPPER CASTE population groups

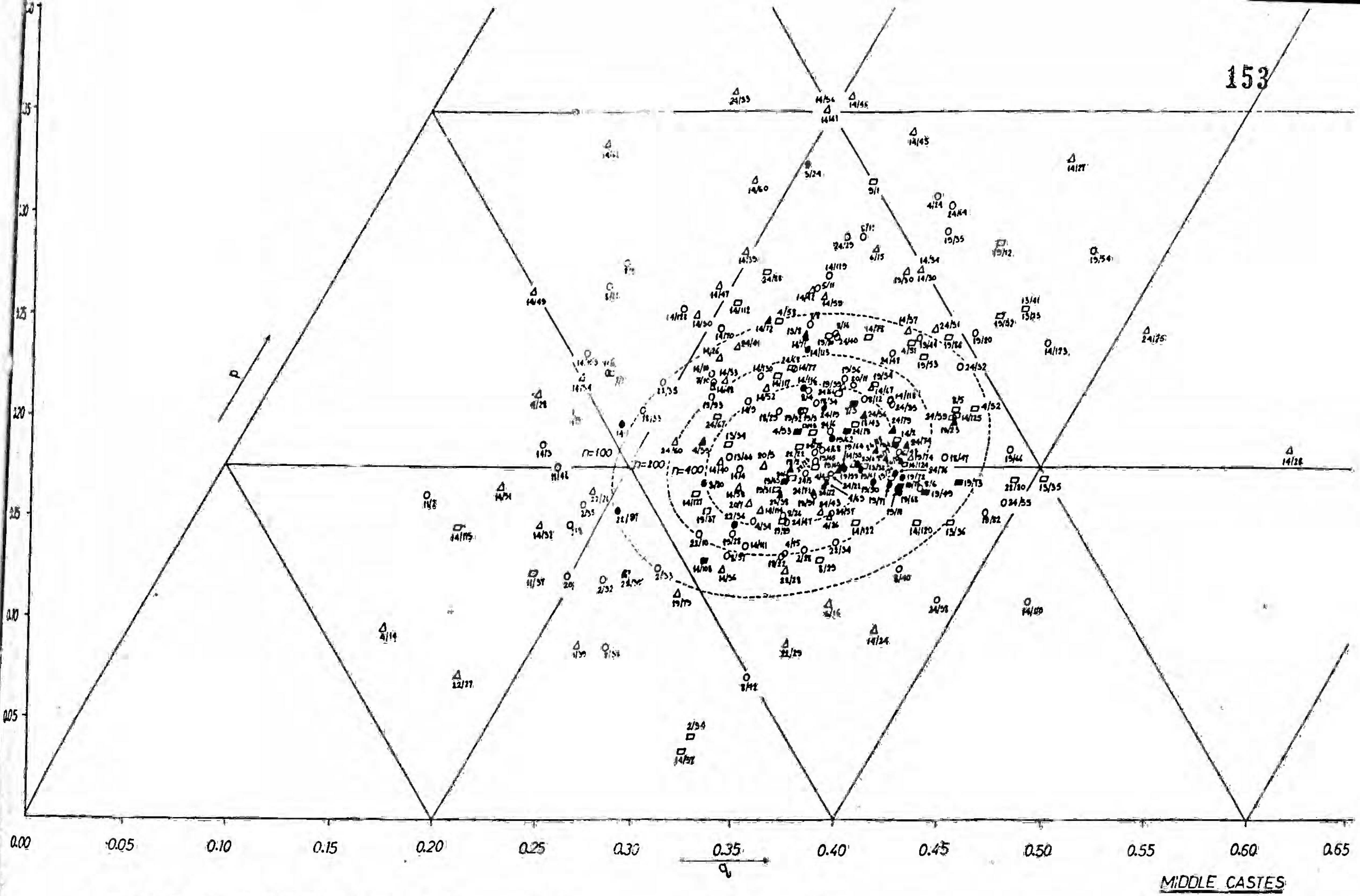

Figure 5.8 Scatter diagram of ABO gene frequencies of [illegible] population groups

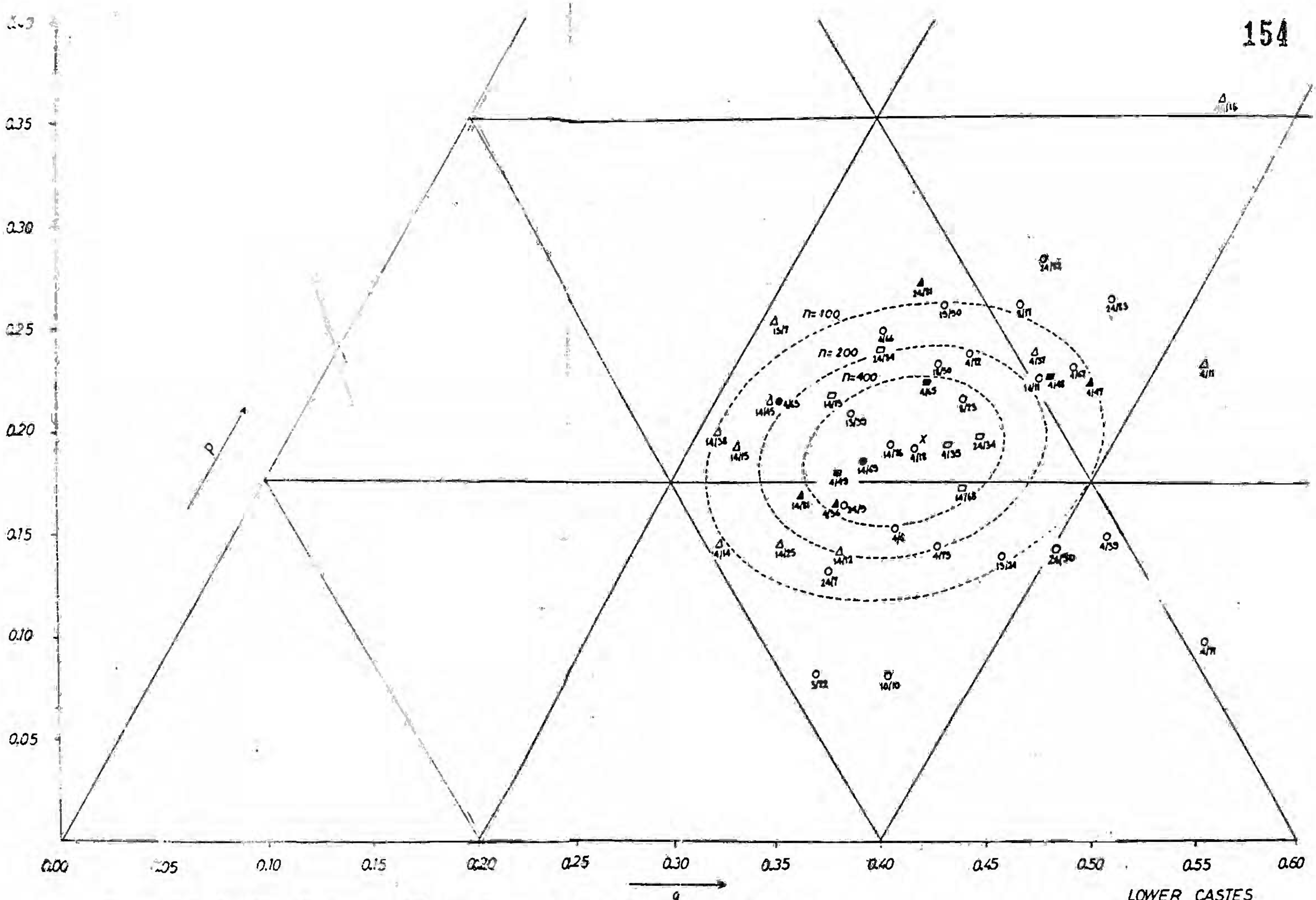

Figure 5.9 Scatter diagram of ABO gene frequencies of LOWER CASTE population groups

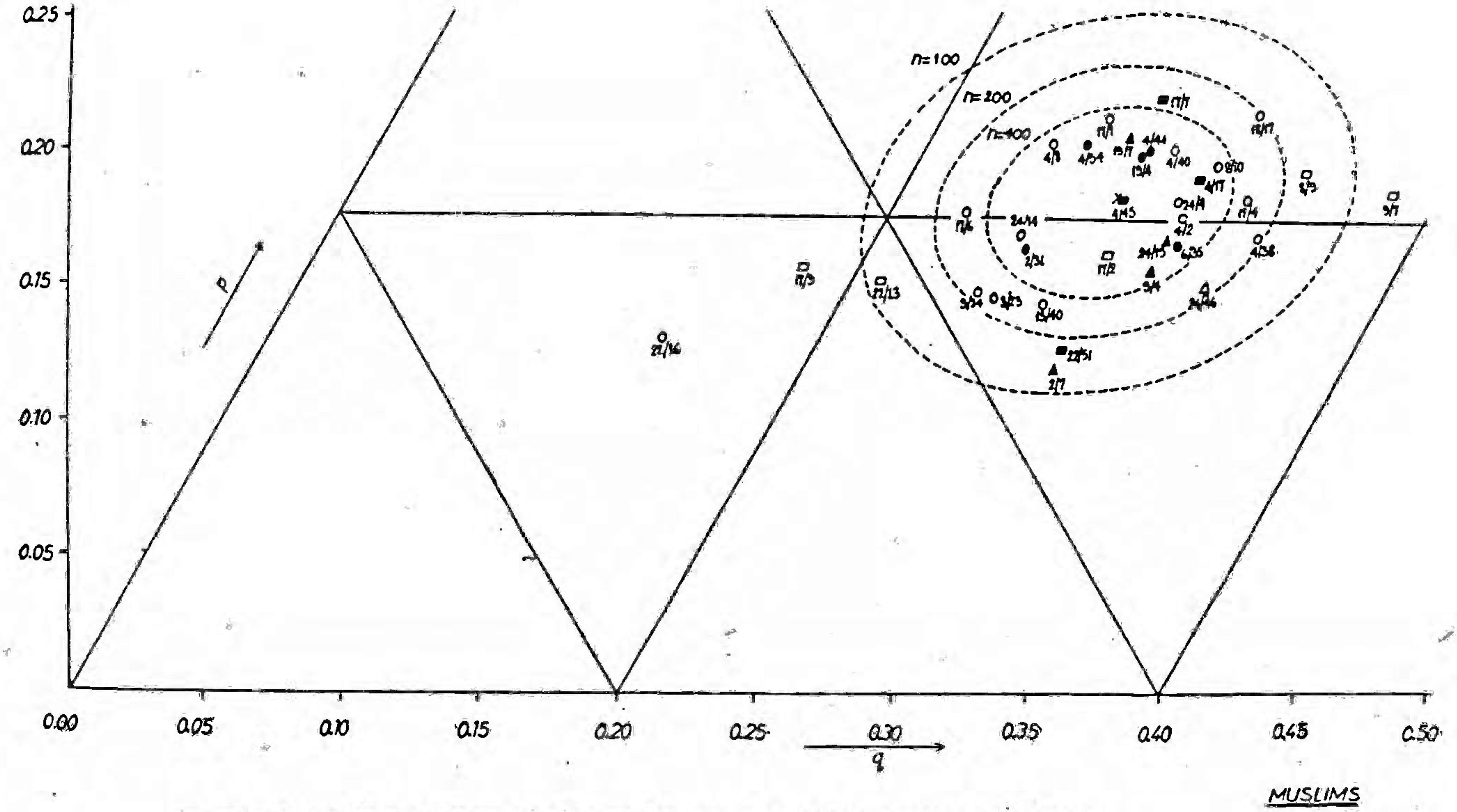

Figure 5.10 Scatter diagram of ABO gene frequencies of MUSLIM population groups

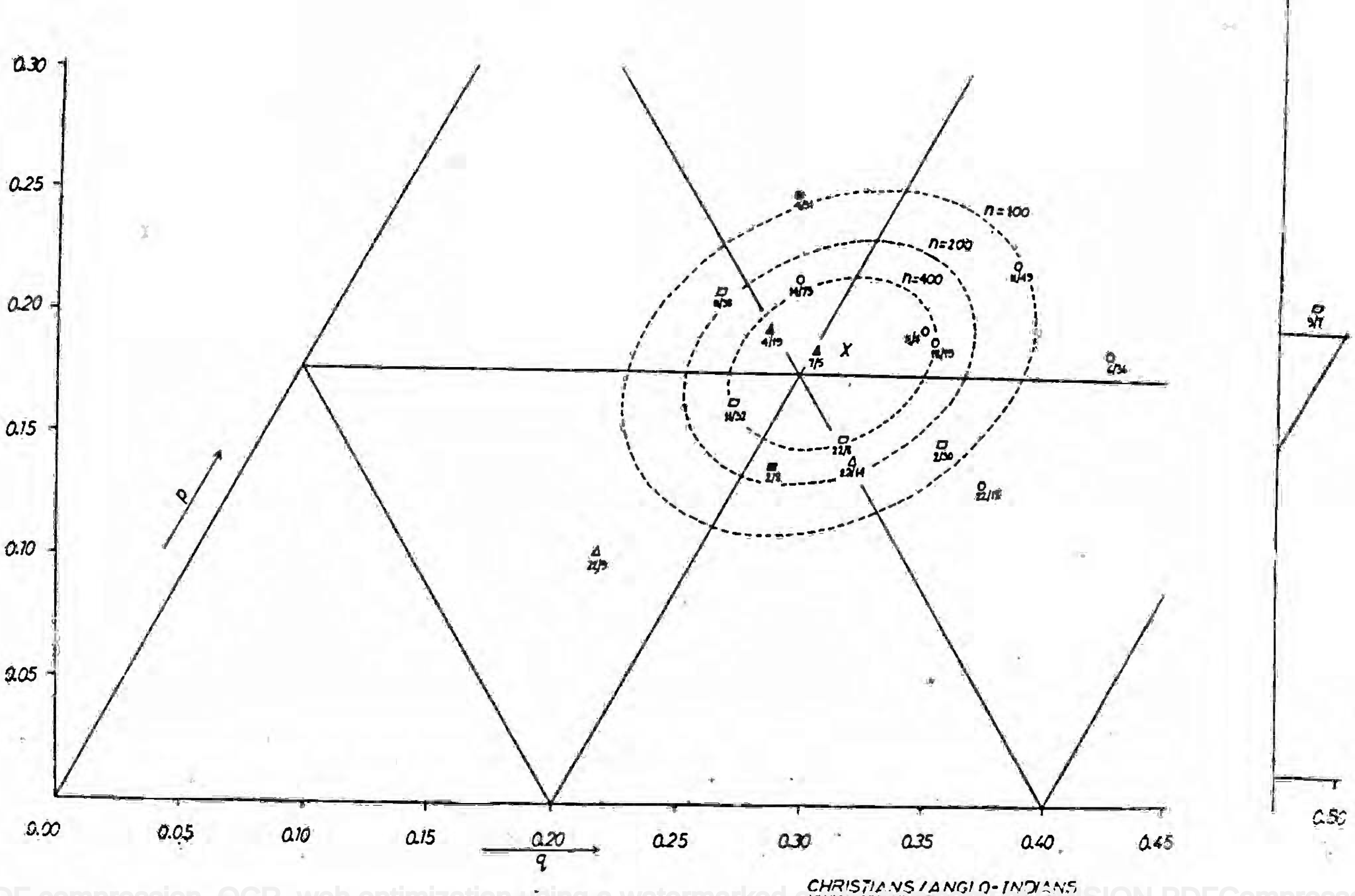

Figure 5.11 Scatter diagram of ABO gene frequencies of CHRISTIAN/ANGLO-INDIAN population groups

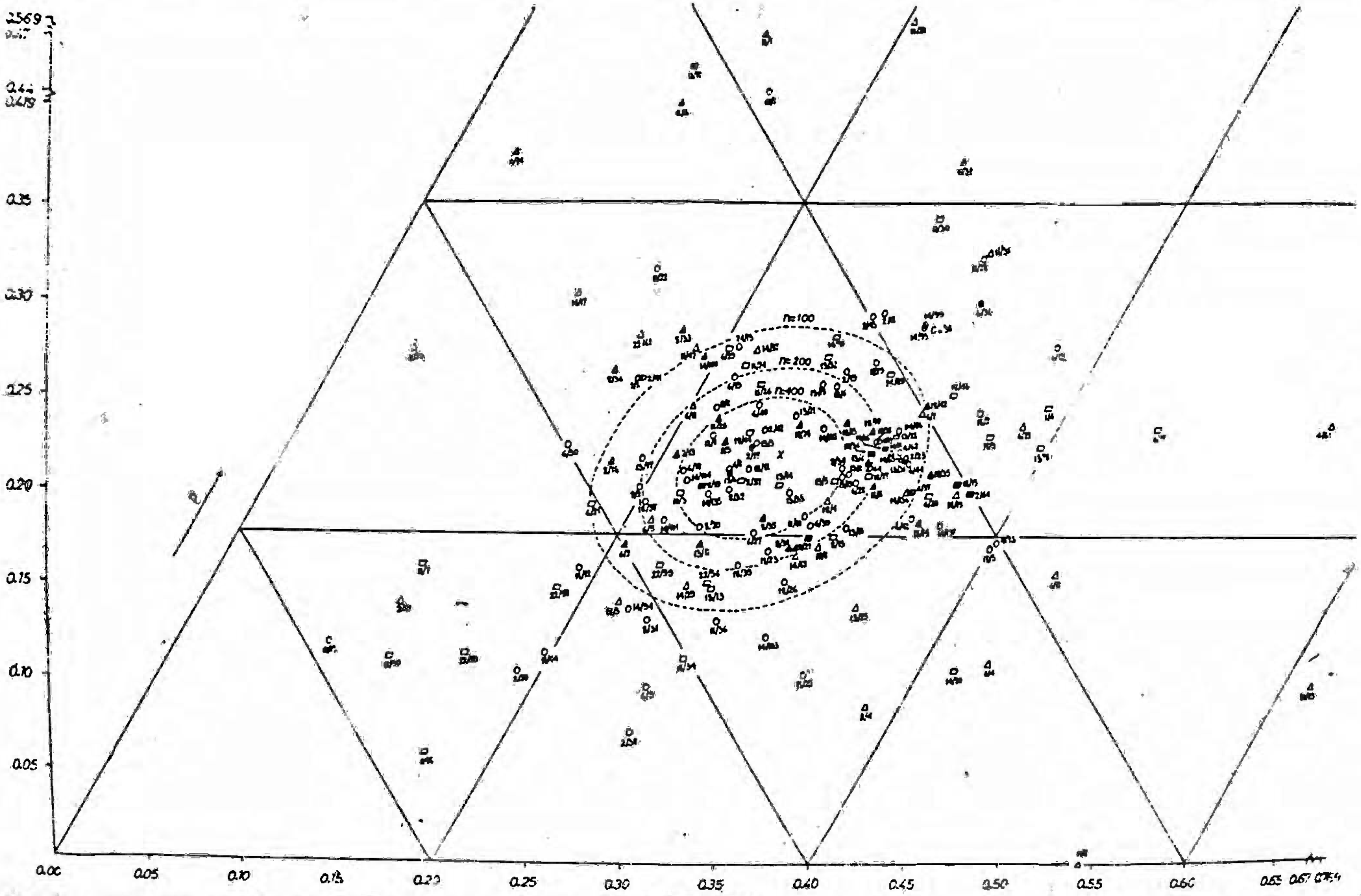

Figure 5.22 Scatter diagram of ABO gene frequencies of AUSTRALOID TRIBAL population groups

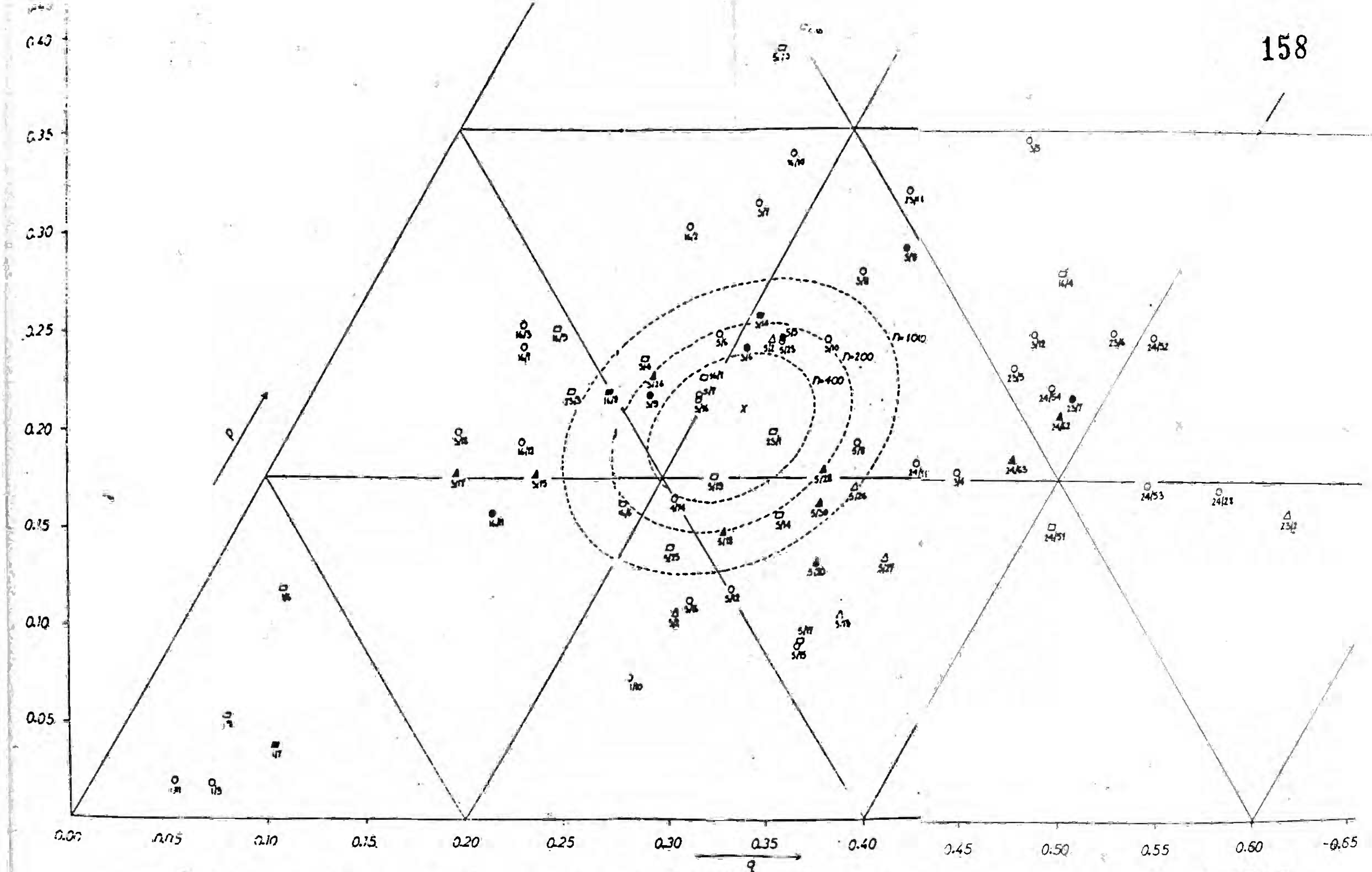

Figure 5.13 Scatter diagram of ABO gene frequencies of MONGOLOID TRIBAL population groups

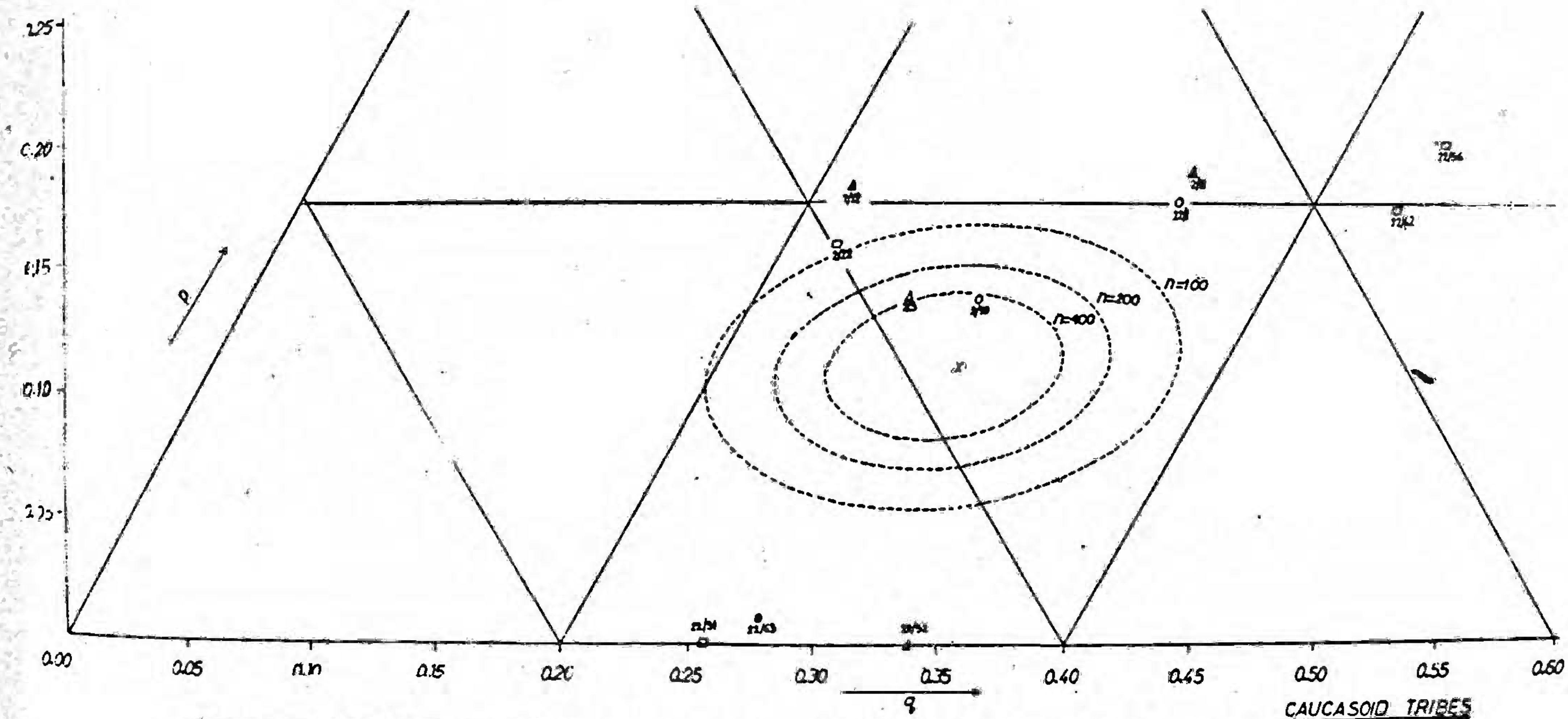

Figure 5.14 Scatter diagram of ABO gene frequencies of CAUCASOID TRIBAL population groups

CHAPTER

VI

CLUSTER ANALYSIS

6.1 Formation of rational homogeneous clusters

Within each of the 19 geographical x socio-religious subsets which showed internal heterogeneity, cluster analysis was performed to partition each such subset into a number of 'rational homogeneous clusters' (RHC's). Using the procedures mentioned in section 4.7, 93 RHC's were formed by breaking-up the 19 subsets. Of these, 41 turned out to be single-point clusters. Including the 13 two-way cross-classified subsets which showed no internal heterogeneity, the 405 data sets for which $n > 100$ were thus grouped into 106 (= 13+93) rational homogeneous clusters.

For the sake of a neater presentation of the results of cluster analysis as also to make the identification codes of the data sets self-explanatory, for the 405 data sets included in this analysis fresh identification codes were given at the end of the analysis. These identification codes are of the form γ-$\sigma\sigma$-mm, where γ is a single-letter code for the geographical zone, σσ is the two-letter code identifying the socio-religious category and mm is a two-digit serial number within the geographical x socio-religious subset. In Table 6.1, the new identification codes have been presented along with the identification codes as in Appendix 1, for the 405 data sets under consideration.

Since the RHC's are homogeneous within themselves in respect of ABO gene frequencies, the combined gene frequencies for each RHC were estimated from the pooled frequencies of phenotypes O, A, B and AB, of the data sets included in the RHC. The composition and the combined ABO gene frequencies of the 106 RHC's have been presented in Table 6.2.

From the sizes and compositions of the RHC's, it was seen that for many two-way cross-classified subsets, only one or two population groups with gene frequencies significantly different from the gene frequencies of the remaining population groups included in the subset makes the subset statistically heterogeneous. Such subsets are divided into a 'large' RHC, and one or more 'small' RHC's. This was seen among the Northern Upper Castes (N-UC), Northern Middle Castes (N-MC), Eastern Middle Castes (E-MC), Eastern Australoid Tribes (E-AT) and Central Middle Castes (C-MC). The nature of heterogeneity and clustering patterns turned out to be in conformity with those described in section 5.2. The compositions of the RHC's were also found to be generally in accordance with the available ethno-historical evidence. Some of these features have been discussed below in some detail.

6.2 Anthropological interpretations of rational homogeneous clusters

6.2.1 Northern Upper Castes (N-UC) . This subset consisting of the Brahmins of the Northern zone [Pandit is a self-styled title of the Sikh Brahmin elite mercantile class of Kashmir (Bowles, 1977)], are remarkably similar. Of the six data sets, only one - the Brahmin sample of Kulu and Katrain (N-UC-06) - is significantly deviated from the rest. This sample has a very high A gene frequency (0.30) compared to the pooled frequency (0.18) of the other five data sets. It also has a slightly higher B gene frequency, and consequently a much lower O gene frequency.

6.2.2 Northern Middle Castes (N-MC) . Like the upper castes, the similarity among the Northern middle castes is also remarkable. There are 34 data sets of the middle castes, who grouped themselves into 6 RHC's. Of these, 28 samples consisting of Jats, Aroras, Khattris, Rajputs, Ahirs, Gujars,

6.4

etc., formed one RHC (N-MC*1). Of the population groups from which more than one independent data set was available, the Rajputs exhibited the maximum amount of variation. The 8 samples of Rajputs were included in 4 distinct RHC's. This large variation is, however, not surprising in view of the fact that there has been a considerable amount of admixture of the Rajputs with the land-holding and ruling families of some tribes, especially, the Kolis and the Bhils (Enthoven, 1920). Moreover, several lower castes occupying the same terrain as the Rajputs claim Rajput descent, imitate Rajput customs and call themselves as Rajputs in a bid to gain higher social status (Enthoven, 1920). For example, in Bulandshahr, the Ahirs claim to be Chauhan Rajputs, in the north-western provinces the Jats claim Rajput descent (Crooke, 1896). Therefore, the Rajputs are really a mixed group, and hence biological homogeneity within this group is not expected.

It is believed that the Jats, Gujars and Ahirs are derived from a common ethnic stock (Crooke, 1896). From the present analysis also it was seen that these groups cluster together (N-MC*1). However, a sample of Jats drawn from Delhi constitutes a separate RHC (N-MC*5). This sample has a much higher A gene frequency and a much lower B gene frequency as compared to the other Jat samples.

6.5

Along with the Jats, Gujars and Ahirs, several trading communities, e.g., Seths, Aroras and Khattris, are found to group themselves. Although nothing very definite is known about the ethno-history of these trading groups, it is known that these groups have a north-western origin, which is also true of the Jats, Gujars, Ahirs and Rajputs (Crooke, 1896). It is, therefore, quite possible that all these groups have evolved from the same ethnic stock, which may be the reason for their clustering together.

6.2.3 Eastern Middle Castes (E-MC). The 16 data sets of middle castes of the Eastern zone grouped themselves into 4 homogeneous RHC's, of which 3 turned out to be single point clusters. The homogeneity among the Kayasthas is significant. All the 6 samples of Kayasthas belong to the same RHC (E-MC*1). The Ranas are a title of a sub-caste of Kayasthas (Risley, 1908), and are, therefore, rightly clustered along with them. The Vaidyas and Kayasthas are almost indistinguishable from a cultural viewpoint (Risley, 1908), and may have originated from a common ethnic stock as is suggested by their clustering together.

6.2.4 Eastern Lower Castes (E-LC). Six RHC's were formed of the 16 data sets included in this subset. Of these 6 RHC's, there is one large RHC containing 9 samples, and 4 single point clusters. The three independent Mahishya samples have all been included in the same RHC (E-LC*2), whereas the Rajbanshis exhibited a good deal of variation. The Rajbanshis are a rather mixed caste and in western Bengal Rajbanshi is a title of the Bagdis (Risley, 1908). The two Bagdi sub-castes - Tentulia and Duley - sampled in Chandernagore (Hooghly) were included in the same RHC (E-LC*3) along with a sample of Rajbanshis (E-LC-12).

6.2.5 <u>Eastern Australoid tribes</u> (E-AT). Nine RHC's were formed of the 39 data sets of Eastern Australoid tribes. One of these (E-AT*1) contains 28 data sets, and there are 5 single point clusters. Of the 4 independent samples of Santals, 3 were included in the RHC E-AT*1, while one sample (E-AT-31) drawn from Chinsurah (West Bengal), fell in a different RHC (E-AT*3). It may be mentioned that this sample of Santals also exhibited peculiar departures from the Santals sampled at other localities in respect of the frequency of G-6-PD deficiency and colour-blindness (B.N. Mukherjee, personal communication). Admixture with local populations is suspected to have caused this departure. With respect to the ABO blood groups this sample has a much lower A gene frequency and a much higher B gene frequency as compared to the other Santal samples. The Oraons are represented by

5 independent samples. Four of these were included in one RHC (E-AT*1), while one sample from Ranchi (E-AT-39) grouped itself as a separate cluster (E-AT*9).

While in the Oraon samples included in E-AT*1, the A gene frequency varies from 0.18 to 0.22, for the Oraon sample from Ranchi (E-AT-39) the frequency is 0.09. Both the Munda samples (E-AT-04 and E-AT-10) belong to the same RHC (E-AT*1). The Hos, Mundas, Gadabas, Oraons, Juangs and Bhumijs belong to the same linguistic family - Kolarian (Risley, 1908, Russell, 1916). They may, therefore, have a common ethnic bearing too, which is indicated by their inclusion in the same RHC (E-AT*1).

6.2.6 Eastern Mongoloid tribes (E-MT). The 31 Mongoloid tribal samples of the Eastern zone grouped themselves into 10 RHC's. Except for the data sets of the Nicobar Is. (E-MT*4), a large amount of heterogeneity was observed among the other populations of this zone. The populations of the Nicobar Is., as has been mentioned earlier, have very low A and B gene frequencies. The other population groups included in this subset are mainly from Assam and the North-East Frontier provinces including Rabhas, Riangs, Garos, Khasis, Abors, Kukis, Nagas, etc. However, barring the Riangs, all the other

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populations from which more than one sample is available seem to be quite heterogeneous, as the independent samples from the same population do not fall in the same cluster. The Abors and the Nagas are said to be the same group. In Assam, the Nagas occupying the northern faces of the mountains all pass under the general name of Nagas, while those situated on the higher ranges are known as Abors (Elwin, 1969). Thus, although not much heterogeneity is expected between the Abors and Nagas, the present analysis does not substantiate this. About the Rabhas also 'there seems to be a good deal of uncertainty as to what these people really are'. 'In lower Assam, it is asserted that they are an offshoot of the Garos, while in Kamrup and Darrang it is thought that they are Kacharis on the road to Hinduism' (Gait, 1892). Again, some anthropologists believe that the Galongs are a sub-group of the Abors, while some believe that they are a separate group of people (Srivastava, 1962). From the foregoing account it is clear that the ethnohistory of this region is not well-documented, and therefore it was difficult to interpret the results of the present analysis in the light of the scanty ethnological data available. However, most of these groups, although known by a general name in a very large area, are really made up of a number of extremely localised isolates of small numerical strength because of the restriction on mobility due to the inaccessible and mountainous terrain of this region. This may be the reason why there is so much heterogeneity among the samples of the same population group.

6.2.7 Southern Middle castes (S-MC) . The 14 southern middle caste samples of this zone grouped themselves into 4 RHC's. Among the 14 samples, there are 4 samples of Nayars (Nairs), and these 4 samples were found to fall in 3 different RHC's. This shows that the Nairs are quite heterogeneous, which is, however, not surprising because they are a mixed caste. The original Nayars were undoubtedly a military body, but through successive waves of immigration from Karnataka and Tamilnadu members of several tribes and castes came and settled down in Kerala (the original habitat of the Nayars) and adopted the caste name of Nayar to attain a more respectable place in the social ladder (Thurston, 1909). Further, the Nayars being matrilinial, have been having close marital relations with many other groups, especially the Namboodiris since a very long time. The Reddys and Kammas who grouped themselves in the same RHC (S-MC*1), 'seem to have branched off from one and the same Dravidian stock' (Francis, 1901). The Pillais and Mudaliars also belong to the same cluster. They are the same people known as Vellalas. The Vellalas generally take the title of Mudali in the northern and Pillai in the southern districts (Thurston, 1909). The Izhavans who constitute an independent cluster (S-MC*4), are traditionally toddy tappers and are believed to have come from Sri Lanka in a not-too-distant past (Bhanu, 1973).

6.2.8 Southern Australoid tribes (S-AT). A great deal of heterogeneity was observed among the Australoid tribes of the Southern zone. Ten RHC's were formed of the 25 data sets included in this subset. The two Paniyan samples (S-AT-12 and S-AT-13) and Malapantrans (S-AT-14) having a very high A gene frequency (0.42) form one cluster (S-AT*3). Not much is known about the ethnic relationships among the tribes included in this subset. It was, therefore, difficult to interpret the cluster configurations obtained.

6.2.9 Western Upper castes (W-UC). Four RHC's were formed of the 21 data sets included in this subset. Among the Brahmins of this zone, the Desasthas showed the greatest amount of variation. They are quite widespread and are found chiefly in the southern districts of Maharashtra (Sanghvi, 1954), as also in the neighbouring states of Karnataka and Andhra Pradesh. Of the 9 independent samples of the Dasastha Brahmins, 5 fell in one RHC (W-UC*1) together with two samples of Audich

Brahmins, who are found all over Gujarat, and, it appears, have entered Gujarat from nothern India (Vyas et al., 1958). In another RHC (W-UC*3), there are three samples of Audichs, Deasasthas and Nagar Brahmins. The Nagar Brahmins, like the Audichs, are also from Gujarat. The 3 samples of Chitpavan Brahmins (the Koknasths are Chitpavans) are all included in the same RHC (W-UC*2). This group is numerically much smaller as compared to the Desasths or Audichs, and are found chiefly in the south-western parts of Maharashtra. In W-UC*2 are also included 2 samples of Desasthas, 1 sample of Madhyandins, 3 samples of Saraswat Brahmins, and 1 sample of Nagar Brahmins. The Saraswat Brahmins are found in the north-western districts of Karnataka and south-western districts of Maharashtra, and appear to be quite homogeneous as all the 3 samples from this group are included in the same cluster. It must, however, be mentioned that the clustering together of Saraswats, Chitpavans, Desasths and Madhyandins are in discordance with some earlier studies (Karve and Dandekar, 1951; Malhotra, 1966, etc.).

6.2.10 <u>Western Middle castes</u> (W-MC). The 36 data sets included in this subset were grouped into 8 RHC's, of which 4 turned out to be single-point clusters. The Marathas who are spread over the whole of Maharashtra show a good deal of variation. The reason for this may be that although prior to 1947 they constituted one single endogamous group, several other groups, e.g. the Kunbis, started calling themselves as Marathas after 1947, for certain political reasons. Therefore, the present day Marathas are a mixed group, and hence show a lot of variation. The shepherd caste of Dhangars are divided into several endogamous groups, of which 10 have been included in the present analysis. Of these 10 groups 5 were included in one RHC (W-MC*4), and 2 groups - Thellari and Gadhari formed two independent RHC's (W-MC*6 and W-MC*8, respectively). By and large, however, there is a good deal of variation among the middle caste groups of this zone.

6.2.11 Western Australoid tribes (W-AT). There are 23 data sets of the Australoid tribes of this zone, who grouped themselves in 8 RHC's. Of the 7 samples of Bhils, 5 are included in one RHC (W-AT*2), while the remaining two samples group themselves with the Kolis in two distinct RHC's (W-AT*3 and W-AT*4). The Bhils occupy a large geographical area and have undergone considerable admixture with the neighbouring peoples (Sarkar, 1954), hence the heterogeneity among the Bhil samples. The four populations included in W-AT*1 are all from Gujarat. In W-AT*2, together with the Bhils are included some populations, Dubla, Paura, Dhanka and Naika. These groups are found chiefly in Gujarat and share their habitat with the Bhils. The Korkus are found to the east of the Bhilli tract - in the north-eastern part of Maharashtra sharing borders with southern Madhya Pradesh. They are the only Austric speakers in Maharashtra, and the two samples of Korkus forming a separate RHC (W-AT*5) is suggestive of their distinct identity. The Katkaris and Warlies who form two clusters (W-AT*7 and W-AT*8) are isolated groups living in the mountainous tracts of the Western Ghats. The Yeravas, who also form a distinct cluster (W-AT*6), are from Karnataka.

6.2.12 Central Middle castes (C-MC) . A very good deal of homogeneity was observed among the middle castes of this zone. The 26 data sets formed 4 RHC's, of which one RHC (C-MC*4) contains 22 sets. Of the 8 independent samples of Rajputs, 6 were included in C-MC*4 while the remaining two grouped themselves separately (C-MC*2). The Rajputs, as has been mentioned earlier, are a mixed group and hence they are not homogeneous.

6.2.13 Central Lower Castes (C-LC) . Unlike the middle castes, the lower castes of the central zone exhibited a lot of heterogeneity. The 8 samples formed 3 RHC's. The 3 sub-castes of Pasis - Gujar, Baurasi and Raj, clustered together

(C-LC*1), while one sample (C-LC-08) with a much lower A gene frequency and a higher B gene frequency was included in another RHC (C-LC*3).

6.2.14 Himalayan Mongoloid Tribes (H-MT) . The 13 data sets included in this subset formed 3 RHC's, of which one is a single point cluster. Interesting homogeneity was observed among the samples from this zone. All the 5 Tibetan samples were included in the same cluster, (H-MT*2), which also included 3 Sherpa samples and the Dogpars of Nepal. The 2 samples of Gurkhas clustered together with the Bhutanese. Whereas among the Gurkhas and Bhutanese the A, B and O gene frequencies are about 0.24, 0.18 and 0.58, respectively, among the Tibetans and Sherpas these are, respectively, about 0.13, 0.24 and 0.63.

6.3 Formation of superclusters

Since the RHC's were formed only within the two-way classified geographical x socio-religious subsets, in order to find similarities among the RHC's belonging to different subsets, cluster analysis was performed, once again. The combined ABO gene frequencies of the RHC's given in Table 6.2 were used for finding pairwise distances among the RHC's. Upon an application of the methods described in section 4.7,

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the 106 RHC's were clustered into 39 homogeneous 'superclusters' in terms of the RHC's. The composition and structure of each of the 39 superclusters are given in Table 6.3. It can be seen, from this table, that 17 of the 39 superclusters contain only one RHC. These superclusters, it is to be noted, are not homogeneous either in respect of geographical location or in respect of socio-religious criteria, but they are internally homogeneous in respect of ABO gene frequencies. This purely statistical finding needs to be carefully examined from ethnical/anthropological viewpoint for an acceptable interpretation.

The Upper Castes of the Central zone who are homogeneous in respect of A, B, O gene frequencies stand out separately as a distinct supercluster (C_{36}). The Middle castes of this (Central) zone are also largely homogeneous. They are, however, not similar to the Upper castes of this zone, but show similarities with the Muslims of the Northern and Eastern zones (C_{39}). The Mongoloid tribes of this zone also stand out separately as a distinct supercluster (C_{21}). The Upper and Middle castes of the Northern zone, who are considerably homogeneous within themselves, also show a great deal of similarity between themselves (C_{38}). In the Eastern zone also, the pattern is similar - most Upper and Middle castes groups cluster together (C_{34}). The Lower castes of this zone, who are not very

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homogeneous within themselves either form separate superclusters (C_8, C_{37}) or cluster with some Mongoloid tribal groups of this zone (C_{19}). The Mongoloid tribal groups of this zone are also quite heterogeneous, they form several independent superclusters also (C_1, C_4, C_{10}). The Australoid tribals of this zone are quite homogeneous and form almost a separate supercluster along with 2 Australoid tribal population groups of the Western zone (C_{33}). The Upper castes of the Southern zone cluster with some Middle caste population groups of this zone (C_{26}), but most Middle caste population groups of this zone fall in a different supercluster (C_{22}) along with the Muslims. Most Caucasoid tribes of the Southern zone show similarities with the Upper and Middle castes of the Northern zone (C_{38}). In the Western zone, while some Upper caste population groups cluster with the Upper castes of the Eastern zone (C_{34}), most Upper caste data sets from this zone form an independent supercluster (C_{20}). Most Middle castes of this zone also group themselves as a separate cluster (C_{28}). Many of the Australoid tribal population groups from this zone also cluster with some Upper caste population groups of this zone (C_{34}). The two Middle caste population groups of the Himalayan zone group themselves as a separate supercluster (C_{13}). Some of the Himalayan Mongoloid tribal population groups stand out separately as a supercluster (C_{31}), while some others group themselves with some caste and tribal population groups of different zones (C_{22}).

A final application of the cluster-analysis technique yielded the dendrogram depicting the similarities among the superclusters presented in Figure 6.1.

Since the superclusters are homogeneous in terms of their constituent RHC's, it was of natural interest to investigate whether they are also homogeneous in terms of the original data sets. For this, therefore, a chi-square test of homogeneity was performed for each supercluster in terms of the ABO gene frequencies of the data sets contained therein. This analysis revealed that all but 3 superclusters are indeed homogeneous even in terms of the population groups. This can of course happen because of the uncertainties of statistical inference.

Using cluster-analytic procedures, the 3 superclusters C_{25}, C_{38} and C_{39}, which turned out to be heterogeneous with respect to the original data sets, were, once again, broken up into 6 homogeneous clusters. The supercluster C_{25} was decomposed into two clusters : $C_{25,1} = \{$E-CH-04$\}$ and $C_{25,2} = \{C_{25} - C_{25,1}\}$. Similarly, each of the remaining two superclusters C_{38} and C_{39} were also decomposed as :

$C_{38,1} = \{$N-UC-01, N-MC-26, S-CT-01$\}$, $C_{38,2} = \{C_{38} - C_{38,1}\}$

and

$C_{39,1} = \{$W-LC-03$\}$, $C_{39,2} = \{C_{39} - C_{39,1}\}$.

Table 6.1 New identification codes for 405 data sets

identi- fication no. in Appendix 1	new identi- fication no.	identi- fication no. in Appendix 1	new identi- fication no.	identi- fication no. in Appendix 1	new identi- fication no.
(1.1)	(2.1)	(1.2)	(2.2)	(1.3)	(2.3)
09005	N-UC-01	09013	N-UC-02	19027	N-UC-03
19051	N-UC-04	19069	N-UC-05	19024	N-UC-06
19002	N-MC-01	19018	N-MC-02	19020	N-MC-03
19044	N-MC-04	19045	N-MC-05	19049	N-MC-06
19050	N-MC-07	19056	N-MC-08	19059	N-MC-09
19060	N-MC-10	19061	N-MC-11	19062	N-MC-12
19063	N-MC-13	19064	N-MC-14	19065	N-MC-15
19066	N-MC-16	19068	N-MC-17	19071	N-MC-18
19072	N-MC-19	19073	N-MC-20	19074	N-MC-21
19075	N-MC-22	19082	N-MC-23	19091	N-MC-24
19092	N-MC-25	20001	N-MC-26	20004	N-MC-27
20010	N-MC-28	19023	N-MC-29	19035	N-MC-30
20008	N-MC-31	19054	N-MC-32	19093	N-MC-33
19028	N-MC-34	09004	N-MU-01	17001	N-MU-02
17004	N-MU-03	17006	N-MU-04	17007	N-MU-05
19004	N-MU-06	19007	N-MU-07	24013	N-AT-01
24086	N-AT-02	24089	N-AT-03	03021	E-UC-01
04003	E-UC-02	04016	E-UC-03	04046	E-UC-04
04055	E-UC-05	04060	E-UC-06	04070	E-UC-07
18023	E-UC-08	18032	E-UC-09	03020	E-MC-01
04004	E-MC-02	04015	E-MC-03	04034	E-MC-04
04053	E-MC-05	04059	E-MC-06	04068	E-MC-07
04069	E-MC-08	06043	E-MC-09	18022	E-MC-10
18029	E-MC-11	18034	E-MC-12	18047	E-MC-13
18033	E-MC-14	03019	E-MC-15	04024	E-MC-16
04006	E-LC-01	04018	E-LC-02	04036	E-LC-03
04049	E-LC-04	04065	E-LC-05	04066	E-LC-06

....contd.

Table (6.1) contd.

(1.1)	(2.1)	(1.2)	(2.2)	(1.3)	(2.3)
04072	E-LC-07	04073	E-LC-08	18050	E-LC-09
04047	E-LC-10	04048	E-LC-11	04067	E-LC-12
04063	E-LC-13	04039	E-LC-14	04071	E-LC-15
03022	E-LC-16	03023	E-MU-01	03024	E-MU-02
04002	E-MU-03	04008	E-MU-04	04017	E-MU-05
04038	E-MU-06	04040	E-MU-07	04044	E-MU-08
04045	E-MU-09	04054	E-MU-10	06035	E-MU-11
18017	E-MU-12	04019	E-CH-01	04031	E-CH-02
07005	E-CH-03	18019	E-CH-04	06036	E-CH-05
04062	E-AT-01	04064	E-AT-02	06003	E-AT-03
06008	E-AT-04	06013	E-AT-05	06027	E-AT-06
06028	E-AT-07	06037	E-AT-08	06039	E-AT-09
06040	E-AT-10	06042	E-AT-11	06044	E-AT-12
18005	E-AT-13	18006	E-AT-14	18010	E-AT-15
18011	E-AT-16	18012	E-AT-17	18013	E-AT-18
18014	E-AT-19	18015	E-AT-20	18016	E-AT-21
18024	E-AT-22	18026	E-AT-23	18035	E-AT-24
18036	E-AT-25	18038	E-AT-26	18039	E-AT-27
18042	E-AT-28	06031	E-AT-29	06038	E-AT-30
04075	E-AT-31	18002	E-AT-32	06002	E-AT-33
18037	E-AT-34	06012	E-AT-35	06030	E-AT-36
18025	E-AT-37	06032	E-AT-38	06009	E-AT-39
03004	E-MT-01	03012	E-MT-02	23005	E-MT-03
23006	E-MT-04	23007	E-MT-05	03015	E-MT-06
03017	E-MT-07	03018	E-MT-08	16011	E-MT-09
16012	E-MT-10	03007	E-MT-11	16002	E-MT-12
16010	E-MT-13	01001	E-MT-14	01007	E-MT-15

...contd.

Table (6.1) contd.

(1.1)	(2.1)	(1.2)	(2.2)	(1.3)	(2.3)
01011	E-MT-16	03008	E-MT-17	03010	E-MT-18
03011	E-MT-19	23004	E-MT-20	03006	E-MT-21
03009	E-MT-22	03014	E-MT-23	03016	E-MT-24
03026	E-MT-25	16008	E-MT-26	16001	E-MT-27
16003	E-MT-28	04074	E-MT-29	03005	E-MT-30
01010	E-MT-31	01005	E-NT-01	22011	S-UC-01
22017	S-UC-02	22049	S-UC-03	02028	S-MC-01
02032	S-MC-02	02033	S-MC-03	22010	S-MC-04
22034	S-MC-05	22036	S-MC-06	22038	S-MC-07
22039	S-MC-08	02035	S-MC-09	11046	S-MC-10
22037	S-MC-11	11006	S-MC-12	22035	S-MC-13
11002	S-MC-14	02007	S-MU-01	02031	S-MU-02
22051	S-MU-03	22016	S-MU-04	11004	S-CH-01
11049	S-CH-02	02008	S-CH-03	22018	S-CH-04
02023	S-AT-01	02044	S-AT-02	11023	S-AT-03
11041	S-AT-04	02005	S-AT-05	02013	S-AT-06
02016	S-AT-07	02017	S-AT-08	02042	S-AT-09
11025	S-AT-10	12001	S-AT-11	11016	S-AT-12
11017	S-AT-13	11022	S-AT-14	02008	S-AT-15
02019	S-AT-16	02043	S-AT-17	11029	S-AT-18
02020	S-AT-19	11044	S-AT-20	02038	S-AT-21
11012	S-AT-22	11028	S-AT-23	11036	S-AT-24
11015	S-AT-25	02010	S-CT-01	02011	S-CT-02
22001	S-CT-03	02012	S-CT-04	22063	S-CT-05
08039	W-UC-01	08007	W-UC-02	10007	W-UC-03
10009	W-UC-04	14007	W-UC-05	14066	W-UC-06
10005	W-UC-07	14008	W-UC-08	14105	W-UC-09

...contd.

Table (6.1) contd.

(1.1)	(2.1)	(1.2)	(2.2)	(1.3)	(2.3)
14106	W-UC-10	14006	W-UC-11	14021	W-UC-12
14131	W-UC-13	14107	W-UC-14	14132	W-UC-15
14064	W-UC-16	10008	W-UC-17	08015	W-UC-18
10004	W-UC-19	08025	W-UC-20	10007	W-UC-21
08006	W-MC-01	08040	W-MC-02	08026	W-MC-03
08037	W-MC-04	14004	W-MC-05	14108	W-MC-06
14111	W-MC-07	07009	W-MC-08	08022	W-MC-09
14001	W-MC-10	14003	W-MC-11	14005	W-MC-12
14109	W-MC-13	07003	W-MC-14	07008	W-MC-15
07010	W-MC-16	08004	W-MC-17	08011	W-MC-18
08012	W-MC-19	08016	W-MC-20	14009	W-MC-21
14010	W-MC-22	14070	W-MC-23	14071	W-MC-24
14072	W-MC-25	14077	W-MC-26	14113	W-MC-27
14116	W-MC-28	14118	W-MC-29	14119	W-MC-30
14128	W-MC-31	14130	W-MC-32	08042	W-MC-33
14123	W-MC-34	08038	W-MC-35	14110	W-MC-36
08017	W-LC-01	08023	W-LC-02	10010	W-LC-03
14011	W-LC-04	14069	W-LC-05	14076	W-LC-06
14081	W-LC-07	14129	W-LC-08	08009	W-MU-01
08010	W-MU-02	14082	W-PA-01	14091	W-PA-02
14098	W-PA-03	08008	W-AT-01	08033	W-AT-02
08036	W-AT-03	14100	W-AT-04	08019	W-AT-05
08020	W-AT-06	08021	W-AT-07	08027	W-AT-08
08030	W-AT-09	08032	W-AT-10	08035	W-AT-11
14101	W-AT-12	14104	W-AT-13	14135	W-AT-14
08034	W-AT-15	14102	W-AT-16	08031	W-AT-17
14094	W-AT-18	14093	W-AT-19	14099	W-AT-20

...contd.

Table (6.1) contd.

(1.1)	(2.1)	(1.2)	(2.2)	(1.3)	(2.3)
10002	W-AT-21	14137	W-AT-22	14103	W-AT-23
13028	C-UC-01	13042	C-UC-02	24020	C-UC-03
24021	C-UC-04	24036	C-UC-05	24049	C-UC-06
24065	C-UC-07	24080	C-UC-08	24058	C-MC-01
24029	C-MC-02	24064	C-MC-03	24055	C-MC-04
13044	C-MC-05	24005	C-MC-06	24006	C-MC-07
24019	C-MC-08	24022	C-MC-09	24032	C-MC-10
24035	C-MC-11	24040	C-MC-12	24047	C-MC-13
24048	C-MC-14	24056	C-MC-15	24057	C-MC-16
24071	C-MC-17	24072	C-MC-18	24073	C-MC-19
24074	C-MC-20	24075	C-MC-21	24076	C-MC-22
24077	C-MC-23	24078	C-MC-24	24079	C-MC-25
24085	C-MC-26	24081	C-LC-01	24082	C-LC-02
24083	C-LC-03	13039	C-LC-04	24007	C-LC-05
24009	C-LC-06	13024	C-LC-07	24050	C-LC-08
13040	C-MU-01	24004	C-MU-02	24014	C-MU-03
24015	C-MU-04	13002	C-AT-01	13003	C-AT-02
13006	C-AT-03	13010	C-AT-04	13011	C-AT-05
13015	C-AT-06	13017	C-AT-07	13019	C-AT-08
13021	C-AT-09	13033	C-AT-10	24011	C-MT-01
24028	C-MT-02	24052	C-MT-03	24053	C-MT-04
24054	C-MT-05	24062	C-MT-06	24063	C-MT-07
05011	H-MC-01	05024	H-MC-02	05005	H-MT-01
05007	H-MT-02	05023	H-MT-03	05006	H-MT-04
05008	H-MT-05	05012	H-MT-06	05015	H-MT-07
05016	H-MT-08	05018	H-MT-09	05020	H-MT-10
05028	H-MT-11	05030	H-MT-12	05029	H-MT-13

Table 6.2 Composition and combined ABO gene frequencies of Rational Homogeneous Clusters

sl. no.	designation of RHC	no. of population groups included	population groups included	sample size	combined estimates of gene frequencies p	q	r
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	N-UC*1	5	N-UC-1 to N-UC-5	1338	0.176	0.277	0.547
2	N-UC*2	1	N-UC-6	110	0.295	0.282	0.423
3	N-MC*1	28	N-MC-1 to N-MC-28	13185	0.174	0.277	0.549
4	N-MC*2	2	N-MC-29 and N-MC-30	449	0.294	0.248	0.458
5	N-MC*3	1	N-MC-31	128	0.120	0.170	0.710
6	N-MC*4	1	N-MC-32	185	0.280	0.314	0.406
7	N-MC*5	1	N-MC-33	105	0.208	0.190	0.602
8	N-MC*6	1	N-MC-34	112	0.140	0.234	0.626
9	N-MU	7	N-MU-1 to N-MU-7	3537	0.195	0.241	0.564
10	N-AT	3	N-AT-1 to N-AT-3	442	0.252	0.236	0.512
11	E-UC	9	E-UC-1 to E-UC-9	2193	0.173	0.223	0.604
12	E-MC*1	13	E-MC-1 to E-MC-13	2797	0.172	0.240	0.588
13	E-MC*2	1	E-MC-14	200	0.201	0.164	0.634

...contd.

Table (6.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
14	E-MC*3	1	E-MC-15	145	0.145	0.158	0.697
15	E-MC*4	1	E-MC-16	194	0.307	0.236	0.457
16	E-LC*1	9	E-LC-1 to E-LC-9	1922	0.198	0.252	0.550
17	E-LC*2	3	E-LC-10 to E-LC-12	733	0.226	0.309	0.465
18	E-LC*3	1	E-LC-13	422	0.214	0.197	0.589
19	E-LC*4	1	E-LC-14	133	0.148	0.364	0.487
20	E-LC*5	1	E-LC-15	122	0.098	0.430	0.472
21	E-LC*6	1	E-LC-16	161	0.081	0.278	0.640
22	E-MU	12	E-MU-1 to E-MU-12	3957	0.187	0.247	0.566
23	E-CH*1	4	E-CH-1 to E-CH-4	867	0.212	0.157	0.631
24	E-CH*2	1	E-CH-5	153	0.184	0.277	0.539
25	E-AT*1	28	E-AT-1 to E-AT-28	5922	0.208	0.267	0.525
26	E-AT*2	2	E-AT-29 and E-AT-30	855	0.295	0.273	0.432
27	E-AT*3	2	E-AT-31 and E-AT-32	230	0.170	0.346	0.484
28	E-AT*4	2	E-AT-33 and E-AT-34	435	0.181	0.177	0.643
29	E-AT*5	1	E-AT-35	114	0.275	0.322	0.403
30	E-AT*6	1	E-AT-36	111	0.223	0.125	0.652

...contd.

Table (6.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
31	E-AT*7	1	E-AT-37	168	0.101	0.294	0.605
32	E-AT*8	1	E-AT-38	206	0.373	0.231	0.396
33	E-AT*9	1	E-AT-39	155	0.094	0.225	0.681
34	E-MT*1	5	E-MT-1 to E-MT-5	1143	0.222	0.317	0.461
35	E-MT*2	5	E-MT-6 to E-MT-10	1388	0.173	0.098	0.729
36	E-MT*3	3	E-MT-11 to E-MT-13	465	0.316	0.140	0.544
37	E-MT*4	3	E-MT-14 to E-MT-16	660	0.029	0.056	0.915
38	E-MT*5	4	E-MT-17 to E-MT-20	1304	0.284	0.217	0.499
39	E-MT*6	6	E-MT-21 to E-MT-26	2123	0.229	0.157	0.614
40	E-MT*7	2	E-MT-27 to E-MT-28	292	0.246	0.077	0.677
41	E-MT*8	1	E-MT-29	200	0.164	0.182	0.654
42	E-MT*9	1	E-MT-30	191	0.346	0.246	0.408
43	E-MT*10	1	E-MT-31	113	0.073	0.207	0.720
44	E-NT	1	E-NT-1	122	0.123	0.261	0.615
45	S-UC	3	S-UC-1 to S-UC-3	415	0.137	0.193	0.670
46	S-MC*1	8	S-MC-1 to S-MC-8	1799	0.137	0.229	0.634

.. contd.

Table (6.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
47	S-MC*2	3	S-MC-9 to S-MC-11	842	0.155	0.170	0.674
48	S-MC*3	2	S-MC-12 and S-MC-13	262	0.217	0.154	0.629
49	S-MC*4	1	S-MC-14	132	0.160	0.089	0.750
50	S-MU*1	3	S-MU-1 to S-MU-3	1326	0.144	0.235	0.621
51	S-MU*2	1	S-MU-4	161	0.129	0.122	0.748
52	S-CH*1	2	S-CH-1 and S-CH-2	272	0.207	0.216	0.578
53	S-CH*2	1	S-CH-3	324	0.137	0.181	0.682
54	S-CH*3	1	S-CH-4	131	0.131	0.258	0.611
55	S-AT*1	4	S-AT-1 to S-AT-4	665	0.193	0.292	0.515
56	S-AT*2	7	S-AT-5 to S-AT-11	1841	0.223	0.191	0.586
57	S-AT*3	3	S-AT-12 to S-AT-14	678	0.415	0.081	0.503
58	S-AT*4	4	S-AT-15 to S-AT-18	593	0.276	0.235	0.489
59	S-AT*5	2	S-AT-19 and S-AT-20	334	0.108	0.167	0.726
60	S-AT*6	1	S-AT-21	200	0.070	0.229	0.701
61	S-AT*7	1	S-AT-22	107	0.158	0.163	0.679
62	S-AT*8	1	S-AT-23	140	0.322	0.266	0.412

...contd.

Table (6.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
63	S-AT*9	1	S-AT-24	166	0.129	0.240	0.631
64	S-AT*10	1	S-AT-25	167	0.118	0.068	0.814
65	S-CT*1	3	S-CT-1 to S-CT-3	655	0.169	0.282	0.549
66	S-CT*2	1	S-CT-4	203	0.182	0.182	0.635
67	S-CT*3	1	S-CT-5	543	0.011	0.236	0.753
68	W-UC*1	7	W-UC-1 to W-UC-7	1815	0.184	0.221	0.595
69	W-UC*2	10	W-UC-8 to W-UC-17	1683	0.180	0.144	0.676
70	W-UC*3	3	W-UC-18 to W-UC-20	756	0.218	0.178	0.604
71	W-UC*4	1	W-UC-21	268	0.256	0.203	0.541
72	W-MC*1	2	W-MC-1 and W-MC-2	268	0.144	0.306	0.550
73	W-MC*2	5	W-MC-3 to W-MC-7	941	0.138	0.235	0.626
74	W-MC*3	6	W-MC-8 to W-MC-13	1450	0.213	0.138	0.648
75	W-MC*4	19	W-MC-14 to W-MC-32	4164	0.228	0.216	0.556
76	W-MC*5	1	W-MC-33	134	0.069	0.276	0.655
77	W-MC*6	1	W-MC-34	109	0.235	0.318	0.447
78	W-MC*7	1	W-MC-35	200	0.084	0.208	0.708
79	W-MC*8	1	W-MC-36	108	0.107	0.374	0.519

...contd.

Table (6.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
80	W-LC*1	7	W-LC-1 to W-LC-7	1406	0.186	0.259	0.555
81	W-LC*2	1	W-LC-8	106	0.150	0.290	0.560
82	W-MU	2	W-MU-1 and W-MU-2	220	0.192	0.310	0.498
83	W-PA	3	W-PA-1 to W-PA-3	2658	0.177	0.219	0.604
84	W-AT*1	4	W-AT-1 to W-AT-4	712	0.268	0.151	0.581
85	W-AT*2	10	W-AT-5 to W-AT-14	1865	0.188	0.212	0.600
86	W-AT*3	2	W-AT-15 and W-AT-16	285	0.221	0.251	0.528
87	W-AT*4	2	W-AT-17 and W-AT-18	286	0.132	0.203	0.665
88	W-AT*5	2	W-AT-19 and W-AT-20	274	0.286	0.257	0.457
89	W-AT*6	1	W-AT-21	117	0.439	0.114	0.448
90	W-AT*7	1	W-AT-22	109	0.181	0.315	0.504
91	W-AT*8	1	W-AT-23	123	0.121	0.267	0.613
92	C-UC	8	C-UC-1 to C-UC-8	1186	0.210	0.238	0.552
93	C-MC*1	1	C-MC-1	200	0.108	0.336	0.556
94	C-MC*2	2	C-MC-2 and C-MC-3	285	0.297	0.230	0.473

...contd.

Table (6.2) contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
95	C-MC*3	1	C-MC-4	200	0.156	0.340	0.504
96	C-MC*4	22	C-MC-5 to C-MC-26	4860	0.183	0.265	0.552
97	C-LC*1	3	C-LC-1 to C-LC-3	488	0.272	0.260	0.468
98	C-LC*2	3	C-LC-4 to C-LC-6	421	0.166	0.246	0.587
99	C-LC*3	2	C-LC-7 and C-LC-8	292	0.141	0.338	0.520
100	C-MU	4	C-MU-1 to C-MU-4	538	0.164	0.250	0.586
101	C-AT	10	C-AT-1 to C-AT-10	1959	0.201	0.222	0.577
102	C-MT	7	C-MT-1 to C-MU-7	1208	0.196	0.343	0.461
103	H-MC	2	H-MC-1 and H-MC-2	659	0.308	0.185	0.506
104	H-MT*1	3	H-MT-1 to H-MT-3	3213	0.243	0.189	0.568
105	H-MT*2	9	H-MT-4 to H-MT-12	1674	0.145	0.236	0.618
106	H-MT*3	1	H-MT-13	250	0.393	0.117	0.490

Table 6.3 Composition of superclusters

super-cluster no.	no. of RHC's included	no. of population groups included	supercluster structure
(1)	(2)	(3)	(4)
C_1	1	3	E-MT*4
C_2	1	1	S-CT*3
C_3	3	5	((H-MT*3, W-AT*6 : 2.74), S-AT*3 : 3.48)
C_4	1	2	E-MT*7
C_5	1	1	S-AT*10
C_6	2	6	(E-MT*2, S-MC*4 : 1.44)
C_7	1	1	S-MU*2
C_8	1	1	E-LC*5
C_9	4	4	(((E-MT*10, W-MC*7 : 1.20), S-AT*6 : 1.53), E-AT*9 : 1.70)
C_{10}	1	3	E-MT*3
C_{11}	2	2	(W-MC*8, C-MC*1 : 2.33)
C_{12}	1	4	W-AT*1
C_{13}	1	2	H-MC
C_{14}	2	2	(E-LC*6, W-MC*5 : 1.48)
C_{15}	1	1	E-AT*7
C_{16}	2	2	(E-AT*5, N-MC*4 : 0.51)
C_{17}	10	24	(((E-AT*2, N-UC*2 : 0.63), ((((N-MC*2, W-AT*5 : 0.63), C-LC*1 : 0.98), (E-MC*4, C-MC*2 : 0.92) : 0.98), (E-MT*5, S-AT*4 : 1.24) : 1.33) : 1.43), N-AT : 1.63)

...contd.

Table (6.3) contd.

(1)	(2)	(3)	(4)
C_{18}	3	3	((E-MT*9, S-AT*8 : 1.65), E-AT*8 : 1.65)
C_{19}	3	9	((E-LC*2, E-MT*1 : 0.51), W-MC*6 : 0.98)
C_{20}	1	10	W-UC*2
C_{21}	1	7	C-MT
C_{22}	9	30	(((((H-MT*2, S-MU*1 : 0.00), (N-MC*6, W-MC*2:0.18) : 0.40), S-MC*1 : 0.44), S-AT*9 : 0.77), ((W-AT*8, E-NT : 0.40), S-CH*3 : 0.68) : 1.27)
C_{23}	4	6	(((C-LC*3, C-MC*3 : 1.31), E-AT*3 : 1.32), E-LC*4 : 1.45)
C_{24}	2	3	(N-MC*3, S-AT*5 : 1.16)
C_{25}	6	20	((((E-CH*1, S-MC*3 : 0.40), E-MC*2 : 0.87), E-MT*6 : 0.94), (E-AT*6, W-MC*3 : 1.20) : 1.42)
C_{26}	9	15	(((E-AT*4, S-CT*2 : 0.40), (((S-AT*7, S-MC*2 : 0.54), E-MC*3 : 1.20), E-MT*8 : 1.28) : 1.29), ((W-AT*4, S-UC*1 : 0.77), S-CH*2 : 0.90) : 1.57)
C_{27}	1	1	W-UC*4
C_{28}	1	19	W-MC*4
C_{29}	2	3	(W-LC*2, W-MC*1 : 1.02)
C_{30}	3	7	((W-AT*7, W-MU : 0.81), S-AT*1 : 1.23)
C_{31}	1	3	H-MT*1
C_{32}	4	12	(((E-LC*3, S-AT*2 : 0.68), N-MC*5 : 0.77), W-UC*3 : 1.01)
C_{33}	2	30	(E-AT*1, W-AT*3 : 1.17)
C_{34}	7	49	(((C-LC*2, C-MU : 0.31), E-MC*1 : 0.48), (((W-PA, E-UC : 0.36), W-UC*1 : 0.60), W-AT*2 : 0.65))

...contd.

Table (6.3) contd.

(1)	(2)	(3)	(4)
C_{35}	2	12	(S-CH*1, C-AT : 0.54)
C_{36}	1	8	C-UC
C_{37}	1	9	E-LC*1
C_{38}	4	37	(((N-UC*1, N-MC*1 : 0.18), S-CT*1 : 0.44), E-CH*2 : 0.63)
C_{39}	4	48	((W-LC*1, C-MC*4 : 0.40), (N-MU, E-MU : 0.68) : 0.81)

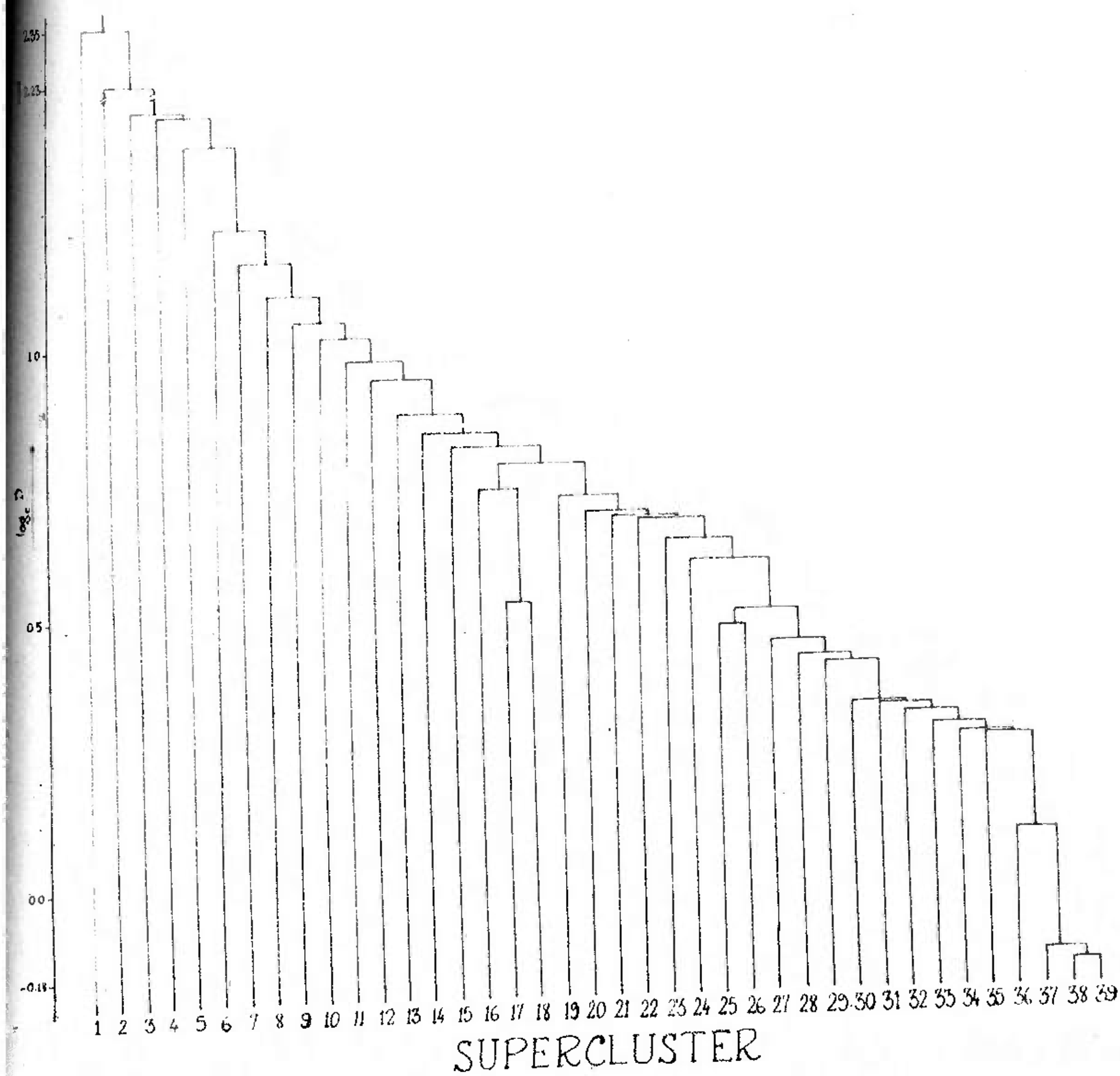

Figure 6.1 Dendrogram depicting resemblances among Superclusters

CHAPTER VII

ANALYSIS OF VARIATION OF ABO GENE FREQUENCIES IN TERMS OF MICRO-GEOGRAPHICAL VARIATION WITHIN ZONES

As have been seen in the preceding chapters, although most socio-religious categories were significantly heterogeneous in respect of ABO gene frequencies, a cross-classification of the data sets belonging to a socio-religious category by geographical zones helped in explaining a good deal of heterogeneity. Allowance made for macro-geographical variation thus resulted in significant reductions in the variations of ABO gene frequencies within socio-religious categories. Compared to the entire sub-continent, the geographical zones, however, apart from being relatively more uniform spatially, are also ecologically quite homogeneous. The reduction in heterogeneity of ABO gene frequencies within socio-religious categories upon a cross-classification by geographical zones, therefore, not only represents the effect of spatial variation at a macro level, but also the effects of macro-ecological variation. There is, however, a large amount of spatial variation even within a geographical zone. It is, therefore, of interest to examine whether a consideratior of the micro-geographical variation within a zone further helps in reducing the heterogeneity of ABO gene frequencies. In order to study micro-geographical variation, the latitudes and longitudes of locations of sampling of the data sets have been considered.

Although the 7 socio-religious categories which are distributed in more than one geographical zone comprised a total of 396 data sets (see table 5.4), for this analysis only 252 data sets have been used since the exact location of sampling were not available for the remaining data sets. The conclusions of this analysis should, therefore, be accepted as tentative. The latitudes and longitudes of the locations of sampling for the 252 data sets included in the present analysis were obtained from Bartholomew (1959), and have been presented in Table 7.1.

Within an anthropological category, let n_{ij}, p_{ij}, q_{ij}, T_{ij} and t_{ij} denote the sample size, the A and B gene frequencies and the latitude and longitude of the location of sampling, respectively, for the j-th data set belonging to the i-th geographical zone ($i = 1,2,\ldots,k$, $j = 1,2,\ldots,n_i$). Since the purpose of this analysis is to determine whether a consideration of the latitude and longitude of the location of sampling within a geographical zone results in a significant reduction of the variation in gene frequencies, we have tried to fit a model of the type.

$$p_{ij} = p_i + \delta_{pT}.T_{ij} + \delta_{pt}.t_{ij}, \text{ and}$$

$$q_{ij} = q_i + \delta_{qT}.T_{ij} + \delta_{qt}.t_{ij} \quad (i = 1,2,\ldots,k, \; j = 1,2,\ldots,n_i).$$

Methods of estimation and testing the significance of the parameters of the model given above have been presented in section 4.8. The error sum of squares, Q_3, corresponding to this model is:

$$Q_3 = \sum_i \sum_j n_{ij} \Big[\alpha_{ij} (p_{ij} - \hat{p}_i - \hat{\delta}_{pT}.T_{ij} - \hat{\delta}_{pt}.t_{ij})^2$$

$$+ 2\beta_{ij} (p_{ij} - \hat{p}_i - \hat{\delta}_{pT}.T_{ij} - \hat{\delta}_{pt}.t_{ij}).$$

$$(q_{ij} - \hat{q}_i - \hat{\delta}_{qT}.T_{ij} - \hat{\delta}_{qt}.t_{ij})^2$$

$$+ \eta_{ij} (q_{ij} - \hat{q}_i - \hat{\delta}_{qT}.T_{ij} - \hat{\delta}_{qt}.t_{ij})^2\Big], \quad (7.1)$$

where $\mathcal{D}^{-1}(p_{ij}, q_{ij}) = n_{ij} \begin{bmatrix} \alpha_{ij} & \beta_{ij} \\ \beta_{ij} & \eta_{ij} \end{bmatrix}$, the information

matrix computed at (p_{ij}, q_{ij}). Under the model, Q_3 follows asymptotically a chi-square distribution with $2(\sum_i n_i)-2k-4$ d.f. In order to understand the amount of reduction brought about by the addition of extra variables (latitude and longitude) to explain the variation in gene frequencies, we have also computed the error sums of squares under the following two models (which have been considered in earlier chapters).

(1) $p_{ij} = p$ and $q_{ij} = q$; that is, the gene frequencies of all data sets within a socio-religious category are equal,

(2) $p_{ij} = p_i$ and $q_{ij} = q_i$; that is, gene frequencies of all data sets within a geographical x socio-religious subset are all equal, $(i = 1,2,\ldots,k; \quad j = 1,2,\ldots,n_i)$.

The corresponding error sums of squares are:

$$Q_1 = \sum_i \sum_j n_{ij} \Big[\alpha_{ij} (p_{ij} - \bar{p})^2 + 2\beta_{ij} (p_{ij} - \bar{p})(q_{ij} - \bar{q}) + \eta_{ij} (q_{ij} - \bar{q})^2\Big], \qquad (7.2)$$

and

$$Q_2 = \sum_i \sum_j n_{ij} \Big[\alpha_{ij} (p_{ij} - \bar{p}_i)^2 + 2\beta_{ij} (p_{ij} - \bar{p}_i)(q_{ij} - \bar{q}_i) + \eta_{ij} (q_{ij} - \bar{q}_i)^2\Big]. \qquad (7.3)$$

where $\bar{p}$, $\bar{q}$, $\bar{p}_i$ and $\bar{q}_i$ are as given by equations (4.8.12) and (4.8.13) of section 4.8 of chapter IV. Under the respective models, Q_1 and Q_2 follow asymptotically chi-square distributions with $2(\sum_i n_i) - 2$ and $2(\sum_i n_i) - 2k$ degrees of freedom, respectively. Within a socio-religious category, the reduction from Q_1 to Q_2 indicates the amount of reduction in the error sum of squares brought about by cross-classifying the data sets into geographical zones under the assumption that within each such cross-classified subset the gene frequencies are constant, over that obtained by assuming that the gene frequencies of the data sets within the socio-religious category are all same. The reduction from Q_2 to Q_3 indicates, similarly, the extent to which the error sum of squares gets reduced once a further allowance is made for the variation in latitude and longitude within a geographical zone.

In Table 7.2 the values of Q_1, Q_2 and Q_3 and the percentage reductions (from Q_1 to Q_2 and from Q_2 to Q_3) in the error sum of squares have been presented for each of the 7 socio-religious categories under consideration. This analysis revealed that at the 5% level, the δ-values are significant for all socio-religious categories except the Upper castes. This means that, in general, the consideration of micro-geographical variation within zones is useful in a further reduction of the variation in gene frequencies. Upon a closer look at Table 7.2, it is however, seen that although a large amount of reduction was brought about in the error sum of squares when allowance was made for macro-geographical (zonal) variation, the corresponding reduction was much smaller when a further allowance was made for micro-geographical variation within zones. With the exception of the Muslims, Christians/Anglo-Indians and Mongoloid tribes, the percentage reductions from Q_2 to Q_3 were rather small for all the remaining socio-religious categories. Moreover, it is to be noted that the numbers of data sets of Muslims and Christians/Anglo-Indians included in the present analysis were rather small. Among the Upper castes, the amount of variation existing after making an allowance for macro-geographical variation (Q_2) was insignificant, while for all the other socio-religious categories, the amount of heterogeneity existing even after making allowance for micro-geographical variation within zones (Q_3) was significant.

Table 7.1 Latitudes and longitudes of locations of sampling of data sets within socio-religious x geographical subsets.

anthropo-logical category	geographical zone	sl.no. within geogra-phical zone	identifi-cation no. of data set (as in Appendix 1)	Latitude deg.min	Longitude deg.min
(1)	(2)	(3)	(4)	(5)	(6)
Upper caste	Northern	1	09013	33.44	75.11
		2	19024	31.60	77.06
		3	19027	32.33	76.10
		4	19051	28.40	77.14
		5	19069	28.40	77.14
	Eastern	1	03021	26.20	91.02
		2	04003	22.29	88.11
		3	04016	22.35	88.21
		4	04046	22.52	88.21
		5	04060	22.29	88.11
		6	04070	22.35	88.12
	Southern	1	22011	13.05	80.18
		2	22017	13.05	80.18
		3	22049	11.59	79.50
	Western	1	08025	18.56	72.51
		2	14006	18.56	72.51
		3	14007	18.56	72.51
		4	14008	18.56	72.51
		5	14107	18.56	72.51
		6	14131	18.34	73.58
		7	14132	18.34	73.58

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
	Central	1	13028	23.11	75.47
		2	13042	23.01	75.12
		3	24020	26.45	83.23
		4	24021	26.50	80.54
		5	24036	29.36	79.40
		6	24065	30.37	78.19
		7	24080	28.40	77.14
Total no. of data sets = 28					
Middle caste	Northern	1	19002	30.54	76.57
		2	19018	28.40	77.14
		3	19020	31.12	77.24
		4	19023	31.60	77.06
		5	19028	32.33	76.10
		6	19044	28.40	77.14
		7	19045	28.40	77.14
		8	19049	28.40	77.14
		9	19050	28.40	77.14
		10	19054	32.20	78.01
		11	19056	31.07	77.09
		12	19066	32.04	76.29
		13	19068	28.40	77.14
		14	19071	28.40	77.14
		15	19072	28.40	77.14
		16	19073	28.40	77.14
		17	19074	28.40	77.14
		18	19075	28.40	77.14
		19	19091	28.40	77.14
		20	19092	28.40	77.14
		21	19093	28.40	77.14

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
	Eastern	1	03019	26.20	91.02
		2	03020	26.20	91.02
		3	04004	22.29	88.11
		4	04015	22.35	88.21
		5	04024	23.42	90.22
		6	04034	22.11	88.12
		7	04068	22.35	88.12
		8	04069	22.35	88.12
		9	06043	26.10	85.54
		10	18047	18.48	82.41
	Southern	1	02028	17.22	78.26
		2	02032	17.22	78.26
		3	02033	17.22	78.26
		4	02035	17.22	78.26
		5	11006	13.05	80.18
		6	22010	13.05	80.18
	Western	1	07010	15.31	73.52
		2	08004	22.30	69.20
		3	08006	22.30	69.20
		4	08011	21.49	73.36
		5	08022	18.56	72.51
		6	14001	18.56	72.51
		7	14009	18.26	73.21
		8	14010	18.56	72.51
		9	14070	18.54	72.49
		10	14071	17.00	73.20

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
	Western	11	14072	18.56	72.51
		12	14108	20.30	75.40
		13	14109	17.35	73.30
		14	14110	20.00	75.02
		15	14111	20.10	75.02
		16	14118	21.02	79.37
		17	14119	17.00	74.35
		18	14123	21.00	74.50
		19	14128	18.40	74.00
		20	14130	18.34	73.58
	Central	1	13044	23.31	75.48
		2	24029	30.28	78.06
		3	24032	30.19	78.03
		4	24035	29.36	79.40
		5	24040	30.28	78.06
		6	24055	26.50	80.54
		7	24056	26.50	80.54
		8	24057	26.50	80.54
		9	24058	26.50	80.54
		10	24064	30.37	78.19
		11	24071	28.40	77.14
		12	24072	28.40	77.14
		13	24073	28.40	77.14
		14	24074	28.40	77.14
		15	24075	28.40	77.14
		16	24076	28.40	77.14
		17	24077	28.40	77.14
		18	24078	28.40	77.14
		19	24079	28.40	77.14
		20	24085	26.50	80.54
	Himalayan	1	05024	27.42	85.19

Total no. of data sets = 78

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
Lower caste	Eastern	1	03022	26.20	91.02
		2	04006	22.29	88.11
		3	04036	22.11	88.12
		4	04039	22.11	88.12
		5	04047	22.52	88.21
		6	04048	22.52	88.21
		7	04063	22.25	87.24
		8	04065	22.25	87.24
		9	04066	26.30	88.50
		10	04067	26.18	89.32
		11	04071	22.11	88.12
		12	04072	22.11	88.12
		13	04073	22.31	88.20
		14	18050	18.48	82.41
	Western	1	08017	22.00	69.45
		2	14069	18.56	72.51
		3	14081	21.10	79.12
		4	14129	18.34	73.58
	Central	1	13039	23.31	75.48
		2	13024	23.11	75.50
Total no. of data sets = 20					
Muslim	Northern	1	17001	30.15	67.00
	Eastern	1	03023	27.29	94.56
		2	03024	26.10	91.45
		3	04002	22.29	88.11
		4	04008	22.29	88.11

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
	Eastern	5	04017	22.35	88.21
		6	04038	22.11	88.12
		7	04040	26.18	89.32
		8	04045	22.52	88.21
		9	18017	22.16	85.01
	Southern	1	02007	17.42	83.24
		2	02031	17.22	78.26
		3	22016	13.05	80.18
	Central	1	13040	23.15	75.50
Total no. of data sets = 14					
Christian/ Anglo-Indian	Eastern	1	04019	22.35	88.21
		2	04031	22.35	88.21
		3	18019	22.16	85.01
	Southern	1	02008	17.42	83.24
		2	11004	10.00	76.16
		3	11049	10.00	76.16
		4	22018	1[illegible].05	80.18
Total no. of data sets = 7					
Australoid Tribe	Northern	1	24086	29.22	79.26
		2	24089	30.19	78.03
	Eastern	1	04062	22.38	88.52
		2	04064	22.25	87.24
		3	04075	22.53	88.25
		4	06002	24.17	87.15

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
	Eastern	5	06003	24.17	87.15
		6	06008	23.10	86.51
		7	06009	23.22	85.20
		8	06012	23.53	84.17
		9	06013	23.53	84.17
		10	06028	23.22	85.20
		11	06030	23.20	86.00
		12	06031	23.20	86.00
		13	06032	23.20	86.00
		14	06037	24.20	87.37
		15	06040	23.22	85.20
		16	06044	22.20	87.39
		17	18005	18.48	82.41
		18	18006	18.48	82.41
		19	18010	18.48	82.41
		20	18011	18.48	82.41
		21	18014	18.48	82.41
		22	18015	18.48	82.41
		23	18016	18.48	82.41
		24	18042	18.48	82.41
	Southern	1	02013	17.42	82.00
		2	02016	17.42	82.00
		3	02017	18.18	82.57
		4	02018	17.38	83.04
		5	02019	17.38	83.04
		6	02020	14.29	80.00
		7	02023	15.51	78.01
		8	02038	14.29	80.00
		9	02042	19.40	78.31
		10	02043	19.40	78.31

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
	Southern	11	02044	19.40	78.31
		12	11012	9.32	76.24
		13	11015	8.41	76.57
		14	11016	11.15	75.45
		15	11017	11.15	75.45
		16	11022	8.53	76.38
		17	11023	8.45	77.43
		18	11025	8.53	76.38
		19	11028	9.32	76.26
		20	11029	9.55	77.06
		21	11036	10.24	76.51
		22	11041	10.24	76.54
		23	11044	10.24	76.54
		24	12001	10.32	72.43
	Western	1	08008	21.40	69.40
		2	08027	21.10	72.57
		3	08030	21.10	72.54
		4	08031	21.10	72.54
		5	08032	21.10	72.54
		6	08033	21.10	72.54
		7	08035	21.40	73.02
		8	08036	21.10	72.54
		9	10002	12.29	75.40
		10	14099	20.58	77.50
		11	14100	19.41	73.38
		12	14101	20.52	74.50
		13	14102	20.00	73.52
		14	14103	19.14	73.02
		15	14104	23.38	73.02
		16	14135	20.52	74.50

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
	Central	1	13002	19.04	82.05
		2	13003	21.49	76.23
		3	13006	26.12	78.09
		4	13010	19.24	81.37
		5	13011	19.06	81.35
		6	13016	18.48	80.55
		7	13017	23.31	77.47
		8	13019	28.18	79.48
		9	13021	19.22	81.24
		10	13033	22.18	75.34
Total no. of data sets = 76					
Mongoloid Tribe	Eastern	1	01003	9.00	92.47
		2	01007	9.00	92.47
		3	01011	9.00	92.47
		4	03004	25.32	90.14
		5	03005	28.36	95.03
		6	03006	28.36	95.03
		7	03007	28.36	95.03
		8	03008	28.36	95.03
		9	03009	28.36	95.03
		10	03010	26.10	90.38
		11	03011	26.10	90.38
		12	03012	26.10	90.38
		13	03014	25.34	91.53
		14	03015	25.34	91.53
		15	03016	25.34	91.53
		16	03017	25.34	91.53

Table (7.1) contd.

(1)	(2)	(3)	(4)	(5)	(6)
	Eastern	17	03018	25.34	91.53
		18	03026	25.34	91.53
		19	04074	27.02	88.20
		20	16003	25.40	94.08
		21	16012	25.40	94.08
	Central	1	24028	29.36	79.40
		2	24052	28.10	80.14
		3	24053	27.21	81.47
		4	24054	28.32	80.43
		5	24062	28.32	80.43
		6	24063	29.22	79.26
	Himalayan	1	05020	27.02	88.34
		2	05030	27.02	88.20

Total no. of data sets = 29

Table 7.2 Error sums of squares and percentage reductions for 7 anthropological categories

Anthropological categories	upper caste	middle caste	lower caste	Muslim	Christian/ Anglo-Indian	Australoid tribe	Mongoloid tribe
No. of data sets (N)	28	78	20	14	7	76	29
No. of zones (k)	5	6	3	4	2	5	3
Total chi-square (Q_1)	226.2934* (54)	875.0426* (154)	198.5783* (38)	90.1878* (26)	54.2658* (12)	1567.4663* (150)	2361.5462* (56)
Chi-square after allowing for zonal variation (Q_2)	58.0760 (46)	497.7305* (144)	195.5466* (34)	55.4642* (20)	29.0094* (10)	1269.9646* (142)	1859.6498* (52)
% reduction from Q_1 to Q_2	74.34	43.12	1.53	38.50	46.54	18.98	21.25
Chi-square after allowing for zonal variation and latudinal and longitudinal variation within zones (Q_3)	55.9190 (42)	487.0478* (140)	165.3062* (30)	32.7067* (16)	14.1819* (6)	1214.1128* (138)	343.7708* (48)
% reduction from Q_2 to Q_3	3.71	2.15	15.46	41.03	51.11	4.40	81.51

Note: (1) Figures in parentheses indicate degrees of freedom

(2) Figures marked with a * are significant at the 5% level.

CHAPTER VIII

UNIDIMENSIONAL REPRESENTATION OF GENE FREQUENCIES: DIRECTIONS OF MAXIMUM AND MINIMUM VARIATION

When the estimated frequencies (p, q) of the genes A and B for different populations within the same geographical zone and socio-religious group were represented graphically on a two-dimensional plane, in many cases they showed considerable variation, as were also evident from the rather large values of the chi-square statistic for testing homogeneity of the gene frequencies. It was then considered pertinent to ask whether the large variability could be explained in terms of variation in any one particular direction. What one then secks is a linear combination λ of p and q, $\lambda = ap + bq$, where a and b are constants to be determined such that the variability of λ between the different populations is the maximum for all choices of a and b. The variability of λ can be measured in terms of the chi-square statistic appropriate for testing the homogeneity of the different populations in respect of the values of λ in these populations. The algebra for carrying out this maximisation have been given in section 4.9 of Chapter IV, ignoring the sampling fluctuation in the estimates of the dispersion matrix of the estimated gene frequencies. It is seen that this procedure gives two sets of values of (a,b), one set (a_{max}, b_{max}) generating the maximum value of chi-square and the other set (a_{min}, b_{min}) leading to the minimum value of the chi-square. Thus, $\lambda_1 = a_{max}.p + b_{max}.q$ is the linear combination which has the largest variability between the populations, and $\lambda_2 = a_{min}.p + b_{min}.q$ the smallest variation. If the corresponding chi-squares are denoted as χ_1^2 and χ_2^2, respectively, then $\chi_1^2 + \chi_2^2$ is the total heterogeneity chi-square and $\chi_1^2/(\chi_1^2 + \chi_2^2)$ is the proportion explained by the linear combination λ_1.

In Table 8.1 are given the values of (a_{max}, b_{max}), (a_{min}, b_{min}) and the proportion explained by λ_1 expressed as a percentage for all heterogeneous geographical x socio-religious subsets. Restricting our attention to only those subsets containing 10 or more population groups, it was found that the percentage variability explained by λ_1 varies from 94.32% for the 13 Mongoloid tribal population groups of the Himalayan zone to only 56.97% for the Lower castes of the Eastern zone. It was also interesting to note that λ_1 explains 81.67% of the variability between the 31 Mongoloid tribal population groups of the Eastern zone. The variability between different Mongoloid tribal groups within these two zones in terms of the A and B gene frequencies can thus be largely attributed to variation in one direction. The directions are, however, different in the two zones as measured by the values of (a_{max}, b_{max}) which are: (0.606, 0.796) in the Eastern zone and (0.960, -0.280) in the Himalayan zone. Graphical representations of the directions of maximum and minimum variation have been given in Figures 8.1 and 8.2 for the 31 Mongoloid tribal population groups of the Eastern zone.

For most of the subsets, the variation appears to be spread all over the two-dimensional plane and not much of it can be ascribed to any single direction.

Table 8.1 Directions of maximum and minimum variation within heterogeneous geographical x socio-religious subsets

geographical x socio-religious subset	no. of data sets	a_{max}	b_{max}	a_{min}	b_{min}	% variation explained by $\lambda_1 = a_{max}p + b_{max}q$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
N-UC	6	0.981	0.196	0.018	0.9998	95.96
N-MC	34	0.979	0.204	0.006	0.99999	68.29
E-MC	16	0.935	0.354	0.236	-0.972	62.21
E-LC	16	0.741	-0.672	0.762	0.648	56.97
E-CH	5	0.176	-0.984	0.923	0.385	85.78
E-AT	39	0.917	0.398	0.251	-0.968	68.93
E-MT	31	0.606	0.796	0.760	-0.649	81.67
S-MC	14	0.173	-0.985	0.960	0.281	75.06
S-MU	4	0.201	0.980	0.9997	0.023	71.80
S-CH	4	0.893	0.450	0.416	-0.909	73.93
S-AT	25	0.978	-0.206	0.354	0.935	66.68
S-CT	5	0.979	0.205	0.187	-0.982	92.10
W-UC	21	0.466	0.885	0.934	-0.356	72.75
W-MC	36	0.682	-0.731	0.733	0.680	60.84
W-LC	8	0.986	0.167	0.057	0.998	80.49
W-AT	23	0.954	-0.299	0.447	0.895	71.09
C-MC	26	0.984	-0.180	0.459	0.889	77.67
C-LC	8	1.000	-0.0007	0.288	0.958	73.98
H-MT	13	0.960	-0.280	0.420	0.907	94.32

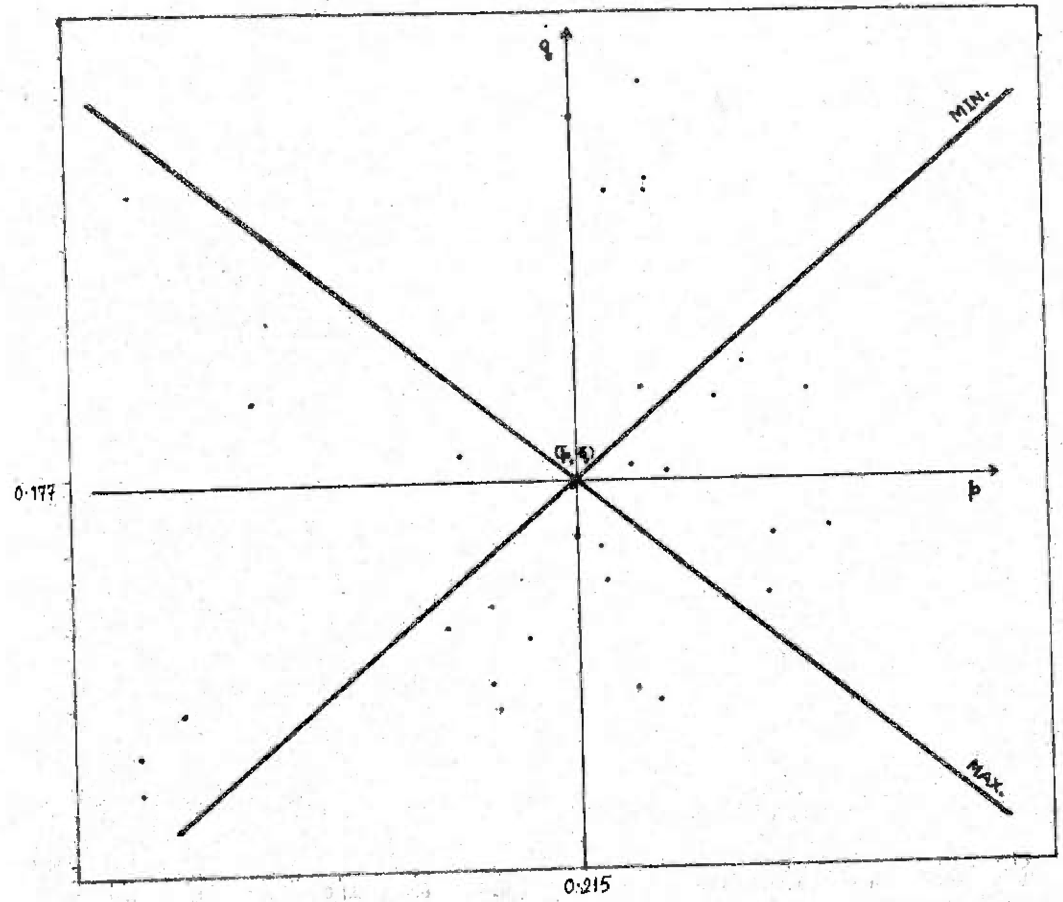

Figure 8.1 Directions of Maximum and Minimum variation of gene frequencies p and q for Mongoloid Tribes of Eastern Zone

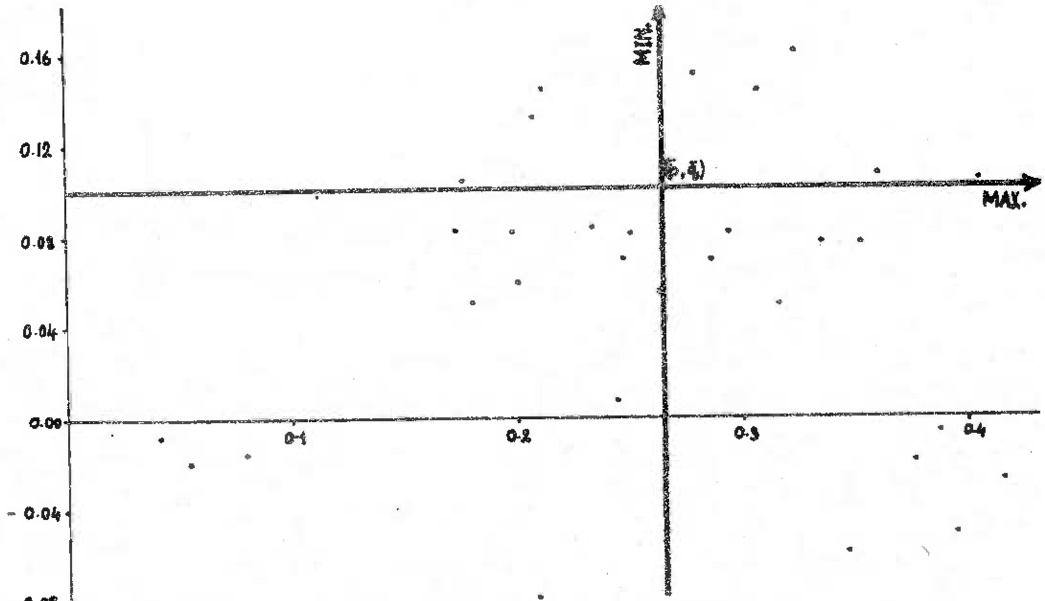

Figure 8.2 The distribution of the Mongoloid tribal groups of the Eastern zone with respect to λ_1 and λ_2, where $\lambda_1 = a_{max}.p + b_{max}.q$, and $\lambda_2 = a_{min}.p + b_{min}.q$

APPENDIX - 1

O-A-B-AB BLOOD-GROUP FREQUENCIES FOR POPULATION GROUPS OF THE INDIAN SUB-CONTINENT

Cumulative Sl.no.	Identification code: Area	Identification code: Sl.no. within Area	Population group	Location of sampling	Sample size (n)	% frequencies of blood groups: O	A	B	AB	Reference
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	01	001	Onge	Settlements around Bumila and Dugong creeks and the village Tambebul on the N.E. part of Little Andaman Is.	34	14.71	67.66	5.88	11.76	Sarkar (1952)
2	01	002	Andamanese	Havelock and Neil Is.	21	9.52	57.14	23.81	9.52	Sarkar (1952)
3	01	003	Nicobarese	Car Nicobar Is.	136	86.03	3.68	10.29	0.00	Sarkar (1952)
4	01	004	Oraon	Andaman Is.	100	19.00	25.00	38.00	18.00	Lehmann and Ikin (cf. Mourant et al. 1958)
5	01	005	Bhantu	Caddlegung, Anicate and Junglighat villages, South Andaman Is.	122	36.07	18.85	40.98	4.10	Agrawal (1963)
6	01	006	Camorta	Nicobar Is.	58	72.41	20.69	5.17	1.72	Agrawal (1964)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
7	01	007	Car Nicobar Is.		324	79.32	7.10	12.96	0.62	Agrawal (1964)
8	01	008	Nancowry	Nicobar Is.	96	81.25	10.42	8.33	0.00	Agrawal (1964)
9	01	009	Non-tribal Indians	Andaman Is.	514	34.24	22.76	34.82	8.17	Agrawal (1965)
10	01	010	Coastal Nicobarese		113	52.21	10.62	33.63	3.54	Agrawal (1968)
11	01	011	Car Nicobarese		200	89.00	4.00	7.00	0.00	Gupta and Dash-Sharma (1973)
12	02	001	Adi Hindu		75	32.00	18.67	44.00	5.33	Macfarlane (1940)
13	02	002	Chenchu	Dist. Mehbub Nagar and Amrabad	100	37.00	37.00	18.00	8.00	Macfarlane (1940)
14	02	003	Banjara	Hyderabad	43	39.50	21.00	34.90	4.60	Macfarlane (1940)
15	02	004	Bhil	Dist. Aurangabad and Amrabad Taluka	44	31.82	13.64	52.27	2.27	Macfarlane (1940)
16	02	005	Yenadi		276	34.80	29.70	25.00	10.50	Reddi (1945)
17	02	006	Telegu speakers		134	41.79	23.13	29.10	5.97	Ayer and Mummurthi (1953)
18	02	007	Muslim	Visakhapatnam	270	38.89	17.04	38.89	5.18	Dronamraju et al. (1967)
19	02	008	Christian	Visakhapatnam	324	47.53	19.44	26.85	6.17	Dronamraju et al. (1967)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
20	02	009	Hindu	Visakhapatnam	5486	43.78	19.83	31.48	4.90	Dronamraju et al. (1967)
21	02	010	Lambadi	Nizamabad Dist.	195	37.95	18.46	36.41	7.18	Ramachandriah (1967)
22	02	011	Lambadi	Anantapur Dist.	260	27.31	21.92	38.46	12.31	Ramachandriah (1967)
23	02	012	Lambadi	Krishna Dist.	203	39.40	27.59	27.59	5.42	Ramachandriah (1967)
24	02	013	Koya dora	Rampachodavaram Block East Godavari Dist.	300	37.67	30.00	23.33	9.00	Malleswara Rao (1971)
25	02	014	Brahmin	Hyderabad and Secunderabad	383	26.89	26.89	30.81	15.41	Murty and Lakshmi (1971)
26	02	015	Non-brahmin	Hyderabad and Secunderabad	138	37.68	11.59	35.51	15.22	Murty and Lakshmi (1971)
27	02	016	Konda reddi	Rampachodavaram Block, East Godavari Dist.	227	41.85	29.96	21.14	7.05	Poornima (1971)
28	02	017	Bagatha	Aruku valley Visakhapatnam Dist.	480	32.50	30.00	27.92	9.58	Gollareddy (1973)
29	02	018	Bagatha	Chintapalli, Visakhapatnam Dist.	152	22.37	36.18	27.63	13.82	Rao and Golla Reddy (1973)
30	02	019	Valmiki	Chintapalli, Visakhapatnam Dist.	197	27.92	30.45	25.89	15.74	Rao and Golla Reddy (1973)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(1[illegible])
31	02	020	Yennadi	Nellore and Sriharikath	145	53.10	17.24	27.59	2.06	Negi and Maitra (1974)
32	02	021	Erukula	Anantpur	35	57.14	25.71	17.14	0.00	Negi and Maitra (1974)
33	02	022	Lambadi	Anantpur and Kurnool	100	41.00	25.00	30.00	4.00	Negi and Maitra (1974)
34	02	023	Chenchu	Kurnool	120	24.17	27.50	37.50	10.83	Negi and Maitra (1974)
35	02	024	South Indian Castes	Hyderabad	1370	37.81	24.82	31.68	5.69	Padma and Murty (1974)
36	02	025	North Indian Castes	Hyderabad	99	30.30	20.20	38.38	11.11	Padma and Murty (1974)
37	02	026	West Indian Castes	Hyderabad	109	33.03	15.60	43.12	8.26	Padma and Murty (1974)
38	02	027	Backward Castes	Hyderabad	221	34.40	24.90	32.10	8.60	Padma and Murty (1974)
39	02	028	Kshatriya	Hyderabad	147	35.40	18.40	40.10	6.10	Padma and Murty (1974)
40	02	029	Scheduled Castes	Hyderabad	142	31.70	23.90	38.00	6.30	Padma and Murty (1974)
41	02	030	Christian	Hyderabad	63	36.50	22.20	36.50	4.80	Padma and Murty (1974)
42	02	031	Muslim	Hyderabad	722	37.30	23.40	33.00	6.30	Padma and Murty (1974)
43	02	032	Reddy	Hyderabad	135	47.40	18.50	30.40	3.70	Padma and Murty (1974)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
44	02	033	Kamma	Hyderabad	104	44.20	18.30	32.70	4.80	Padma and Murty (1974)
45	02	034	Vaisya	Hyderabad	52	48.10	5.80	44.20	1.90	Padma and Murty (1974)
46	02	035	Velama	Hyderabad	115	47.00	23.50	24.30	5.20	Padma and Murty (1974)
47	02	036	Brahmin	Hyderabad	601	34.60	29.50	30.40	5.50	Padma and Murty (1974)
48	02	037	Pantakapu	Chitoor Dist.	76	30.50	31.90	33.30	4.10	Reddi (1974)
49	02	038	Yenadi	Nellore Dist.	200	48.50	11.00	38.00	2.50	Reddi (1974)
50	02	039	Vedagalai-Ayyangar Brahmin	Chittoor Dist.	52	42.80	23.20	26.70	7.10	Reddi (1974)
51	02	040	Konda Reddi	Addatigela Block, East Godavari Dist.	592	28.55	31.08	29.22	11.15	Veerraju (1974)
52	02	041	Naikapod	Adilabad Dist.	53	37.73	35.85	16.99	9.43	Mukherjee et al. (1977)
53	02	042	Koya	Adilabad Dist.	200	29.50	33.00	30.00	7.50	Mukherjee et al. (1977)
54	02	043	Raj Gond	Adilabad Dist.	102	20.59	39.22	30.39	9.80	Mukherjee et al. (1977)
55	02	044	Kolam	Adilabad Dist.	331	22.36	23.87	42.29	11.48	Mukherjee et al. (1977)
56	02	045	Pardhan	Adilabad Dist.	141	26.95	23.40	44.68	4.97	Mukherjee et al. (1977)
57	03	001	Assamese	Dibrugarh and other areas	2000	33.65	24.55	32.55	9.25	Mitra (1933)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
58	03	002	Khasi	Khasi and Jayantia Hills)	50	46.60	15.60	33.30	4.50	Basu (1938)
59	03	003	Khasi	Cherapunji	200	33.00	35.00	18.50	13.50	Macfarlane (1941)
60	03	004	Garo	Garo Hills	142	26.76	22.53	40.84	9.86	Majumdar (1950)
61	03	005	Pasi Abor	Abor Hills, Siang Frontier Division	191	19.40	37.70	22.50	20.40	Bhattacharjee (1954)
62	03	006	Minyong Abor	Abor Hills, Siang Frontier Division	553	35.08	32.55	22.42	9.95	Bhattacharjee (1954)
63	03	007	Pangi Abor	Abor Hills, Siang Frontier Division	197	27.41	45.69	20.30	6.60	Bhattacharjee (1954)
64	03	008	Padam Abor	Abor Hills, Siang Frontier Division	754	24.27	36.07	26.00	13.66	Bhattacharjee (1954)
65	03	009	Galong Abor	Abor Hills, Siang Frontier Division	500	40.75	32.25	20.75	6.25	Kumar (1954)
66	03	010	Maitori Rabha	Darrang, Garo Hills, Goalpara, Kamrup	200	28.50	34.00	29.00	8.50	Das (1958)
67	03	011	Pati Rabha	Darrang, Garo Hills, Goalpara, Kamrup	200	26.50	36.00	25.50	12.00	Das (1958)
68	03	012	Rangdani Rabha	Darrang, Garo Hills, Goalpara, Kamrup	200	21.50	27.50	35.00	16.00	Das (1958)
69	03	013	Assamese		200	38.00	40.50	19.00	2.50	Mathew (1959)
70	03	014	Khasi	Shillong	315	31.43	36.83	24.13	7.62	Miki et al.(1960)
71	03	015	Khasi	United Khasi and Jaintia Hill Dists.	202	49.00	29.20	18.80	2.99	Das (1968)
72	03	016	Bhoi	United Khasi and Jaintia Hill Dists.	192	38.69	30.43	23.04	7.84	Das (1968)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
73	03	017	War	United Khasi and Jaintia Hill Dists.	230	55.72	28.64	11.97	3.67	Das (1968)
74	03	018	Pnar	United Khasi and Jaintia Hill Dists.	197	52.79	33.50	11.61	2.10	Das (1968)
75	03	019	Baisya	Kamrup Dist.	145	48.27	22.76	24.82	4.13	Das et al. (1973)
76	03	020	Kalita	Kamrup Dist.	454	38.54	24.22	31.29	5.94	Das et al. (1973)
77	03	021	Brahmin	Kamrup Dist.	360	38.33	23.05	33.05	5.55	Das et al. (1973)
78	03	022	Kaibarta	Kamrup Dist.	161	40.37	11.80	44.09	3.74	Das et al. (1973)
79	03	023	Muslim	Dibrugarh	112	40.18	20.53	33.03	6.25	Das (1974)
80	03	024	Muslim	Gauhati and neighbourhood	150	43.33	18.00	29.33	9.33	Ali (1974)
81	03	025	Hindu	Gauhati and neighbourhood	150	40.67	26.67	29.33	3.33	Ali (1974)
82	03	026	Khasi	Khasi and Jaintia Hills	250	39.60	34.00	20.40	6.00	Bhattacharjee (1975)
83	04	001	Bengali (Mixed)		311	37.90	19.30	34.10	8.70	Chaudhary (1936)
84	04	002	Muslim	Budge Budge	120	28.30	23.30	40.00	8.30	Macfarlane (1938)
85	04	003	Brahmin	Budge Budge	200	35.50	29.50	29.50	5.50	Macfarlane (1938)
86	04	004	Kayastha	Budge Budge	200	32.00	23.00	37.50	7.50	Macfarlane (1938)
87	04	005	Non-caste Hindu	Budge Budge	320	30.94	22.19	40.00	6.87	Macfarlane (1938)
88	04	006	Mahishya	Budge Budge	160	32.50	20.00	39.37	8.12	Macfarlane (1938)
89	04	007	Artisans and Traders	Budge Budge	85	29.41	25.88	38.82	5.88	Macfarlane (1938)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
90	04	008	Mohamedan	Budge Budge	136	33.10	29.40	30.90	6.60	Macfarlane (1938)
91	04	009	Brahmin and Kayastha	Budge Budge	100	43.00	17.00	29.00	11.00	Macfarlane (1938)
92	04	010	Depressed Class	Budge Budge	75	29.33	22.67	42.67	5.33	Macfarlane (1938)
93	04	011	Bagdi		44	15.91	25.00	43.18	15.91	Sarkar (1938)
94	04	012	Depressed Class	Calcutta	160	38.75	23.75	30.62	6.87	Grewal and Chandra (1940)
95	04	013	Other high Castes	Calcutta	504	32.74	21.63	36.11	9.52	Grewal and Chandra (1940)
96	04	014	Vaidya	Calcutta	50	64.00	16.00	18.00	2.00	Grewal and Chandra (1940)
97	04	015	Kayastha	Calcutta	149	35.57	19.46	40.27	4.70	Grewal and Chandra (1940)
98	04	016	Brahmin	Calcutta	201	37.81	19.90	35.32	6.97	Grewal and Chandra (1940)
99	04	017	Muslim	Calcutta	321	29.59	24.61	36.45	9.34	Grewal and Chandra (1940)
100	04	018	Bagdi	South Bengal	107	29.91	24.30	35.51	10.28	Macfarlane and Sarkar (1941)
101	04	019	Anglo Indian	Calcutta	210	42.38	29.52	22.86	5.24	Macfarlane (1942)
102	04	020	Rangpore Convicts		148	32.43	21.62	37.84	8.11	Majumdar (1949)
103	04	021	Malda Convicts		45	31.11	26.67	31.11	11.11	Majumdar (1949)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
104	04	022	Barisal Convicts		136	31.62	22.06	37.50	8.82	Majumdar (1949)
105	04	023	Mymensingh Convicts		112	30.36	23.21	37.50	8.93	Majumdar (1949)
106	04	024	Sankha Banik	Dacca	194	19.59	39.17	28.86	12.37	Majumdar (1950-51)
107	04	025	Bengali	Calcutta Schools and Sarisa, Diamond Harbour	414	36.71	22.22	34.06	7.00	Buchi (1953a)
108	04	026	Kayastha	Calcutta	47	34.05	19.15	38.30	8.50	Das et al.(1953)
109	04	027	Brahmin	Calcutta	49	42.86	14.29	30.61	12.24	Das et al.(1953)
110	04	028	Vaidya	Calcutta	19	42.11	36.84	21.05	0.00	Das et al.(1953)
111	04	029	High-Caste Bengali	Calcutta	675	35.15	22.99	35.72	6.19	Sarkar et al. (1953)
112	04	030	Low-Caste Bengali	Calcutta	312	31.17	20.67	39.79	8.35	Sarkar et al. (1953)
113	04	031	Anglo-Indian	Calcutta	346	37.28	37.86	19.36	5.49	Sarkar et al. (1953)
114	04	032	Bengalis	West Pakistan	122	39.34	27.05	27.87	5.74	Boyd and Boyd (1954)
115	04	033	Brahmin	Diamond Harbour Sub-Division, 24 Parganas Dist.	100	28.00	38.00	27.00	7.00	Sen (1954)
116	04	034	Kayastha	Diamond Harbour Sub-Division, 24 Parganas Dist.	140	37.86	20.00	35.00	7.14	Sen (1954)
117	04	035	Kaora	Diamond Harbour Sub-Division, 24 Parganas Dist.	78	26.92	25.64	38.46	8.97	Sen (1954)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
118	04	036	Mahishya	Diamond Harbour Sub-Division, 24 Parganas Dist.	277	34.30	22.74	35.74	7.22	Sen (1954)
119	04	037	Bagdi	Diamond Harbour Sub-Division, 24 Parganas Dist.	38	23.68	26.32	34.21	15.79	Sen (1954)
120	04	038	Muslim	Diamond Harbour Sub-Division, 24 Parganas Dist.	128	28.12	21.87	41.41	8.59	Sen (1954)
121	04	039	Pod	Diamond Harbour Sub-Division, 24 Parganas Dist.	133	25.56	14.29	46.62	13.53	Sen (1954)
122	04	040	Muslim	Coochbehar	192	29.70	26.50	34.40	9.40	Biswas (1955)
123	04	041	Hindu	Coochbehar	1137	35.00	23.30	32.60	9.00	Biswas (1955)
124	04	042	Koch	Coochbehar	238	34.40	27.30	32.80	5.50	Biswas (1955)
125	04	043	Hindu Patients		6247	32.37	24.07	36.24	7.31	Dasgupta and Chatterjee (1955)
126	04	044	Muslim Patients		1209	30.93	26.39	33.25	9.43	Dasgupta and Chatterjee (1955)
127	04	045	Muslim	Chandernagore, Hooghly Dist.	354	33.33	23.73	33.90	9.04	Bhattacharjee (1956)
128	04	046	Rarhi Brahmin	Chandernagore, Hooghly Dist.	372	36.02	24.46	30.38	9.14	Bhattacharjee (1956)
129	04	047	Duley	Chandernagore, Hooghly Dist.	241	21.99	24.07	38.17	15.77	Kumar (1957)
130	04	048	Tentulia Bagdi	Chandernagore, Hooghly Dist.	342	21.93	26.90	38.01	13.16	Kumar (1957)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
131	04	049	Nama Sudra		383	35.25	22.45	31.85	10.44	Majumdar (1958)
132	04	050	Artisan (Miscl.)		139	35.97	20.14	33.81	10.07	Majumdar (1958)
133	04	051	Banik		52	28.85	25.00	28.85	17.31	Majumdar (1958)
134	04	052	Rishi		72	23.61	25.00	40.28	11.11	Majumdar (1958)
135	04	053	Kayastha		364	32.42	26.10	33.24	8.24	Majumdar (1958)
136	04	054	Muslim		520	33.46	26.92	30.38	9.23	Majumdar (1958)
137	04	055	Brahmin		237	34.18	21.10	35.44	9.28	Majumdar (1958)
138	04	056	Marak Sangma		71	26.76	23.94	38.03	11.27	Majumdar (1958)
139	04	057	Bengalees		154	31.82	30.52	31.17	6.49	Mathew (1959)
140	04	058	Vaidya	U.K.	88	31.82	31.82	25.00	11.36	Sen (1960)
141	04	059	Kayastha	U.K.	269	37.17	27.13	29.37	6.32	Sen (1960)
142	04	060	Brahmin	U.K.	188	38.30	22.34	32.98	6.38	Sen (1960)
143	04	061	Munda	Nazat, Basirhat Sub-Division, 24 Parganas Dist.	27	7.41	22.22	51.85	18.52	Ray (1962)
144	04	062	Oraon	Nazat, Basirhat Sub-Division, 24 Parganas Dist.	111	24.32	27.93	36.94	10.81	Ray (1962)
145	04	063	Rajbanshi	Midnapore Dist.	422	36.02	28.20	25.59	10.19	Das and Bhattacharjee(1963)
146	04	064	Santal	Midnapore Dist.	336	25.89	27.98	36.31	9.82	Chaudhuri et al. (1967)
147	04	065	Rajbanshi	Midnapur	307	28.01	27.69	32.25	12.05	Das et al. (1967)
148	04	066	Rajbanshi	Jalpaiguri	200	28.00	32.50	28.50	11.00	Das et al. (1967)
149	04	067	Rajbanshi	Coochbehar	150	22.67	24.66	36.00	16.67	Das et al. (1967)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
150	04	068	Vaidya	Calcutta	129	30.23	26.36	37.21	6.20	Chaudhuri et al. (1969)
151	04	069	Kayastha	Calcutta	229	31.88	23.14	37.99	6.99	Chaudhuri et al. (1969)
152	04	070	Brahmin	Calcutta	235	31.49	25.53	32.77	10.21	Chaudhuri et al. (1969)
153	04	071	Poundra Kshatriya	Sarisa, Diamond Harbour, Kulpi; 24 Parganas Dist.	122	23.77	8.20	57.38	10.65	Roy and Das (1973)
154	04	072	Kaora	Sarisa, Diamond Harbour, Kulpi; 24 Parganas Dist.	200	26.00	28.00	32.00	14.00	Das et al. (1974)
155	04	073	Mahisya	Barisa and Sarsuna	108	32.41	16.66	40.74	10.19	Chakraborty et al. (1975)
156	04	074	Tamang	Darjeeling	200	42.00	25.00	28.00	5.00	Bhattacharjee(1977)
157	04	075	Santhal	Chinsura, Hooghly Dist.	115	23.48	19.13	45.22	12.17	Mukherjee et al. (1977)
158	05	001	Tibetans	Gyantse	187	14.97	47.06	13.90	24.06	Gates (1936)
159	05	002	Lepcha	Kalimpong	33	30.30	36.40	27.30	6.06	Macfarlane (1937)
160	05	003	Nepalese	Kalimpong	78	33.30	34.60	23.10	9.00	Macfarlane (1937)
161	05	004	Bhotia		80	38.75	36.25	20.00	5.00	Macfarlane (1941a)
162	05	005	Gurkha	Nepal	2869	31.80	33.80	25.20	9.20	Agar (1946)
163	05	006	Tibetans	Tibet-Indian Border in North Bengal and Sikkim	150	42.00	20.00	30.67	7.33	Buchi (1952)
164	05	007	Gurkha		190	37.37	32.11	24.21	6.32	Mathew (1959)
165	05	008	Dogpar	Nepal	135	31.85	24.44	33.33	10.37	Horrobin et al. (1963)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
166	05	009	Gurung and Magar		105	36.19	31.43	29.52	2.86	Horrobin et al. (1963)
167	05	010	Kiranti	Rai and Limbu, Nepal	85	20.00	57.65	16.47	5.88	Horrobin et al. (1963)
168	05	011	Newar	Nepal	150	28.00	34.67	26.67	10.67	Horrobin et al. (1963)
169	05	012	Sherpa	Bahandar, Nepal	103	43.69	15.53	33.98	6.80	Heinrich (1966)
170	05	013	Sherpa	Dhunge, Nepal	45	37.78	13.33	42.22	6.67	Heinrich (1966)
171	05	014	Sherpa	Gyapchu, Nepal	64	34.38	25.00	37.50	3.13	Heinrich (1966)
172	05	015	Sherpa	N.E. Solu, Nepal	112	41.07	11.61	41.96	5.36	Heinrich (1966)
173	05	016	Sherpa	N.W. Solu, Nepal	165	45.45	16.36	33.33	4.85	Heinrich (1966)
174	05	017	Sherpa	S. Solu, Nepal	74	40.54	12.16	41.89	5.41	Heinrich (1966)
175	05	018	Tibetans	Dalhousie, Mussoorie, and Delhi	290	40.69	21.38	32.07	5.85	Tiwari (1966)
176	05	019	Tibetans	Rahla, Near Manali	62	41.93	22.58	25.81	9.68	Bhalla and Kaul (1966)
177	05	020	Tibetans	Kalimpong	233	37.34	17.17	38.20	7.30	Bhattacharjee(1968)
178	05	021	Lunana	Bhutan	41	17.07	9.76	51.22	21.95	Glasgow et al.(1968)
179	05	022	Thimbu	Bhutan	31	48.38	19.35	25.81	6.45	Glasgow et al.(1968)
180	05	023	Bhutanese		154	31.82	33.77	25.32	9.09	Mourant et al.(1969)
181	05	024	Newar	Kathmandu	509	25.70	42.50	20.00	11.70	Bhasin (1970)
182	05	025	Tibetans	Central Tibet	100	46.00	19.00	28.00	7.00	Bhalla (1971)
183	05	026	Tibetans	Eastern Tibet	42	33.33	21.43	35.71	9.52	Bhalla (1971)
184	05	027	Tibetans	Western Tibet	40	35.00	15.00	40.00	10.00	Bhalla (1971)
185	05	028	Tibetans	Chandragiri, Orissa	230	34.78	22.61	32.61	10.00	Patel (1971)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
186	05	029	Rai Nepalese		250	24.00	54.00	12.80	9.20	Bhattacharjee and Moitra (1974)
187	05	030	Tibetans	Darjeeling	256	35.16	21.49	35.16	8.20	Singh et al.(1974)
188	06	001	Oraon, Munda and Santhal		589	24.30	27.50	36.80	11.40	Malone and Lahiri (1929)
189	06	002	Hill Male	Santhal Parganas	235	42.12	25.53	26.81	5.53	Sarkar (1936)
190	06	003	Santhal	Santhal Parganas	339	34.03	20.94	34.81	11.21	Sarkar (1936)
191	06	004	Plains Male	Santhal Parganas	34	29.41	8.82	50.00	11.76	Sarkar (1936)
192	06	005	Malpaharia	Santhal Parganas	27	40.74	25.93	25.93	7.41	Sarkar (1936)
193	06	006	Other Castes	Santhal Parganas	185	42.70	20.00	30.27	7.03	Sarkar (1936)
194	06	007	Oraon	Darjeeling, Santhal Parganas and Calcutta	35	25.71	25.71	31.43	17.14	Sarkar (1937)
195	06	008	Munda	Barajumda, Singhbhum Dist.	120	33.33	30.00	29.17	7.50	Macfarlane (1941b)
196	06	009	Oraon	Ranchi	155	47.10	12.90	34.84	5.16	Sarkar (1942)
197	06	010	Birhor	Palamau	39	20.51	17.95	51.28	10.26	Sarkar (1949)
198	06	011	Chero	Palamau	35	34.28	34.28	22.86	8.57	Sarkar (1949)
199	06	012	Korwa	Palamau	114	19.30	27.19	32.46	21.05	Sarkar (1949)
200	06	013	Oraon	Palamau	115	26.09	27.83	33.91	12.17	Sarkar (1949)
201	06	014	Asura	Palamau	21	38.10	57.14	0.00	8.76	Sarkar (1949)
202	06	015	Bhuiya	Palamau	35	25.71	34.29	25.71	14.29	Sarkar (1949)
203	06	016	Kisan	Palamau	30	36.67	13.32	43.33	6.67	Sarkar (1949)
204	06	017	Kharwar	Palamau	53	16.98	20.75	41.51	20.75	Sarkar (1949)
205	06	018	Ho	Kolhan, Singhbhum Dist.	186	34.95	31.72	27.96	5.38	Majumdar (1950)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
206	06	019	Birhor		102	31.37	35.29	23.53	9.80	Majumdar (1950)
207	06	020	Santal	Pakur Sub-Division, Santal Parganas	68	25.00	23.53	39.70	11.76	Sarkar and Sen (1952)
208	06	021	Plains Male	Pakur Sub-Division, Santal Parganas	75	44.00	28.00	21.33	6.67	Sarkar and Sen (1952)
209	06	022	Malpaharia	Pakur Sub-Division, Santal Parganas	31	22.58	22.58	35.48	19.35	Sarkar and Sen (1952)
210	06	023	Other Castes	Pakur Sub-Division, Santal Parganas	77	31.16	27.27	38.96	2.60	Sarkar and Sen (1952)
211	06	024	Birjia	Palamau	129	10.85	17.05	61.24	10.85	Sarkar (1954)
212	06	025	Adivasis		126	21.43	29.37	32.54	16.67	Mathew (1959)
213	06	026	Biharis		96	22.92	30.21	28.13	18.75	Mathew (1959)
214	06	027	Bhumij		121	35.54	23.14	32.23	9.09	Gupta (1962,
215	06	028	Oraon	Ranchi Dist.	125	25.60	28.80	38.40	7.20	Kirk et al.(1962)
216	06	029	Ho	Seraikella Sub-Division, Singhbhum Dist.	63	31.75	36.51	20.63	11.11	Ghosh (1964)
217	06	030	Kurmi Mahato	Ajodhya and Dalma Hills	111	42.34	34.23	18.02	5.41	Basu et al.(1966)
218	06	031	Southern Pahira	Ajodhya and Dalma Hills	671	17.88	34.58	31.45	16.10	Basu et al.(1966)
219	06	032	Northern Pahira	Ajodhya and Dalma Hills	206	16.99	41.75	21.84	19.42	Basu et al.(1966)
220	06	033	Other Tribes and Castes	Ajodhya and Dalma Hills	78	25.64	28.21	42.31	3.84	Basu et al.(1966)
221	06	034	Hindu		8553	31.38	21.59	38.47	8.56	Gupta (1968)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
222	06	035	Muslim		551	32.85	20.33	36.84	9.98	Gupta (1968)
223	06	036	Christian		153	28.76	23.53	37.91	9.80	Gupta (1968)
224	06	037	Santal	Damin, Santal Parganas	400	26.25	23.50	38.00	12.25	Bhattacharjee (1969)
225	06	038	Dudh Kharia	Ranchi, Simdega, Thethai and Tanger	184	21.20	33.15	29.89	15.76	Bhattacharjee and Kumar (1969)
226	06	039	Desi Bhumij	Singhbhum, Bahragora	150	30.67	24.67	36.67	7.99	Kumar and Mukherjee (1969)
227	06	040	Munda	Ranchi Dist.	105	30.48	33.33	26.67	9.52	Tyagi (1969)
228	06	041	Munda	Khunti	180	27.78	22.73	29.44	20.00	Dash Sharma (1972)
229	06	042	Oraon	Banari	186	26.34	22.58	40.32	10.75	Dash Sharma (1973)
230	06	043	Dushad	Darbhanga	162	29.01	22.22	38.27	10.50	Dash Sharma (1974)
231	06	044	Ho	Jagannathpur Block, Singhbhum Dist.	200	25.00	26.00	37.00	12.00	Kumar and Mukherjee (1975)
232	07	001	Hindu		200	33.50	24.50	31.00	11.00	Figueriedo (1935)
233	07	002	Christian		309	31.07	22.65	30.42	15.86	Figueriedo (1935)
234	07	003	Maratha		400	29.25	26.75	34.00	10.00	Correia (1936)
235	07	004	Hindu		158	33.54	28.48	30.38	7.59	Silva (1953)
236	07	005	Christian		203	40.87	27.59	25.62	5.91	Silva (1953)
237	07	006	Goan Students	Uganda	50	34.00	34.00	30.00	2.00	Rife (1956)
238	07	007	Hindu Gavda		100	40.00	34.00	21.00	5.00	Malhotra (1971)
239	07	008	Christian Gavda		192	29.17	32.81	28.13	9.89	Malhotra (1971)
240	07	009	Nav Hindu Gavda		102	35.29	42.16	17.65	4.90	Malhotra (1971)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
241	07	010	Catholic Brahmin	Panjim	118	34.74	31.36	27.12	6.78	Bhatia et al. (1976)
242	08	001	Waghar	Porbandar, Dwarka, Mithapur	120	38.33	21.67	33.33	6.67	Majumdar and Kishen (1948)
243	08	002	Sunni Bohra	Rajpipla, Ahmad, Kutch, Bombay	132	34.09	20.45	40.91	4.55	Majumdar and Kishen (1948)
244	08	003	Satwara	Ahmedabad, Billi-mora, Porbandar, Dwarka, Mithapur	100	25.00	25.00	38.00	12.00	Majumdar and Kishen (1948)
245	08	004	Rabari	Porbandar, Jamnagar, Kutch	134	32.84	26.12	29.10	11.94	Majumdar and Kishen (1948)
246	08	005	Miana	Kutch, Dwarka, Mithapur	100	24.00	26.00	40.00	10.00	Majumdar and Kishen (1948)
247	08	006	Luhana	Porbandar, Jamnagar, Kutch	147	28.57	20.41	41.50	9.52	Majumdar and Kishen (1948)
248	08	007	Audich Brahmin	Kutch, Nawa Nagar, Porbandar, Bombay, Dwarka	106	33.96	22.64	29.25	14.15	Majumdar and Kishen (1948)
249	08	008	Mher	Porbandar	104	30.77	36.54	26.92	5.77	Majumdar and Kishen (1948)
250	08	009	Memon	Kutch, Porbandar, Jamnagar, Bombay	100	25.00	24.00	40.00	10.00	Majumdar and Kishen (1948)
251	08	010	Khoja	Kutch, Porbandar, Jamnagar, Bombay	120	30.00	23.33	35.00	11.67	Majumdar and Kishen (1948)
252	08	011	Machhi	Rajpipla	108	27.78	33.33	22.22	16.67	Majumdar and Kishen (1948)
253	08	012	Kunbi Pattidar	Rajpipla, Billimora, Nawa Nagar, Kutch, Ahmedabad	134	29.85	25.37	32.84	11.94	Majumdar and Kishen (1948)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
254	08	013	Koli	Kutch, Ahmedabad	100	32.00	21.00	36.00	11.00	Majumdar and Kishen (1948)
255	08	014	Kharwa	Porbandar	106	37.74	22.64	28.30	11.32	Majumdar and Kishen (1948)
256	08	015	Nagar Brahmin	Kutch, Rajkot, Jamnagar, Bombay	107	33.64	32.71	26.17	7.48	Majumdar and Kishen (1948)
257	08	016	Bhatia	Kutch, Nawa Nagar, Porbandar, Bombay	106	30.19	29.24	27.36	13.21	Majumdar and Kishen (1948)
258	08	017	Bhangi	Porbandar, Jamnagar	126	23.81	28.57	30.16	17.46	Majumdar and Kishen (1948)
259	08	018	Misc. Tribals	Ahmedabad, Billimora	100	33.00	23.00	35.00	9.00	Majumdar and Kishen (1948)
260	08	019	Panchmahal Bhil		369	37.12	27.37	26.56	8.94	Majumdar and Kishen (1948)
261	08	020	Rajpipla Bhil		156	38.46	24.36	28.85	8.33	Majumdar and Kishen (1948)
262	08	021	Khandesh Bhil		400	40.00	29.00	24.00	7.00	Majumdar and Kishen (1948)
263	08	022	Kapol Vania	Bombay	200	39.50	38.00	14.50	8.00	Vyas et al. (1958)
264	08	023	Bhangi Harijans of Saurashtra	Bombay and Rajkot	200	24.50	29.00	37.50	9.00	Vyas et al. (1958)
265	08	024	Cutchi Lohana	Bombay	200	31.00	24.00	40.00	5.00	Vyas et al. (1958)
266	08	025	Audichya Brahmin	Bombay	200	37.00	32.50	22 50	8.00	Vyas et al. (1958)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
267	08	026	Leva Patidar	Bombay and Nadiad, Khera Dist.	200	35.00	21.50	37.50	6.00	Vyas et al. (1958)
268	08	027	Talavia Dubla	Hansapore, Rayam and Varad, Surat Dist.	212	33.06	22.20	36.30	8.50	Vyas et al. (1958)
269	08	028	Lewa Patel		100	31.00	23.00	43.00	3.00	Bhende (1959)
270	08	029	Kadwa Patel		100	37.00	15.00	39.00	9.00	Bhende (1959)
271	C8	030	Dubla	Surat	212	33.40	22.20	35.90	8.50	Vyas et al. (1962)
272	08	031	Koli	Surat	176	45.50	17.00	30.10	7.40	Vyas et al. (1962)
273	08	032	Naika	Surat	171	33.33	29.24	31.00	6.43	Vyas et al.(1962)
274	08	033	Gamit	Surat	203	34.50	37.90	16.30	11.30	Vyas et al.(1962)
275	08	034	Bhil	Panchmahal	158	29.10	25.90	32.90	12.00	Vyas et al.(1962)
276	08	035	Dhanka	Broach	205	32.20	26.80	34.60	6.30	Vyas et al.(1962)
277	08	036	Dhodia	Surat	201	37.80	38.30	16.40	7.50	Vyas et al.(1962)
278	08	037	Lad Vania		200	39.00	19.50	37.00	4.50	Parikh et al. (1969)
279	08	038	Visa Oswal Jain		200	48.50	14.50	35.50	1.50	Parikh et al. (1969)
280	08	039	Audich Brahmin		200	44.00	21.00	29.50	5.50	Parikh et al. (1969)
281	08	040	Cutchi Lohana		121	33.06	14.05	43.80	9.09	Bhatia et al. (1976)
282	08	041	Halai Lohana		117	36.76	9.40	43.59	10.25	Bhatia et al. (1976)
283	08	042	Sindhi Lohana		134	44.03	8.21	42.54	5.22	Bhatia et al. (1976)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
284	09	001	Dogra		62	24.19	38.71	22.58	14.52	Mathew (1959)
285	09	002	Jammu Hindu		200	25.00	27.50	38.50	9.00	Mathew (1959)
286	09	003	Donors and Patients	Srinagar	1900	35.00	27.00	30.00	8.00	Kaul et al. (1962)
287	09	004	Muslim	Kashmir	294	32.65	21.43	39.12	6.80	Bhattacharjee (1966)
288	09	005	Pandit	Kashmir	320	35.63	17.50	38.75	8.12	Bhattacharjee (1966)
289	09	006	Buddhist	Ladakh	90	31.11	25.56	33.33	10.00	Bansal (1967)
290	09	007	Muslim	Ladakh	60	23.33	21.67	43.33	11.67	Bansal (1967)
291	09	008	Ladakhi		141	33.33	27.66	31.92	7.09	Bhattacharjee (1968)
292	09	009	Bodh	Leh, Ladakh	114	30.70	25.44	31.58	12.28	A.S.I. (1977)
293	09	010	Dardi	Kargil, Ladakh	125	24.80	34.40	29.60	11.20	A.S.I. (1977)
294	09	011	Porig-Pa	Kargil, Ladakh	244	29.51	25.41	34.02	11.06	A.S.I. (1977)
295	09	012	Bodh	Kargil, Ladakh	99	22.22	28.28	38.38	11.11	A.S.I. (1977)
296	09	013	Pandit	Anantnag	109	32.11	21.10	37.61	9.18	A.S.I. (1977)
297	09	014	Muslim	Anantnag	111	26.13	31.53	37.84	4.50	A.S.I. (1977)
298	10	001	Kannada Speakers		154	46.75	24.03	25.97	3.25	Ayer and Mummurthi (1953)
299	10	002	Yerava	Coorg	117	19.66	58.97	11.97	9.40	Negi and Maitra (1974)
300	10	003	Jene Kurumba	Mysore	71	35.21	30.99	29.58	4.23	Negi and Maitra (1974)
301	10	004	Desastha Brahmin (Vaishnava)		449	35.63	31.63	26.95	5.79	Patkar (1974)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
302	10	005	Desastha Brahmin (Smarth)		272	41.18	23.90	27.57	7.35	Patkar (1974)
303	10	006	Desastha Brahmin (Jangam)		268	29.28	34.25	26.12	10.35	Patkar (1974)
304	10	007	Desastha Brahmin (Panchamsali)		473	29.60	28.54	33.83	8.03	Patkar (1974)
305	10	008	Desastha Brahmin (Hanbar)		215	46.98	22.79	26.05	4.18	Patkar (1974)
306	10	009	Desastha Brahmin (Berad)		410	32.68	25.86	32.92	8.54	Patkar (1974)
307	10	010	Samagar		130	37.69	10.00	46.92	5.39	Patkar (1974)
308	11	001	Paniyan	Wynaad	250	20.00	62.40	7.60	10.00	Aiyappan (1936)
309	11	002	Izhavan	Ernakulam	132	58.33	24.44	12.12	5.30	Macfarlane(1936)
310	11	003	Pre-Dravidian Tribes	Ernakulam	50	52.00	26.00	12.00	10.00	Macfarlane(1936)
311	11	004	Syrian Christian	Ernakulam	140	36.43	26.43	28.57	8.57	Macfarlane (1936)
312	11	005	Lower Caste Malayali		260	48.10	29.20	16.10	6.50	Macfarlane (1936)
313	11	006	Nair		121	38.80	35.50	22.40	3.30	Macfarlane(1936)
314	11	007	Iluva		77	58.30	24.20	12.20	5.30	Macfarlane(1936)
315	11	008	Nayadi	Olavakkot, Malavar	50	28.00	0.00	72.00	0.00	Aiyappan (1939)
316	11	009	Kannikar	South Travancore	211	51.18	18.49	29.86	0.47	Karunakaran (1939)
317	11	010	Pulayan		280	44.28	24.28	31.07	0.36	Iyer (1946)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
318	11	011	Muthuvan		89	19.10	42.70	31.46	6.74	Iyer (1946)
319	11	012	Urali	North Travancore	107	45.79	24.30	25.23	4.67	Bose (1952b)
320	11	013	Kannikar	South Travancore	151	39.73	35.10	22.52	2.65	Bose (1952b)
321	11	014	Malayalam Speakers		177	44.07	20.34	31.07	4.52	Ayer and Mummurthi (1953)
322	11	015	Kannikar	South Travancore, Western Ghats	167	65.87	20.96	11.98	1.20	Buchi (1953b)
323	11	016	Paniyan	Malavar Wynaad	249	25.30	59.50	8.40	6.80	Das and Ghosh (1954)
324	11	017	Paniyan	Malavar Wynaad	313	22.36	64.22	7.67	5.75	Sarkar (1954)
325	11	018	Mullu Kuruma	Malavar Wynaad	80	63.75	10.00	25.00	1.25	Sarkar (1954)
326	11	019	Vettu Kuruma	Malavar Wynaad	17	11.76	11.76	70.59	5.88	Sarkar (1954)
327	11	020	Jene Kuruma	Malavar Wynaad	17	47.06	47.06	5.88	0.00	Sarkar (1954)
328	11	021	Adiyan	Malavar Wynaad	38	10.53	68.42	7.89	13.16	Sarkar (1954)
329	11	022	Malapantran	Central Travancore	116	32.76	44.83	13.79	8.62	Buchi (1955)
330	11	023	Pallar	Tirunelveli Dist.	112	33.93	23.21	35.71	7.14	Buchi (1955)
331	11	024	Mamman	Travancore	64	34.37	31.25	18.75	15.62	Roy (1955)
332	11	025	Ulladan	Central Travancore	245	32.65	33.47	25.71	8.16	Roy (1955)
333	11	026	Aryan	Central Travancore	78	32.05	32.05	23.08	12.82	Roy (1955)
334	11	027	Vethuvan	Travancore	64	16.06	46.88	30.81	6.25	Roy (1955)
335	11	028	Muthuvan	N.E. Travancore	140	15.71	38.57	30.71	15.00	Roy (1955)
336	11	029	Ulladan	Cardamom Hills	142	24.65	32.29	28.87	14.08	Buchi (1957)
337	11	030	Mala Vedan	Quilon Dist.	78	16.67	42.31	26.92	14.10	Buchi (1958)
338	11	031	Malakuruvan	Vadasserikara	36	13.89	44.44	33.33	8.34	Buchi (1959)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
339	11	032	Syrian Christian		71	43.66	28.17	26.76	1.41	Mathew (1959)
340	11	033	Malayalees		121	43.80	27.27	23.97	4.96	Mathew (1959)
341	11	034	Kadar	Anaimalai Hills	78	41.02	17.95	38.46	2.56	Sarkar and Banerjee (1959)
342	11	035	Nair	Achenkovil, Shencottah	29	44.83	31.03	20.69	3.45	Buchi (1960)
343	11	036	Kadar	Anaimalai and Trichur Hills	166	39.16	18.67	36.75	5.42	Buchi (1961)
344	11	037	Nair	Armed Forces Medical College, Poona	84	51.19	20.23	26.19	2.39	Bird et al. (1962)
345	11	038	Christian	Armed Forces Medical College, Poona	59	44.07	32.21	18.64	5.08	Bird et al. (1962)
346	11	039	Ezhava	Armed Forces Medical College, Poona	43	51.16	13.95	32.56	2.33	Bird et al. (1962)
347	11	040	Hurchiar		115	53.04	22.61	24.35	0.00	Hargrave (1963)
348	11	041	Kadar	Koda, Anaimalai Hills	102	29.41	25.49	37.25	7.85	Hargrave (1963)
349	11	042	Pulaiya		28	28.57	42.86	25.00	3.57	Chaudhuri et al. (1964)
350	11	043	Kuruva		23	52.17	17.39	17.39	13.04	Chaudhuri et al. (1964)
351	11	044	Kadar	Annamalai Hills	189	52.37	16.41	26.46	4.76	Saha et al. (1974)
352	11	045	Brahmin	Kannamangalam	40	20.00	27.50	40.00	12.50	Saha et al. (1976)
353	11	046	Nayar	Kannamangalam	117	46.15	28.21	22.22	3.42	Saha et al. (1976)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
354	11	047	Izhava	Ernakulam	48	52.08	14.58	18.75	14.58	Saha et al.(1976)
355	11	048	Scheduled Castes	Ernakulam	43	39.53	16.28	37.21	6.98	Saha et al. (1976)
356	11	049	Christian	Ernakulam	132	31.06	28.79	29.55	10.61	Saha et al.(1976)
357	11	050	Malayaran	Kalady	58	62.08	18.96	17.24	1.72	Saha et al.(1976)
358	12	001	Koya	Kavartty Is.	113	35.40	30.80	23.89	10.62	Bhattacharjee (1972)
359	13	001	Hindu Soldiers	Central Provinces and Berar	118	27.97	21.19	38.14	12.71	House and Mahalanobis (1939)
360	13	002	Maria Gond	Jagdalpur	123	28.45	26.02	34.15	11.38	Macfarlane(1941)
361	13	003	Balahi	Khandwa, Nimar Dist.	200	30.50	32.00	30.00	7.50	Macfarlane (1941)
362	13	004	Maria	Dantewara Tehsil	50	26.00	28.00	36.00	10.00	Sarkar (1950)
363	13	005	Maria	Jagdalpur	50	26.00	30.00	38.00	6.00	Sarkar (1950)
364	13	006	Bhil	Gwalior	534	34.64	28.09	28.09	9.18	Bose (1952a)
365	13	007	Mahar		25	32.00	36.00	24.00	8.00	Mathew (1959)
366	13	008	Maratha		26	30.77	30.77	26.92	11.54	Mathew (1959)
367	13	009	Western Muria	Bastar, Kondagaon Tehsil, West of Bade Dongar Hills	169	28.99	17.75	38.47	14.79	Negi and Ahmed (1962)
368	13	010	Eastern Muria	Bastar, Kondagaon Tehsil, East of Bade Dongar Hills	143	27.97	25.18	39.86	6.99	Negi and Ahmed (1962)
369	13	011	Bisonhorn Maria	Bastar, Dantewara, Jagdalpur	218	39.00	22.90	29.80	8.30	Negi and Ahmed (1962)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
370	13	012	Mahra	Jagdalpur Tehsil, Bastar	123	21.95	30.08	33.33	14.64	Negi and Ahmed (1962)
371	13	013	San Bhatra	Bastar	88	40.91	18.18	31.82	9.09	Negi and Ahmed (1962)
372	13	014	Manjhela Bhatra	Jagdalpur Tehsil, Bastar	64	29.69	29.69	34.37	6.25	Negi and Ahmed (1962)
373	13	015	Bade Bhatra	Bastar	153	26.14	33.99	29.41	10.46	Negi and Ahmed (1962)
374	13	016	Hill Maria	Bijaipur Marh, Bastar	85	45.90	10.90	34.10	9.40	Negi and Ahmed (1962)
375	13	017	Panu	Dewas Dist., Ankya, Pitaoli, Udayagari	154	37.66	32.47	24.03	5.84	Hargrave (1963)
376	13	018	Kanwar	North Bilaspur	91	17.58	26.37	45.05	10.99	Negi (1963)
377	13	019	Gond	North Bilaspur	129	28.68	26.36	34.11	10.85	Negi (1963)
378	13	020	Dorla	Bastar	200	34.00	31.50	30.50	4.00	Negi and Ahmed (1963)
379	13	021	Dhurwa	Bastar	200	29.00	31.50	29.00	10.50	Negi and Ahmed (1963)
380	13	022	Northern Dhurwa	Bastar	60	23.33	30.00	36.67	10.00	Negi and Ahmed (1963)
381	13	023	Rajput	Dewas, Dhar, Indore, Mandsaur, Ratlam	100	20.00	29.00	36.00	15.00	Kumar (1965)
382	13	024	Chamar	Dhar, Indore, Mandsaur, Ratlam, Ujjain	109	27.52	18.35	46.79	7.34	Kumar (1965)
383	13	025	Balai	Dhar, Mandsaur, Ratlam, Ujjain	47	31.91	17.02	42.55	8.51	Kumar (1965)
384	13	026	Bhil	Ratlam	88	27.27	32.95	35.23	4.55	Kumar (1965)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
385	13	027	Other Hindu	Ratlam	117	36.75	29.06	26.50	7.69	Kumar (1965)
386	13	028	Brahmin	Dhar, Indore, Mandsaur, Ratlam	137	27.01	27.74	37.96	7.30	Kumar (1965)
387	13	029	Jain and Vaishya	Mandsaur, Ratlam	86	44.19	19.77	26.74	9.30	Kumar (1965)
388	13	030	Jain and Vaishya	Dhar, Dist., Bagh, Bandnawar	100	33.00	26.00	38.00	3.00	Kumar (1966)
389	13	031	Balai	Indore Dist.	100	25.00	27.00	35.00	13.00	Kumar (1966)
390	13	032	Bhil	Dhar Dist., Bandnawar, Bagh, Madawari	54	24.07	37.04	29.63	9.26	Kumar (1966)
391	13	033	Bhilala	Dhar Dist., Bagh, Madawari	173	32.37	25.43	31.79	10.40	Kumar (1966)
392	13	034	Teli	Dhar, Indore, Mandsaur, Ratlam, Ujjain	74	39.19	22.97	27.03	10.81	Kumar (1966)
393	13	035	Rami Mali	Indore Dist.	100	24.00	18.00	45.00	13.00	Kumar (1966)
394	13	036	Khati	Indore Dist., Rangwasa, Tihi	100	28.00	18.00	45.00	9.00	Kumar (1966)
395	13	037	Kadve Kulmi	Indore Dist.	100	29.00	12.00	53.00	6.00	Kumar (1966)
396	13	038	Dhakar	Dewas Dist., Sadar Sub-Division	53	32.08	20.75	35.85	11.32	Kumar and Ghosh (1967)
397	13	039	Mehtar	Ujjain Dist., Mehidpur, Ujjain	145	31.72	27.59	31.03	9.66	Kumar and Ghosh (1967)
398	13	040	Nayta Muslim	Narwer, Ujjain Dist.	103	37.86	20.39	35.92	5.83	Kumar and Ghosh (1967)
399	13	041	Rajput	Ratlam and Dhar Dists.	100	20.00	29.00	36.00	15.00	Kumar and Ghosh (1967)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
400	13	042	Brahmin	Ratlam and Dhar Dists.	137	27.01	27.74	37.96	7.30	Kumar and Ghosh (1967)
401	13	043	Jain and Vaishya	Mehidpur, Ujjain, Ujjain Dist.	56	37.50	25.00	30.36	7.14	Kumar and Ghosh (1967)
402	13	044	Rajput	Mehidpur, Ujjain, Ujjain Dist.	107	38.32	23.36	28.97	9.35	Kumar and Ghosh (1967)
403	13	045	Dhakar	Mandsaur Dist.	61	32.79	24.59	32.79	9.84	Kumar and Ghosh (1967)
404	13	046	Bade Bhinjwar	Chhattisgarh	233	33.04	35.62	24.46	6.87	Negi and Ahmed (1971)
405	14	001	Maratha	Deccan Plateau	572	41.95	28.68	22.90	6.47	Karve (1948)
406	14	002	Maratha	Deccan Plateau	85	29.41	22.35	36.47	11.77	Karve (1948)
407	14	003	Maratha	Deccan Plateau	194	47.42	28.87	19.07	4.64	Karve (1948)
408	14	004	Maratha	Manal	116	34.47	26.75	34.47	4.31	Karve (1948)
409	14	005	Maratha	Konkan	198	45.45	29.80	18.18	6.57	Karve (1948)
410	14	006	V.N.Brahmin	Bombay	200	41.00	30.00	24.50	4.50	Sanghvi and Khanolkar (1949)
411	14	007	Desasth Brahmin	Bombay	200	37.50	25.00	30.00	7.50	Sanghvi and Khanolkar (1949)
412	14	008	Koknasth Brahmin	Bombay	200	51.00	24.00	20.00	5.00	Sanghvi and Khanolkar (1949)
413	14	009	Chandrasenia Kayasth Prabhu	Bombay and Poona	200	34.50	28.50	28.50	8.50	Sanghvi and Khanolkar (1949)
414	14	010	Maratha	Bombay	200	35.50	31.00	25.50	8.00	Sanghvi and Khanolkar (1949)
415	14	011	Mahar	Des	102	23.53	25.49	36.27	14.71	Karve and Dandekar (1951)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
416	14	012	Agari	Konkan	27	33.33	22.22	40.74	3.70	Karve and Dandekar (1951)
417	14	013	Andha	Des	55	29.09	32.73	32.73	5.45	Karve and Dandekar (1951)
418	14	014	Bari	Khandesh	49	38.78	24.49	34.69	2.04	Karve and Dandekar (1951)
419	14	015	Bhandari	Konkan	26	38.46	26.92	26.92	7.69	Karve and Dandekar (1951)
420	14	016	Bhavasar	Des	27	11.11	37.04	29.63	22.22	Karve and Dandekar (1951)
421	14	017	Bhil Mavachi	Khandesh	29	37.93	44.83	10.34	6.90	Karve and Dandekar (1951)
422	14	018	Tadvi Bhil	Khandesh	36	25.00	27.78	36.11	11.11	Karve and Dandekar (1951)
423	14	019	Bhil (Misc.)	Khandesh	41	29.27	17.07	34.15	19.51	Karve and Dandekar (1951)
424	14	020	Charak Brahmin	C.P. and Berar	26	23.08	34.62	38.46	3.85	Karve and Dandekar (1951)
425	14	021	Chitpavan Brahmin	Konkan	104	46.15	28.85	16.35	8.65	Karve and Dandekar (1951)
426	14	022	Karhade Brahmin	Konkan	39	33.33	38.46	17.95	10.26	Karve and Dandekar (1951)
427	14	023	Saraswat Brahmin	Konkan	37	40.54	29.73	27.03	2.70	Karve and Dandekar (1951)
428	14	024	Burud	Des	28	35.71	10.71	46.43	7.14	Karve and Dandekar (1951)
429	14	025	Chambhar	Des	49	36.73	22.45	36.73	4.08	Karve and Dandekar (1951)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
430	14	026	Dhangar Hatkar	Des	30	33.33	33.33	26.67	6.67	Karve and Dandekar (1951)
431	14	027	Dhangar Khutekar	Des	33	15.15	36.36	30.30	18.18	Karve and Dandekar (1951)
432	14	028	Dheewar	C.P. and Berar	25	12.00	24.00	56.00	8.00	Karve and Dandekar (1951)
433	14	029	Gond	C.P. and Berar	26	38.46	23.08	34.62	3.85	Karve and Dandekar (1951)
434	14	030	Govaree	C.P. and Berar	28	21.43	35.71	32.14	10.71	Karve and Dandekar (1951)
435	14	C31	Gujar	Khandesh	44	34.09	22.73	18.18	25.00	Karve and Dandekar (1951)
436	14	032	Gurav	Des	26	50.00	23.08	23.08	3.84	Karve and Dandekar (1951)
437	14	033	Halbee	C.P. and Berar	33	30.30	36.36	30.30	3.03	Karve and Dandekar (1951)
438	14	034	Halbee Koshti	C.P. and Berar	28	21.43	35.71	32.14	10.71	Karve and Dandekar (1951)
439	14	035	Khatri	Konkan	26	65.38	11.54	11.54	11.54	Karve and Dandekar (1951)
440	14	036	Kohalee	C.P. and Berar	26	42.31	15.38	34.62	7.69	Karve and Dandekar (1951)
441	14	037	Kolam	C.P. and Berar	30	26.67	40.00	26.67	6.67	Karve and Dandekar (1951)
442	14	038	Koli Malhar	Konkan	30	43.33	23.33	20.00	13.33	Karve and Dandekar (1951)
443	14	039	Kunbi Dhanoje	C.P. and Berar	229	31.03	37.93	20.69	10.34	Karve and Dandekar (1951)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
444	14	040	Kunbi Khaire	C.P. and Berar	32	40.63	21.88	25.00	12.50	Karve and Dandekar (1951)
445	14	041	Kunbi Mana	C.P. and Berar	26	23.08	46.15	19.31	11.54	Karve and Dandekar (1951)
446	14	042	Kunbi Tirole	C.P. and Berar	49	26.53	36.73	28.57	8.16	Karve and Dandekar (1951)
447	14	043	Lewa	Khandesh	37	21.62	40.54	21.62	16.22	Karve and Dandekar (1951)
448	14	044	Mahar Bhavane	C.P. and Berar	25	60.00	8.00	16.00	16.00	Karve and Dandekar (1951)
449	14	045	Mang	Des	32	31.25	34.38	31.25	3.12	Karve and Dandekar (1951)
450	14	046	Nhavi	Des	28	28.57	39.29	10.71	21.43	Karve and Dandekar (1951)
451	14	047	Parit	Des	26	34.62	34.62	19.23	11.54	Karve and Dandekar (1951)
452	14	048	Kshatriya Pathare	Konkan	26	38.46	26.92	23.08	11.54	Karve and Dandekar (1951)
453	14	049	Powar	C.P. and Berar	31	41.94	41.94	12.90	3.23	Karve and Dandekar (1951)
454	14	050	C.K.Prabhu	Konkan	30	33.33	36.67	23.33	6.67	Karve and Dandekar (1951)
455	14	051	Pathare Prabhu	Konkan	33	54.55	24.24	15.15	6.06	Karve and Dandekar (1951)
456	14	052	Sali	Des	34	35.29	26.47	26.47	11.76	Karve and Dandekar (1951)
457	14	053	Shimpi	Des	31	16.13	32.26	48.39	3.23	Karve and Dandekar (1951)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
458	14	054	Sonar Ahir	Khandesh	41	43.90	31.71	17.07	7.32	Karve and Dandekar (1951)
459	14	055	Sonar Daivadnya	Konkan	28	32.14	21.43	35.71	10.71	Karve and Dandekar (1951)
460	14	056	Sonar (Misc.)	Des	26	23.08	46.15	19.23	11.54	Karve and Dandekar (1951)
461	14	057	Sonkoli	Konkan	45	24.44	31.11	33.33	11.11	Karve and Dandekar (1951)
462	14	058	Teli	Des	40	37.50	22.50	32.50	7.50	Karve and Dandekar (1951)
463	14	059	Thakur	Konkan	29	27.59	34.48	27.59	10.34	Karve and Dandekar (1951)
464	14	060	Vaisnya Wani	Konkan	25	24.00	48.00	24.00	4.00	Karve and Dandekar (1951)
465	14	061	Wadwal	Konkan	25	36.00	48.00	8.00	8.00	Karve and Dandekar (1951)
466	14	062	Wanjari	Khandesh	40	32.50	22.50	37.50	7.50	Karve and Dandekar (1951)
467	14	063	Warli	Konkan	31	35.48	29.03	16.13	19.35	Karve and Dandekar (1951)
468	14	064	Madhyandin Brahmin	Khandesh, Desh C.P. and Berar	282	43.97	25.89	24.82	5.32	Karve and Dandekar (1951)
469	14	065	Katkari	W. Maharashtra	31	25.81	25.81	35.48	12.90	Karve and Dandekar (1951)
470	14	066	Deshasth Rigvedi Brahmin	Des	154	37.01	24.68	31.17	7.14	Karve and Dandekar (1951)
471	14	067	Fulmali	Des	95	27.37	28.42	34.74	9.47	Karve and Dandekar (1951)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
472	14	068	Koli	Des	53	32.08	16.98	35.85	15.09	Karve and Dandekar (1951)
473	14	069	Mahar	Bombay	409	31.80	25.20	34.70	8.30	Sanghvi (1954)
474	14	070	Maratha	Colaba	166	34.90	32.50	22.30	10.30	Sanghvi (1954)
475	14	071	Maratha	Des	226	30.10	31.40	27.90	10.60	Sanghvi (1954)
476	14	072	Maratha	Ratnagiri	288	30.20	34.70	26.80	8.30	Sanghvi (1954)
477	14	073	Christian	Bombay	200	39.50	32.50	22.50	5.50	Sanghvi (1954)
478	14	074	Bombay Hindus	Bombay Blood Banks	3485	38.40	24.80	28.30	8.50	Sanghvi (1954)
479	14	075	Other Regions		178	36.50	27.50	23.60	12.40	Sanghvi (1954)
480	14	076	Mahar		171	31.58	23.98	33.33	11.11	Mathew (1959)
481	14	077	Maratha		181	30.39	30.94	30.39	8.29	Mathew (1959)
482	14	078	Maratha (Kunbi and Teli)	Nagpur	98	25.50	32.40	33.00	9.10	Solanki et al. (1960)
483	14	079	Mahar	Nagpur	120	34.10	24.20	26.70	15.00	Solanki et al. (1960)
484	14	080	Raj Gond	Kamptee, Nagpur Dist.	51	27.45	13.73	52.94	5.88	Bhattacharjee (1961)
485	14	081	Mahar	Nagpur	268	38.06	20.89	30.97	10.08	Das et al.(1961)
486	14	082	Parsi	Bombay	214	39.25	21.03	30.37	9.35	Baxi et al.(1963)
487	14	083	Charak Brahmin	Nagpur	100	35.00	25.00	33.00	7.00	Malhotra (1966)
488	14	084	Madhyandina Brahmin	Pandharpur and Poona	100	38.00	23.00	34.00	5.00	Malhotra (1966)
489	14	085	Kanava Brahmin	Pandharpur	100	35.00	23.00	40.00	2.00	Malhotra (1966)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
490	14	086	Desastha Rgvedi Brahmin	Pandharpur and Poona	100	35.00	27.00	30.00	8.00	Malhotra (1966)
491	14	087	Saraswat Brahmin	Bombay and Poona	100	41.00	33.00	24.00	2.00	Malhotra (1966)
492	14	088	Karhade Brahmin	Pandharpur and Poona	100	32.00	33.00	27.00	8.00	Malhotra (1966)
493	14	089	Devrukhe Brahmin	Bombay	100	27.00	26.00	42.00	5.00	Malhotra (1966)
494	14	090	Chitpavan Brahmin	Pandharpur and Poona	100	51.00	29.00	18.00	2.00	Malhotra (1966)
495	14	091	Parsi	Bombay	2282	36.55	24.15	31.16	8.15	Undevia (1969)
496	14	092	Zoroastrian Irani	Bombay	200	21.00	18.50	40.50	20.00	Undevia (1969)
497	14	093	Korku		137	22.63	32.11	27.74	17.52	Cited in Bhattacharjee and Kumar (1969)
498	14	094	Bhil	Dhulia, W. Khandesh	110	45.45	19.09	29.09	6.36	Gulati and Srinivasan (1973)
499	14	095	Madia Gond		93	25.84	34.83	25.84	13.49	Kulkarni (1973)
500	14	096	Sunni Muslim	Poona	280	41.43	27.86	28.57	2.14	Ahmadi (1974)
501	14	097	Nandiwalla	Vadapuri, Indapur Taluka, Poona Dist.	80	50.00	3.75	43.75	2.50	Malhotra et al. (1974)
502	14	098	Parsi	Bombay and Poona	162	36.42	28.40	27.77	7.41	Mutalik et al. (1974)
503	14	099	Korku	Amravati	137	22.63	32.12	27.74	17.52	Negi and Maitra (1974)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
504	14	100	Kokna	Nasik and Thana	204	33.82	35.78	19.12	11.27	Negi and Maitra (1974)
505	14	101	Paura	Dhulia, Satpura	109	37.61	28.44	29.36	4.59	Negi and Maitra (1974)
506	14	102	Mahadeb Koli	Nasik	127	27.56	30.71	31.50	10.24	Negi and Maitra (1974)
507	14	103	Warlie	Thana	123	38.21	15.45	39.02	7.32	Negi and Maitra (1974)
508	14	104	Bhill	Ahmednagar	112	35.71	30.36	27.68	6.25	Negi and Maitra (1974)
509	14	105	Gaud Saras-wat Brahmin	Bombay	154	48.71	27.27	21.43	2.59	Bhatia et al. (1976)
510	14	106	Gaud Saras-wat Brahmin	Manipal	109	42.21	33.02	17.44	7.33	Bhatia et al. (1976b)
511	14	107	Chitrapur Saraswat Brahmin	Bombay	202	48.51	27.72	17.33	6.44	Bhatia et al. (1976b)
512	14	108	Ahir Dhangar		317	40.69	18.92	35.65	4.74	Malhotra et al. (1976)
513	14	109	Dange Dhangar		184	41.85	34.78	17.39	5.98	Malhotra et al. (1976)
514	14	110	Gadhari-Dhengar Dhangar		108	27.78	11.11	51.85	9.26	Malhotra et al. (1976)
515	14	111	Gadhari-Nikhar Dhangar		108	38.89	18.52	36.11	6.48	Malhotra et al. (1976)
516	14	112	Hande Dhangar		98	33.67	33.67	21.43	11.22	Malhotra et al. (1976)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
517	14	113	Hatkar Dhangar		665	29.02	32.18	30.22	8.57	Malhotra et al. (1976)
518	14	114	Hattikankan Dhangar		35	40.00	17.14	31.43	11.43	Malhotra et al. (1976)
519	14	115	Kannade Dhangar		90	55.55	23.33	17.78	3.33	Malhotra et al. (1976)
520	14	116	Khutekar Dhangar		511	31.70	27.98	30.14	10.18	Malhotra et al. (1976)
521	14	117	Kurmar Dhangar		95	31.58	30.52	29.47	8.42	Malhotra et al. (1976)
522	14	118	Ladshe Dhangar		121	28.10	25.62	34.71	11.57	Malhotra et al. (1976)
523	14	119	Mendhe Dhangar		170	27.65	34.71	25.88	11.75	Malhotra et al. (1976)
524	14	120	Sangar Dhangar		88	30.68	17.04	42.05	10.22	Malhotra et al. (1976)
525	14	121	Shegar Dhangar		105	14.29	25.71	33.33	26.66	Malhotra et al. (1976)
526	14	122	Telangi Dhangar		90	30.00	22.22	43.33	4.44	Malhotra et al. (1976)
527	14	123	Thellari Dhangar		109	19.27	27.52	39.45	13.76	Malhotra et al. (1976)
528	14	124	Unnikankan Dhangar		64	25.00	26.56	43.75	4.68	Malhotra et al. (1976)
529	14	125	Varhade Dhangar		74	28.39	20.27	35.13	16.21	Malhotra et al. (1976)
530	14	126	Zende Dhangar		1053	26.14	31.37	26.80	15.68	Malhotra et al. (1976)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
531	14	127	Zade Dhangar		78	39.74	23.07	30.77	6.41	Malhotra et al. (1976)
532	14	128	Khatik Dhangar		139	34.53	36.69	21.58	7.19	Malhotra et al. (1976)
533	14	129	Nav-Buddha	Poona	106	29.24	21.71	43.39	5.66	Mukherjee et al. (1977)
534	14	130	Maratha	Poona	105	34.29	28.57	26.66	10.48	Mukherjee et al. (1977)
535	14	131	Desasth Rg-vedi Brahmin	Poona	107	42.99	29.90	19.63	7.48	Mukherjee et al. (1977)
536	14	132	Chitpavan Brahmin	Poona	110	46.36	31.82	17.27	4.55	Mukherjeeet al. (1977)
537	14	133	C.K.P.	Thana and Bombay	129	43.41	17.83	28.68	10.08	Mukherjee et al. (1977)
538	14	134	Parsee	Bombay	139	51.08	20.14	19.43	9.35	Mukherjee et al. (1977)
539	14	135	Bhil	Shahada Taluka, Dhulia Dist.	119	35.29	28.57	29.41	6.73	Mukherjee et al. (1977)
540	14	136	Powra	Shahada Taluka, Dhulia Dist.	42	26.20	23.80	38.10	11.90	Mukherjee et al. (1977)
541	14	137	Katkari	Khandala, Poona Dist. and Khapuli, Colaba Dist.	109	25.69	21.10	41.28	11.93	Mukherjee et al. (1977)
542	15	001	Maldivians	Rawalpindi	211	58.30	17.50	21.80	2.40	Kalra (1947)
543	16	001	Angami Naga	Burma Border	165	46.06	38.79	11.51	3.64	Mitra (1936)
544	16	002	Lushai Naga	Burma Border	141	32.62	44.68	16.31	6.30	Mitra (1936)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
545	16	003	Konyak	Naga Hills	127	45.67	40.16	10.24	3.94	Br. Assoc. Res. Comm. (1939)
546	16	004	Thado Kuki	Naga Hills	83	19.28	30.12	32.53	18.07	Br. Assoc. Res. Comm. (1939)
547	16	005	Angami, Lotha, Rengma, and Sema Naga	Naga Hills	140	40.00	33.57	22.14	4.29	Br. Assoc. Res. Comm. (1939)
548	16	006	Ao Naga	Naga Hills	57	47.37	22.81	22.81	7.02	Br. Assoc. Res. Comm. (1939)
549	16	007	Angami Naga		96	35.40	34.40	25.00	5.20	Sarkar (1940)
550	16	008	Nocte Naga		313	41.21	35.14	20.13	3.51	Bhattacharjee(1957)
551	16	009	Angami Naga	Kohima, Naga Hills	100	45.00	38.00	11.00	6.00	Bhattacharjee(1957)
552	16	010	Thadou Kuki		127	25.20	47.24	18.90	8.66	Chakrabortty (1965)
553	16	011	Zeliang Naga		610	53.61	26.23	17.54	2.62	Chakrabortty (1965)
554	16	012	Angami Naga	Kohima	149	50.34	30.20	14.77	4.70	Seth and Seth(1973)
555	17	001	Pathan	Near Quetta	150	29.33	31.33	33.33	6.00	Malone and Lahiri (1929)
556	17	002	Hazara		100	32.00	25.00	39.00	4.00	Malone and Lahiri (1929)
557	17	003	Baluch	Quetta	74	47.20	24.30	24.30	4.20	Malone and Lahiri (1929)
558	17	004	Muslim	London	101	27.72	23.76	39.60	8.91	Chaudhri et al. (1952)
559	17	005	Urdu		113	35.40	24.78	37.17	2.65	Maranjian (1952)
560	17	006	Hazara		156	39.10	25.64	28.85	6.41	Maranjian (1952)
561	17	007	Pathan		336	29.17	28.87	32.14	9.82	Maranjian (1952)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
562	17	008	Total Lahore		228	32.89	21.49	33.33	12.28	Boyd and Boyd (1954)
563	17	009	Other N.W.F.P.		75	25.33	33.33	36.00	5.33	Boyd and Boyd (1954)
564	17	010	Sindhi		160	38.75	21.25	33.75	6.25	Anand (1961)
565	18	001	Orya Kl andaic		60	45.00	18.33	25.00	11.67	Macfarlane (1941)
566	18	002	Korku		140	20.00	28.57	37.86	13.57	Macfarlane (1941)
567	18	003	Gond	Koraput	23	47.83	17.39	26.09	8.70	Sarkar (1956)
568	18	004	Khond	Koraput	20	30.00	25.00	35.00	10.00	Sarkar (1956)
569	18	005	Juang	Koraput	115	21.74	21.74	47.83	8.69	Sarkar (1956)
570	18	006	Gadaba	Koraput	112	23.21	36.61	33.04	7.14	Sarkar et al. (1960)
571	18	007	Poroja	Koraput	108	36.11	31.48	29.63	2.78	Sarkar et al. (1960)
572	18	008	Khond	Koraput	45	33.33	20.00	35.56	11.11	Sarkar et al. (1960)
573	18	009	Sabar	Koraput	86	22.09	24.42	37.21	16.28	Sarkar et al. (1960)
574	18	010	Bado Gabada	Koraput	225	26.22	28.44	32.89	12.45	Das et al.(1963)
575	18	011	Bareng Paroja	Koraput	225	27.56	24.89	36.00	11.55	Das et al.(1963)
576	18	012	Khond		200	31.50	30.50	31.00	7.00	Hargrave (1963)
577	18	013	Saora		249	26.51	30.92	30.52	12.05	Hargrave (1963)
578	18	014	Pareng Gabada	Koraput	225	24.89	23.56	42.22	9.33	Das et al. (1966)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
579	18	015	Ollaro Gabada	Koraput	325	22.46	24.92	41.23	11.34	Das et al. (1966)
580	18	016	Konda Paroja	Koraput	325	25.23	28.00	35.39	11.38	Das et al. (1966)
581	18	017	Muslim	Rourkela	164	26.21	26.89	35.78	11.12	Seth (1967)
582	18	018	Hindu	Rourkela	215	38.14	24.18	32.55	5.12	Seth (1967)
583	18	019	Christian	Rourkela	108	36.11	25.92	29.63	8.33	Seth (1967)
584	18	020	Brahmin		235	46.30	25.60	26.80	1.30	Ghoshmaulik and Patnaik (1971)
585	18	021	Karan		205	29.30	32.70	36.50	1.40	Ghoshmaulik and Patnaik (1971)
586	18	022	Khandayat		185	35.10	20.00	41.10	3.80	Ghoshmaulik and Patnaik (1971)
587	18	023	Shashama Brahmin		200	30.50	24.50	37.50	7.50	Mahapatra and Misra (1971)
588	18	024	Gabada		250	28 80	31.20	30.00	10.00	Mahapatra (1972)
589	18	025	Halwa		168	35.71	14.28	45.23	4.76	Deka and Ghoshmaulik (1973)
590	18	026	Didayi		108	35.18	19.44	37.03	8.33	Ghoshmaulik (1973)
591	18	027	Paroja		85	29.41	23.42	32.94	14.11	Patnaik (1973)
592	18	028	Pano		200	38.50	27.50	21.50	12.50	Deka (1974)
593	18	029	Teli		200	35.50	24.50	28.00	12.00	Deka (1974)
594	18	030	Badhei		200	42.50	26.00	21.00	10.50	Deka (1974)
595	18	031	Karan		200	44.00	23.00	22.00	11.00	Deka (1974)
596	18	032	Brahmin		200	46.00	25.00	21.50	7.50	Deka (1974)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
597	18	033	Kansari		200	39.00	31.00	25.00	5.00	Deka (1974)
598	18	034	Kaibartu		200	32.50	25.50	30.50	11.50	Deka (1974)
599	18	035	Gadaba		230	24.34	24.34	40.00	11.31	Deka and Patojoshi (1974)
600	18	036	Gadabu		350	25.72	27.71	37.14	9.42	Deka and Patojoshi (1974)
601	18	037	Kutia Khond		200	40.50	27.50	24.50	7.50	Nayak (1974)
602	18	038	Desiya Khond		200	25.00	28.50	37.00	9.50	Nayak (1974)
603	18	039	Dangriyya Khond		200	34.50	24.50	36.50	4.50	Nayak (1974)
604	18	040	Shistha Karami		78	45.94	16.21	28.37	9.45	Patojoshi (1975)
605	18	041	Diyadi	Koraput	108	18.80	37.40	35.30	8.50	Deka (1977)
606	18	042	Bodo Gadaba	Koraput	250	21.20	31.20	36.40	11.20	Deka (1977)
607	18	043	Ollaro Gadaba	Koraput	230	19.40	33.30	38.10	9.30	Deka (1977)
608	18	044	Bhumia	Koraput	141	18.30	19.90	57.40	4.30	Deka (1977)
609	18	045	Dangriya Khond	Koraput	75	28.00	36.00	32.00	4.00	Deka (1977)
610	18	046	Parenga	Koraput	100	19.00	33.00	38.00	10.00	Deka (1977)
611	18	047	Rana	Koraput	116	27.60	20.70	39.90	11.80	Deka (1977)
612	18	048	Mali	Koraput	80	30.00	25.00	35.00	10.00	Deka (1977)
613	18	049	Ghasi	Koraput	90	27.80	31.10	33.30	7.80	Deka (1977)
614	18	050	Paro	Koraput	180	25.30	30.80	34.10	9.90	Deka (1977)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
615	18	051	Mallia	Bhubaneswar	316	53.48	10.76	30.38	5.38	Sahu (1977)
616	19	001	Panjabi Soldiers		262	24.05	15.65	46.18	14.12	Hirschfeld and Hirschfeld (1919)
617	19	002	Jat	Kasauli	277	33.20	24.50	35.50	6.80	Malone and Lahiri (1929)
618	19	003	Khattri	Kasauli	99	33.30	25.30	30.30	11.10	Malone and Lahiri (1929)
619	19	004	Muslim Soldiers		2235	31.63	25.86	32.89	9.62	House and Maha-lanobis (1939)
620	19	005	Hindu Soldiers		615	32.36	22.28	34.63	10.73	House and Maha-lanobis (1939)
621	19	006	Sikh Soldiers		2278	35.34	25.24	30.60	8.82	House and Maha-lanobis (1939)
622	19	007	Muslim Army Donors		265	31.70	26.79	31.70	9.81	Bird and Krishna-swami (1946)
623	19	008	Punjabies	Rawalpindi	2500	34.80	24.50	33.30	7.40	Kalra (1947)
624	19	009	Panjabi		1000	30.64	24.48	34.78	10.10	Khan (1952)
625	19	010	Panjabi		2386	30.72	25.19	35.71	8.38	Maranjian (1952)
626	19	011	Artisan Castes	Kulu	24	25.00	29.17	29.17	16.66	Sastry (1955)
627	19	012	Rajput	Kulu	92	17.39	36.96	34.78	10.87	Sastry (1955)
628	19	013	Brahmin	Kulu	37	43.24	21.62	24.32	10.82	Sastry (1955)
629	19	014	Sikh		600	34.17	25.33	33.17	7.33	Bird et al.(1956)
630	19	015	Sikh		213	32.39	22.54	37.09	7.98	Bird et al.(1956)
631	19	016	Jat	Gohana Tehsil, Rohtak Dist.	93	41.93	22.58	34.41	1.07	Khurana (1956)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
632	19	017	Panjabi Khattri	Delhi	1708	30.03	21.37	40.63	7.96	Anand (1957)
633	19	018	Panjabi Arora	Delhi	1598	28.91	21.46	41.23	8.37	Anand (1957)
634	19	019	Brahmin	Matiana, Simla Hills	71	18.31	22.54	40.85	18.31	Ghosh (1957)
635	19	020	Rajput	Matiana, Simla Hills	196	20.92	30.61	37.25	11.22	Ghosh (1957)
636	19	021	Scheduled Castes	Matiana, Simla Hills	95	32.63	29.47	30.53	7.37	Ghosh (1957)
637	19	022	Lahauli		57	21.05	17.54	42.12	19.29	Delhi University (1958)
638	19	023	Rajput	Kulu and Katrain	268	21.64	34.71	27.61	16.04	Delhi University (1958)
639	19	024	Brahmin	Kulu and Katrain	110	17.27	35.45	32.72	14.54	Delhi University (1958)
640	19	025	Sikh	Amritsar	5240	33.70	23.40	35.50	7.40	Talwar and Sawhney (1958)
641	19	026	Hindu	Amritsar	4760	29.20	20.70	40.90	9.20	Talwar and Sawhney (1958)
642	19	027	Brahmin	Chamba	147	24.49	30.61	35.37	9.52	Chatterjee (1959)
643	19	028	Mahajans	Chamba	112	37.50	21.43	36.61	4.46	Chatterjee (1959)
644	19	029	Arya	Chamba	96	23.96	26.04	34.38	15.63	Chatterjee (1959)
645	19	030	Dogra		24	20.83	37.50	33.33	8.33	Mathew (1959)
646	19	031	Ahir		63	38.10	19.05	31.75	11.11	Mathew (1959)
647	19	032	Sikh (Mazhabi and Ramdasia)		34	23.53	35.29	23.53	17.65	Mathew (1959)
648	19	033	Sikh (Other)		29	55.17	13.79	20.69	10.34	Mathew (1959)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
649	19	034	Ahir		95	26.32	29.47	35.79	8.42	Mathew (1959)
650	19	035	Dogra		181	21.55	34.81	28.73	14.92	Mathew (1959)
651	19	036	Gujjar		66	27.27	24.24	42.42	6.06	Mathew (1959)
652	19	037	Jat		75	40.00	21.33	32.00	6.67	Mathew (1959)
653	19	038	Punjabis		102	29.41	26.47	33.33	10.78	Mathew (1959)
654	19	039	Rajput		43	25.58	32.56	37.21	4.65	Mathew (1959)
655	19	040	Sikh (Mazhabi and Ramdasia)		168	34.52	23.81	35.12	6.55	Mathew (1959)
656	19	041	Sikh (Other)		226	34.96	23.89	33.63	7.52	Mathew (1959)
657	19	042	Panjabi Hindu		203	26.60	21.18	38.92	13.30	Sharma (1959)
658	19	043	Kirnar Kanet Chini Valley		310	32.90	37.42	22.26	7.42	Bhalla (1961)
659	19	044	Saini	Delhi	200	26.00	28.00	32.00	14.00	Singh and Singh (1960)
660	19	045	Jat	Delhi	113	30.97	25.66	37.17	6.20	Delhi University (1962)
661	19	046	Harijan	Rampur Bushahr	41	12.19	14.63	48.78	24.39	Punjab University (1962)
662	19	047	Brahmin	Rampur Bushahr	58	29.31	17.24	34.48	18.96	Punjab University (1962)
663	19	048	Rajput	Rampur Bushahr	126	29.36	13.49	37.30	19.84	Punjab University (1962)
664	19	049	Panjabi Arora	Delhi	342	28.36	20.18	42.11	9.35	Bhalla (1963)
665	19	050	Panjabi Khattri	Delhi	540	30.00	22.04	39.63	8.33	Bhalla (1963)
666	19	051	Panjabi Brahmin	Delhi	402	27.11	25.63	37.81	9.45	Bhalla (1963)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
667	19	052	Chaudhry	Dharam Sala, H.P.	6C	21.67	28.33	35.00	15.00	Khuller (1964)
668	19	053	Rajput		80	23.75	30.00	36.25	10.00	Rao (1964)
669	19	054	Rajput	Manali, Lahul and Spiti	185	17.84	28.65	33.51	20.00	Serah (1965)
670	19	055	Punjabi	Delhi	240	32.50	16.67	43.33	7.50	Ghei (1968)
671	19	056	Rajput	Simla	104	27.88	29.80	33.65	8.65	Kaur (1967)
672	19	057	Sharma Brahmin	Simla	91	25.27	31.87	28.57	14.29	Mavalwala (1967)
673	19	058	Brahmin	Kulu	82	25.60	30.48	36.58	7.31	Shah (1968)
674	19	059	Beri Khatri		998	31.06	23.15	37.67	8.11	Seth (1968)
675	19	060	Punjabi Khatri		281	32.03	22.42	36.65	8.89	Seth (1968)
676	19	061	Khukran Khatri		570	30.35	22.81	38.24	8.60	Seth (1968)
677	19	062	Sareen Khatri		780	31.54	24.36	34.62	9.48	Seth (1968)
678	19	063	Dhakhandian Arora		1248	28.29	23.64	38.30	9.77	Seth (1968)
679	19	064	Uttaradhi Arora		1348	31.23	23.15	37.24	8.38	Seth (1968)
680	19	065	Jat	New Delhi and Punjab	400	34.25	23.25	35.50	7.00	Chattopadhyay (1969)
681	19	066	Rajput	Palampur	113	26.55	17.70	39.82	15.93	Bishnoi (1969)
682	19	067	Lahauli Bodh	Lahul and Spiti Dists.	306	17.00	31.37	39.87	11.77	Chopra and Sidhu (1970)
683	19	068	Arora	Delhi	422	29.62	20.38	40.76	9.24	Shivaraman et al. (1971)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
684	19	069	Brahmin	Delhi	360	28.34	21.66	40.00	10.00	Shivaraman et al. (1971)
685	19	070	Sikh	Delhi	460	27.17	21.52	40.87	10.44	Shivaraman et al. (1971)
686	19	071	Khatri	Delhi	475	29.48	21.47	40.42	8.63	Shivaraman et al. (1971)
687	19	072	Kholi	Delhi	845	28.99	21.30	40.24	9.47	Shivaraman et al. (1971)
688	19	073	Seighal	Delhi	395	26.33	20.76	43.29	9.62	Shivaraman et al. (1971)
689	19	074	Seth	Delhi	210	28.10	22.38	39.52	10.00	Shivaraman et al. (1971)
690	19	075	Kapoor	Delhi	345	29.57	20.58	40.29	9.56	Shivaraman et al. (1971)
691	19	076	Kanet	Kalpa, Kinnaur, H.P.	118	16.10	37.29	30.51	16.10	Negi et al. (1972)
692	19	077	Kanet	Sangla, Kinnaur, H.P.	86	20.93	43.02	25.58	10.46	Negi et al. (1972)
693	19	078	Kanet	Nacchar, Kinnaur, H.P.	101	24.75	37.62	23.76	13.86	Negi et al. (1972)
694	19	079	Koli	Pooh, Kinnaur, H.P.	48	41.67	18.75	37.50	2.08	Negi et al. (1972)
695	19	080	Koli	Nacchar, Kannaur, H.P.	100	29.00	31.00	29.00	11.00	Negi et al. (1972)
696	19	081	Kanet	Pooh, Kinnaur, H.P.	108	27.78	12.96	50.00	9.26	Negi et al. (1975)
697	19	082	Khatri		194	26.29	18.04	45.87	9.80	Bhatia et al. (1976)
698	19	083	Brahmin	Kulu, H.P.	53	15.09	33.96	35.85	15.10	A.S.I. (1977)
699	19	084	Kanet	Manali, H.P.	68	17.94	45.59	19.12	7.35	A.S.I. (1977)
700	19	085	Kanet	Inner Seraj, Kulu, H.P.	43	37.21	20.93	25.58	16.28	A.S.I. (1977)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
701	19	086	Koli	Kulu, H.P.	91	23.08	29.67	35.16	12.09	A.S.I. (1977)
702	19	087	Kanet	Outer Seraj, Kulu, H.P.	41	17.07	31.71	29.27	21.95	A.S.I. (1977)
703	19	088	Punjabi		343	22.74	39.07	25.65	12.53	Kaur et al.(1977)
704	19	089	Rajput	Delhi	100	36.00	20.00	37.00	7.00	Das et al. (1978)
705	19	090	Chamar	Delhi	101	21.78	36.64	33.66	7.92	Das et al. (1978)
706	19	091	Gujjar	Delhi	102	34.31	20.59	36.28	8.82	Das et al. (1978)
707	19	092	Ahir	Delhi	101	29.70	29.70	34.66	5.94	Das et al. (1978)
708	19	093	Jat	Delhi	105	35.24	30.47	27.62	6.67	Das et al. (1978)
709	20	001	Rajput		118	28.80	28.00	33.00	10.20	Malone and Lahiri (1929)
710	20	002	Hindu Soldiers		111	33.33	21.62	35.14	9.91	House and Mahalanobis (1939)
711	20	003	Hindu and Muslim		600	32.50	24.50	35.83	7.17	Goyal and Anand (1955)
712	20	004	Rajput		769	30.95	22.50	37.19	9.36	Negi and Das(1958)
713	20	005	Ahir		22	36.36	22.73	31.82	9.09	Mathew (1959)
714	20	006	Gujjar		73	31.51	26.03	38.36	4.11	Mathew (1959)
715	20	007	Jat		32	34.38	25.00	37.50	3.13	Mathew (1959)
716	20	008	Rajput		128	52.34	16.41	25.00	6.25	Mathew (1959)
717	20	009	Udaipur		3799	34.22	23.14	35.43	7.21	Sharma et al. (1969)
718	20	010	Raiger		101	27.73	16.83	43.56	11.85	Chhabra (1970)
719	21	001	Tamils (Born in Ceylon)	Malaya	2000	39.65	19.55	33.55	7.25	Greene (1929)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
720	21	002	Tamils	Colombo	136	50.74	13.97	30.88	4.41	Hill (1937)
721	21	003	Moor	Colombo	29	34.48	24.14	34.48	6.90	Hill (1937)
722	21	004	Burgher	Colombo	61	57.38	27.87	13.11	1.64	Hill (1937)
723	21	005	Sinhalese		712	47.05	26.26	24.72	1.97	Hill (1937)
724	21	006	Sinhalese Students		340	49.41	22.35	25.88	2.35	Koch and Weera-tunga (1944)
725	21	007	Sinhalese	Colombo	3605	46.42	22.82	26.51	4.24	Seneviratne(1944)
726	21	008	Tamils	Colombo	561	45.99	18.36	29.41	6.24	Seneviratne(1944)
727	21	009	Moor	Colombo	130	42.31	17.69	34.62	5.38	Seneviratne(1944)
728	21	010	Burgher	Colombo	294	46.60	28.57	19.73	5.10	Seneviratne(1944)
729	21	011	Tamil Students		147	44.22	21.77	27.89	6.12	Koch and Weera-tunga (1953)
730	21	012	Tamils	Kalutara, Kurunegala	128	39.10	20.30	30.50	10.10	Kirk et al.(1962)
731	21	013	Sinhalese	Near Colombo	160	40.00	30.00	26.30	3.70	Kirk et al.(1962)
732	21	014	Vedda	Dalukana, Gininda-mana	51	47.10	9.80	41.20	1.90	Kirk et al. (1962)
733	21	015	Wanni Badal	North-Central Province	43	53.50	16.30	23.30	6.90	Kirk et al. (1962)
734	21	016	Wanni Padhu	North-Central Province	42	50.00	26.19	19.05	4.76	Kirk et al. (1962)
735	21	017	Burgher		80	40.00	22.50	35.00	2.50	Wickramasinghe and Ponnuswamy (1963)
736	21	018	Moslem		252	31.75	25.79	32.94	9.52	Wichramasinghe and Ponnuswamy (1963)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
737	21	019	Sinhalese		1068	48.31	16.85	29.31	5.52	Wickramasinghe and Ponnuswamy (1963)
738	21	020	Tamil		660	39.70	21.36	31.67	7.27	Wickramasinghe and Ponnuswamy (1963)
739	21	021	Veddah		254	45.28	7.09	44.88	2.76	Wickramasinghe et al. (1963)
740	21	022	Sinhalese	Anuradhapura	157	48.40	21.00	26.80	3.80	Roberts et al. (1972)
741	22	001	Toda	Nilgiri Hills	200	29.50	19.50	38.00	13.00	Pandit (1934)
742	22	002	Pre-Dravidians		50	48.00	30.00	10.00	12.00	Macfarlane (1936)
743	22	003	Tamil Non-Brahmin		50	42.00	28.00	24.00	6.00	Macfarlane (1936)
744	22	004	Tamil Mixed		1740	43.10	24.00	29.40	3.50	Naidu and Nathan (1938)
745	22	005	Muslim Soldiers	Madras	144	27.08	27.08	36.81	9.03	House and Mahalanobis (1939)
746	22	006	Hindu Soldiers	Madras	1117	42.97	24.08	28.29	4.66	House and Mahalanobis (1939)
747	22	007	Muslim		141	31.21	28.37	38.30	2.13	Seshadrinathan and Timothy(1942)
748	22	008	Christian		95	41.05	23.16	31.58	4.21	Seshadrinathan and Timothy(1942)
749	22	009	Anglo-Indian		47	55.32	19.15	25.53	0.00	Seshadrinathan and Timothy(1942)
750	22	010	Nair	Madras	147	39.46	21.77	34.69	4.08	Reddi (1943a)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
751	22	011	Brahmin	Madras	132	44.70	20.50	31.10	3.80	Reddi (1943a)
752	22	012	Thiya	Madras	113	46.02	31.85	18.58	3.54	Reddi (1943a)
753	22	013	Mohammedan	Madras	95	42.11	25.26	30.53	2.11	Reddi (1943a)
754	22	014	Indian Christian	Madras	27	40.74	22.22	33.33	3.70	Reddi (1943a)
755	22	015	Anglo-Indian	Madras	37	48.65	35.14	13.52	2.70	Reddi (1943a)
756	22	016	Mohammedan	Madras	161	55.90	21.11	20.00	3.10	Reddi (1943b)
757	22	017	Brahmin	Madras	155	45.80	19.40	29.70	5.10	Reddi (1943b)
758	22	018	Indian Christian	Madras	131	37.40	17.60	38.10	6.90	Reddi (1943b)
759	22	019	Adi-Dravida	Madras	70	32.90	17.10	47.10	2.90	Reddi (1943b)
760	22	020	Chetty	Madras	60	21.70	23.30	48.30	6.70	Reddi (1943b)
761	22	021	Anglo-Indian	Madras	59	61.50	25.60	10.30	2.60	Reddi (1943b)
762	22	022	Mudaliar	Madras	56	33.93	23.21	33.93	8.93	Reddi (1943b)
763	22	023	Nair	Madras	56	31.25	25.00	37.50	6.25	Reddi (1943b)
764	22	024	Thiya	Madras	54	57.10	35.70	7.20	0.00	Reddi (1943b)
765	22	025	Asari	Madras	37	35.10	27.00	37.90	0.00	Reddi (1943b)
766	22	026	Baliga	Madras	33	45.50	23.20	23.20	6.10	Reddi (1943b)
767	22	027	Reddy	Madras	29	62.10	10.30	24.10	3.50	Reddi (1943b)
768	22	028	Pillai	Madras	26	38.46	15.38	38.46	7.70	Reddi (1943b)
769	22	029	Naidu	Madras	25	36.00	16.00	48.00	0.00	Reddi (1943b)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
770	22	030	Southern Indians	Singapore	389	31.88	26.73	34.45	6.94	Allen and Scott (1947)
771	22	031	Kota	Nilgiri Hills	86	60.47	0.00	39.53	0.00	Lehmann and Cutbush (1952)
772	22	032	South Indians	Madras	394	42.39	22.33	28.43	6.85	Rao (1952)
773	22	033	Anglo-Indian		153	43.14	23.53	21.57	11.76	Ayer and Mummurthi (1953)
774	22	034	Pillai		182	32.97	19.23	41.76	6.04	Ayer and Mummurthi (1953)
775	22	035	Nair		141	38.30	1.21	23.40	7.09	Ayer and Mummurthi (1953)
776	22	036	Naidu		458	38.43	20.52	34.93	6.11	Ayer and Mummurthi (1953)
777	22	037	Naicker		610	44.43	23.11	27.54	4.92	Ayer and Mummurthi (1953)
778	22	038	Mudaliar		284	34.51	22.89	36.27	6.34	Ayer and Mummurthi (1953)
779	22	039	Chetty		342	47.37	16.99	29.82	5.85	Ayer and Mummurthi (1953)
780	22	040	Brahmin		55	40.00	30.91	27.27	1.82	Ayer and Mummurthi (1953)
781	22	041	Adi-Dravida		515	39.22	18.06	35.34	7.38	Ayer and Mummurthi (1953)
782	22	042	Anglo Indian		56	53.57	30.36	12.50	3.57	Ayer and Mummurthi (1953)
783	22	043	People of Madras		2382	37.70	21.41	33.25	7.64	Sundararajan (1956)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
784	22	044	Andhras	Madras	84	36.90	23.81	33.33	5.95	Mathew (1959)
785	22	045	Tamil Christians		61	29.51	18.03	42.62	9.84	Mathew (1959)
786	22	046	Malayalees		119	43.70	30.25	20.17	5.88	Mathew (1959)
787	22	047	Tamilians		250	45.60	15.60	32.80	6.00	Mathew (1959)
788	22	048	Ayengar Brahmin	Pondicherry	93	37.63	31.13	23.66	7.53	Kherumian and Nioguy (1960)
789	22	049	Ayer Brahmin	Pondicherry	128	43.75	21.09	28.13	7.03	Kherumian and Nioguy (1960)
790	22	050	Macouah Tamil		400	45.00	27.50	24.50	3.00	Nioguy and Olivier (1961)
791	22	051	Tamil Moslem		334	38.92	17.07	37.72	6.29	Nioguy and Olivier (1961)
792	22	052	Kota	Nilgiri Hills	20	50.00	0.00	50.00	0.00	Chaudhuri et al. (1964)
793	22	053	Tamils	Kuala-Lumpur	128	39.80	25.00	28.10	7.00	Kirk et al.(1962)
794	22	054	Irula	Nilgiri Hills	72	40.30	19.40	31.90	8.30	Kirk et al.(1962)
795	22	055	Kurumba	Nilgiri Hills	52	55.80	19.20	23.10	1.79	Kirk et al.(1962)
796	22	056	Toda	Nilgiri Hills	89	19.10	19.10	44.90	16.80	Kirk et al.(1962)
797	22	057	Kota	Nilgiri Hills	552	59.06	0.36	39.49	1.09	Ghosh (1973)
798	22	058	Paliyan	Palni Hills, Madurai	51	50.98	19.61	21.57	7.84	Negi and Maitra (1974)
799	22	059	Pulayan	Palni Hills, Madurai	62	38.71	25.81	32.26	3.23	Negi and Maitra (1974)
800	22	060	Malayali	Yercand and Kolli Hills, Salem	101	25.74	22.77	46.53	4.95	Negi and Maitra (1974)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
801	22	061	Kurumba	Nilgiri Hills	29	34.48	41.38	17.24	6.90	Saha et al.(1976)
802	22	062	Toda	Nilgiri Hills	87	18.39	21.84	50.57	9.20	Saha et al.(1976)
803	22	063	Kota	Nilgiri Hills	543	56.72	1.66	41.07	0.55	Ghosh et al.(1977)
804	23	001	Kaiping	Koithakwa-Charra	100	38.00	24.00	26.00	12.00	Gupta (1958)
805	23	002	Morsam	Dhan-Charra and Gonda-Charra	44	18.18	11.36	52.27	18.18	Gupta (1958)
806	23	003	Rankhal	Rankhal-Para	100	46.00	33.00	15.00	6.00	Gupta (1958)
807	23	004	Tippera	Lemhucherra	150	21.33	41.33	25.33	12.00	Gupta (1958)
808	23	005	Riang	Ranga-Charra	150	22.00	27.33	37.33	13.33	Gupta (1958)
809	23	006	Noatia		142	16.20	28.87	40.84	14.08	Kumar (1960)
810	23	007	Riang	Singhbhum, Bahragora	509	19.84	25.15	42.04	12.97	Kumar and Sastry (1961)
811	24	001	Garhwali		103	22.33	17.47	50.48	9.71	Hirschfeld and Hirschfeld (1919)
812	24	002	Hindu		2357	30.20	24.50	37.20	8.10	Malone and Lahiri (1929)
813	24	003	Hindu Soldiers		838	31.15	26.97	34.49	7.40	House and Maha-lanobis (1939)
814	24	004	Muslim Soldiers		109	33.03	21.10	33.94	11.93	House and Maha-lanobis (1939)
815	24	005	Kayastha		110	36.00	19.90	32.60	11.50	Majumdar and Kishen (1947)
816	24	006	Khatri		126	32.00	24.20	33.30	10.50	Majumdar and Kishen (1947)
817	24	007	Chamar		151	36.30	18.70	39.30	5.70	Majumdar and Kishen (1947)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
818	24	008	Dom		180	33.00	22.94	39.64	4.42	Majumdar and Kishen (1947)
819	24	009	Hill Dom		125	36.00	20.00	33.80	10.20	Majumdar and Kishen (1947)
820	24	010	Tharu		241	27.10	17.00	37.50	18.40	Majumdar and Kishen (1947)
821	24	011	Bhatu		113	27.48	24.77	39.92	7.83	Majumdar and Kishen (1947)
822	24	012	Karwal		155	25.83	22.62	40.64	10.91	Majumdar and Kishen (1947)
823	24	013	Korwa		147	31.70	35.60	20.40	12.30	Majumdar and Kishen (1947)
824	24	014	Shia Muslim		106	35.91	25.58	33.80	4.71	Majumdar and Kishen (1947)
825	24	015	Sunni Muslim		220	32.58	21.39	37.00	9.03	Majumdar and Kishen (1947)
826	24	016	I.T. College Students		202	34.65	21.78	38.62	4.95	Majumdar and Kishen (1947)
827	24	017	Khasa		246	30.67	29.97	27.97	11.39	Majumdar and Kishen (1947)
828	24	018	Khasa Artisans		108	25.44	23.86	40.50	10.20	Majumdar and Kishen (1947)
829	24	019	Kshattriya		416	30.83	26.83	32.73	9.61	Majumdar and Kishen (1947)
830	24	020	Brahmin	Gorakhpur Basti	203	31.30	29.10	31.60	8.00	Majumdar and Kishen (1947)
831	24	021	Brahmin Students	Lucknow	186	27.80	29.40	35.80	7.00	Majumdar and Kishen (1947)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
832	24	022	Kurmi		107	34.30	20.10	34.30	11.30	Majumdar and Kishen (1947)
833	24	023	University Students	Lucknow	582	32.70	22.40	36.70	8.20	Majumdar and Kishen (1947)
834	24	024	Bhoksa		144	30.80	19.20	36.10	13.90	Majumdar and Kishen (1947)
835	24	025	Kolta	Jaunsar Bawar	25	24.00	20.00	32.00	24.00	Delhi University (1951)
836	24	026	Khasa Rajput		67	29.80	29.70	30.00	10.50	Majumdar (1952)
837	24	027	Khasa Brahmin		50	32.00	30.00	26.00	12.00	Majumdar (1952)
838	24	028	Bhotia	Almora Dist.	144	18.06	15.28	50.69	15.97	Tiwari (1952)
839	24	029	Rajput	Jaunsar Bawar	110	25.45	37.27	25.45	11.82	Banerjee and Kumar (1953)
840	24	030	Brahmin	Jaunsar Bawar	38	26.32	31.58	26.32	15.79	Banerjee and Kumar (1953)
841	24	031	Bajgi	Dehradun	26	23.08	30.77	34.61	11.54	Banerjee and Kumar (1953)
842	24	032	Kolta	Dehradun	136	21.32	30.15	39.71	8.82	Banerjee and Kumar (1953)
843	24	033	Rajput	Tehri Garhwal	50	30.00	46.00	10.00	14.00	Kaul (1953)
844	24	034	Kumauni Dom	Almora	74	24.32	27.03	40.54	8.11	Tiwari (1954)
845	24	035	Kumaoni Rajput	Almora	124	29.03	24.19	33.87	12.90	Tiwari (1954)
846	24	036	Kumaoni Brahmin	Almora	108	25.93	27.78	31.48	14.81	Tiwari (1954)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
847	24	037	Jaunpur		278	34.53	21.94	35.61	7.91	Bhatia et al. (1955)
848	24	038	Mainpuri		524	30.34	24.43	34.73	10.50	Bhatia et al. (1955)
849	24	039	Kumaon		111	24.32	27.03	34.23	14.41	Bird and Krishna-swami (1955)
850	24	040	Rajput	Jaunsar Bawar	129	27.91	31.78	30.23	10.08	Jla Devi (1956)
851	24	041	Ahir		43	37.21	27.91	20.93	13.95	Mathew (1959)
852	24	042	Garhwalis		196	20.41	38.27	29.08	12.24	Mathew (1959)
853	24	043	Gujjar		50	34.00	20.00	38.00	8.00	Mathew (1959)
854	24	044	Hindu		77	22.08	23.38	29.87	24.68	Mathew (1959)
855	24	045	Kumaonis		200	25.00	32.00	28.50	14.50	Mathew (1959)
856	24	046	Muslim		47	31.91	19.15	40.43	8.51	Mathew (1959)
857	24	047	Rajput		110	37.27	18.18	35.45	9.09	Mathew O(1959)
858	24	048	Rajput	Kumaon	104	25.00	30.80	34.60	9.60	Delhi University (1960)
859	24	049	Brahmin		150	36.00	28.00	26.00	10.00	Rao (1961)
860	24	050	Pasi		183	24.59	18.58	49.18	7.65	Agrawal (1962)
861	24	051	Panchchi-maha Tharu	Gorakhpur	69	23.19	18.84	49.28	8.70	Srivastava (1965)
862	24	052	Rama Tharu	Kheri and Nainital Dists.	158	15.82	26.58	41.14	16.46	Srivastava (1965)
863	24	053	Danguria Tharu	Bahraich, Gonda	185	17.84	20.54	51.35	10.27	Srivastava (1965)
864	24	054	Rama Tharu	Chandan Chowki	150	22.00	24.00	38.67	15.33	Josh (1966)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
865	24	055	Bhatnagars	Lucknow	200	24.00	20.00	47.50	8.50	Srivastava (1966)
866	24	056	Saxenas	Lucknow	205	28.29	26.83	36.09	8.78	Srivastava (1966)
867	24	057	Srivastavas	Lucknow	200	32.00	21.50	40.50	6.00	Srivastava (1966)
868	24	058	Mathurs	Lucknow	200	31.50	12.50	48.00	8.00	Srivastava (1966)
869	24	059	Rajput	Jaunsar Bawar	100	27.00	22.00	37.00	14.00	Banerjee and Banerjee (1967)
870	24	060	Kolta	Jaunsar Bawar	29	44.83	20.69	20.69	13.79	Banerjee and Banerjee (1967)
871	24	061	Artisans	Jaunsar Bawar	25	16.00	20.00	56.00	8.00	Banerjee and Banerjee (1967)
872	24	062	Rama Tharu Thaku	Chandan Choki, Kheri Dist.	203	21.67	23.15	41.38	13.79	Basu and Chattopadhyay (1967)
873	24	063	Rana Tharu	Nainital, Terai	255	24.31	21.96	42.35	11.37	Kumar (1968)
874	24	064	Rajput	Garhwal Dist.	175	20.57	36.57	28.00	14.86	Tiwari and Bhasin (1968)
875	24	065	Brahmin	Garhwal Dist.	125	29.60	32.80	25.60	12.00	Tiwari and Bhasin (1968)
876	24	066	Shaha		100	27.00	31.00	36.00	6.00	Bali (1969)
877	24	067	Gujar	Ayah Nagar, Delhi	68	33.82	30.88	30.88	4.42	Seth et al. (1969)
878	24	068	Gujar	Meerut	100	33.00	28.00	27.00	12.00	Singh et al.(1969)
879	24	069	Magara	Dehradun	66	30.30	31.82	19.70	18.18	Gulati (1971)
880	24	070	Gurung	Dehradun	46	41.30	19.57	30.43	8.70	Gulati (1971)
881	24	071	Aggarwal	Delhi	244	33.20	22.13	37.29	7.38	Shivaraman et al. (1971)
882	24	072	Gupta	Delhi	310	32.90	21.94	37.10	8.06	Shivaraman et al. (1971)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
383	24	073	Rajput	Delhi	360	28.06	23.05	40.00	8.89	Shivaraman et al. (1971)
384	24	074	Thakur	Delhi	285	28.07	23.16	38.60	10.17	Shivaraman et al. (1971)
385	24	075	Jain	Delhi	165	32.73	23.64	34.54	9.09	Shivaraman et al. (1971)
386	24	076	Jaswal	Delhi	430	30.23	20.47	38.61	10.69	Shivaraman et al. (1971)
387	24	077	Gujjar	Delhi	300	30.67	21.00	36.67	11.66	Shivaraman et al. (1971)
388	24	078	Jat	Delhi	322	29.81	25.78	35.71	8.70	Shivaraman et al. (1971)
389	24	079	Ahir	Delhi	270	28.52	24.07	36.67	10.74	Shivaraman et al. (1971)
390	24	080	Brahmin	Delhi	140	35.00	20.72	32.14	12.14	Shivaraman et al. (1971)
391	24	081	Raj Pasi	Barabanki, Sitapur and Kheri Dists.	222	25.31	34.44	27.80	12.45	Bhatnagar (1973)
392	24	082	Gujar Pasi	Kheri, Sitapur, Barabanki, Lucknow, Rae Bareli and Pratapgarh Dists.	120	19.17	34.17	32.50	14.16	Bhatnagar (1973)
393	24	083	Baurasi Pasi	Kheri, Sitapur, Barabanki, Lucknow, Rae Bareli and Pratapgarh Dists.	146	21.23	26.71	32.19	19.87	Bhatnagar (1973)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
394	24	084	Kaithwas Pasi	Kheri, Sitapur, Barabanki, Lucknow, Rae Bareli and Pratapgarh Dists.	95	28.42	31.58	29.47	10.53	Bhatnagar (1973)
395	24	085	Rajput	Lucknow	300	30.33	22.33	36.67	10.67	Shukla and Tyagi (1973)
396	24	086	Bhoksa	Nainital	195	25.13	27.69	33.85	13.33	Lucknow University (1974)
397	24	087	Khas Brahmin	Jaunsar Bawar	92	20.65	31.52	31.52	16.30	Negi et al. (1975)
398	24	088	Khas Rajput	Jaunsar Bawar	98	26.53	40.82	27.55	5.10	Negi et al. (1975)
399	24	089	Bhoksa	Dehradun	100	22.00	34.00	33.00	11.00	Tyagi et al. (1977)

REFERENCES

ANTHROPOLOGICAL SURVEY OF INDIA (1977) Anthropological Survey of India: N.W. Region (unpublished). [Cited in Negi (1977)].

AGAR, W.T. (1946) Nepalese blood groups. Nature 157. 270.

AGRAWAL, H.N. (1962) Blood groups of the Pasis with special reference to their genetic relationship with other castes of U.P. Eastern Anthrop. 15. 161-164.

AGRAWAL, H.N. (1963) A genetic survey among the Bhantu of Andaman. Bull. Anthrop. Survey of India 12. 143-147.

AGRAWAL, H.N. (1964) A study of ABO blood groups, P.T.C. taste sensitivity, middle phalangeal hair and sickle cell trait among three Nicobarese of Nicobar archipelago. Bull. Anthrop. Survey of India 13. 63-68.

AGRAWAL, H.N. (1965). ABO blood groups in Andaman Islands. Bull. Anthrop. Survey of India 14. 59-60.

AGRAWAL, H.N. (1968) ABO blood groups, P.T.C. taste sensitivity sickle cell trait, middle phalangeal hairs and colour blindness in Coastal Nicobarese of Great Nicobar. Acta genet. (Basel) 18. 147-154.

AHAMADI, A.R. KANEEZ (1974) A_1A_2BO blood groups in Sunni Muslims in Poona. M.Sc. Dissertation, University of Poona (unpublished).

AIYAPPAN, A. (1936) Blood groups of the PreDravidians of the Wynad Plateau, India. Man 36. 255

AIYAPPAN, A. (1939) Blood groups of the Nayadis of Malabar, S. India. Man 39. 199

ALI, MD. HASMAT (1974) ABO blood groups among the Assamese Muslims and Hindus of Kamrup district, Assam. In Contemporary Anthropological Research in North East India (Ed. B.M. Das), Dept. of Anthropology, Dibrugarh University, Dibrugarh, Assam, p.78.

ALLEN, G.V. and M.R.G. SCOTT (1947) Cited in Bhalla (1966).

ANAND, S. (1957) A genetic survey of the ABO blood groups among the Punjabis. The Anthropologist, 4. 28-33.

ANAND, S. (1961) Frequency of ABO blood groups and secretor factor in Sindhis. Proc. 48th Ind. Sc. Cong. Assocn., Abstract pt. 3, pp. 450.

AYER, A.A., and C. MUMMURTHI (1953) Distribution of O, A, B and AB blood groups in the major South Indian Communities. J. Anat. Soc. India 2. 6-12.

BAIS, W.J. and A.W. VERHOEF (1927) Cited in Mourant et al. (1976).

BALAKRISHNAN, V. (1978) A preliminary study of genetic distances among some populations of the Indian sub-continent. J.Hum. Evol. 7. 67-75.

BALI,,R.S. (1961) Delhi University expedition report, 1961.

BANERJEE, M.K. and D.K. BANERJEE (1967) ABO blood group among the Jaunsaris. Man in India 47. 133-138.

BANERJEE, S. and N. KUMAR (1953) Blood group distribution of the people of Jaunsar-Bawar. Bull. Dept. Anthrop. 2.55-60.

BANSAL, I.J.S. (1967) A study of ABO blood groups of the people of Ladakh. Amer. J. Phys. Anthrop. 27. 211-212.

BARTHOLOMEW, J. (1959) The Times Atlas of the World (Mid Century Edition) Vol.II. South-West Asia and Russia. The Times Publishing Co., London.

BASU, A., J. SARKAR, B. ROY, P. DASGUPTA, A. SANYAL and S.S. SARKAR (1966) Anthropo-genetic investigations in the Dalma and Ajodhya Hills and neighbourhood. Sci. and Cult. 32. 273-275.

BASU, R.N. (1938) Blood groups among the Khasis. Nature 142. 797.

BASU, S.K. and P.K. CHATTOPADHYAY (1967) ABO blood groups and and ABH secretion in saliva of the Rana Tharu Thakurs. Eastern Anthrop. 20. 269-276.

BAXI, A.J., H.M. BHATIA and P.K. SUKUMARAN (1963). Personal communication.

BHALLA, V. (1961) A genetic analysis of ABO blood groups among the Kinnar-Kanets of Chinni. Proc. 48th Ind. Sc. Cong. Assocn. Abstracts pt. 3, p.442.

BHALLA, V. (1963) Delhi University expedition report, 1963.

BHALLA, V. (1966) Blood-group distribution pertaining to ABO, MNSs and Rh-Hr systems in the Indian sub-continent (An ethno-geographical variation). Anthropologie 4. 67-86.

BHALLA, V. (1971) Dynamics of gene-frequency variations in Tibet. Proc First Internat. Symp. Hum. Genet., Andhra University, Waltair. (Ed. M.R Chakravartti) pp.147-156.

BHALLA, V and S.S. KAUL (1966) The ABO blood groups and ABH secretions in the Tibetans. Amer. J. Phys. Anthrop. 25. 315-318.

BHANU, B.V. (1973) Population distances - Biological, Cultural and Geographical -- A study on the Ezhavas, Pulayas and Paravas of Kerala. Ph. D. Thesis, University of Poona, Poona (Unpublished).

BHASIN, M.K. (1970) The blood groups of the Newars of Nepal. Hum. Biol. 42. 369-376.

BHATIA, H.M., J. THIN, H. DEBRAY and J. CABANES (1955) Etude anthropologique et genetique de la population du nord de 'L' Inde. Bull. de la Societe 'd' Anthrop. 16. 199-203.

BHATIA, H.M., S.R. SHANBHAG, A.J. BAXI, J.P. BAPAT and R.S. SHARMA (1976) Genetic studies among the endogamous groups of Lohanas of North and West India. Hum. Hered. 26. 298-305.

BHATIA, H.M., S.R. SHANBAG, A.J. BAXI, J. BAPAT, M.S. SATHE, R.S. SHARMA, H. KABEER, Z.S. BHARUCHA and L. SURLACAR (1976) Genetic studies among endogamous groups of Saraswats in Western India. Hum. Hered. 26. 458-467.

BHATNAGAR, B.R. (1973) ABO blood groups among the Pasi - A scheduled caste of Uttar Pradesh. J. Ind. Anthrop. Soc. 8. 173-177.

BHATTACHARJEE, P.N. (1954) Blood group investigations in the Abor tribe. Bull. Dept. Anthrop. (Govt. of India) 3.51-54.

BHATTACHARJEE, P.N. (1956) A genetic survey in the Rarhi Brahmin and the Muslim of West Bengal. A_1A_2BO, M-N, Rh blood groups, ABH secretion, . cell, P.T.C. taste, Middle-Phalangeal hair and Colour blindness - Bull.Dept. Anthrop. (Govt. of India). 5: 18-28.

BHATTACHARJEE, P.N. (1957) A study on A-B-O blood groups, and the A-B-H secretion in the Nocte of North-East Frontier Agency. Bull. Dept. Anthrop. (Govt. of India) 6. 77-80.

BHATTACHARJEE, P.N. (1957) ABO blood groups of the Angami Naga Eastern Anthrop. 11. 42-46.

BHATTACHARJEE, P N (1961) ABO blood groups in the Raj Gonds. Curr. Sci 30. 181-182.

BHATTACHARJEE, P N. (1966) Distribution of the blood groups (A_1A_2BO, MNSs, Rh) and secretor factor among the Muslims and Pandits of Kashmir. Z Morph. Anthrop. 58. 86-94.

BHATTACHARJEE, P N. (1968) Further study of Tibetan blood groups. J. Ind. Anthrop. Soc. 3. 57-66.

BHATTACHARJEE, P.N. (1968) The blood groups (A_1A_2BO, MNS and Rh) of the Ladakis. Acta genet. (Basel) 18. 78-83.

BHATTACHARJEE, P.N. (1969) A genetical study of the Santals of Santal Parganas. The Anthropologist, Special Volume. pp. 93-103.

BHATTACHARJEE, P.N. (1975) Sero-genetical study of the Khasi and their genetic relationship. Eastern Anthrop. 28.171-177.

BHATTACHARJEE, P.N. (1977) Himalayan population: blood groups, haemoglobins, serum proteins and enzymes. Paper presented at Seminar on Human Variation in India, A S I, Calcutta.

BHATTACHARJEE, P.N. and N. KUMAR (1969) A blood group genetic survey in the Dudh Kharias of the Ranchi District (Bihar, India). Hum. Hered. 19. 385-397.

BHATTACHARJEE, P.N., and A. MOITRA (1974) Personal communication.

BHATTACHARJEE, P.N., S. GHOSH and S. BHATTACHARYA (1977) The Tamang: A case of hybridization. Hum. Hered. 27. 1-8.

R.5

BHATTACHARYYA, A. (1946) On a measure of divergence between two multinomial populations. Sankhya 7. 401-406.

BHATTACHARYA, D.K. (1972) A_1A_2 blood groups and colour blindness among the Koyas of Kavartty Islands (Laccadive, Amindive and Minicoy Islands, India). Eastern Anthrop. 25. 39-50.

BHENDE, Y.N. (1959) ABO, MN and Rh blood group frequencies in two endogamous units of Gujrat, Ind. J. Path. 1.213-217.

BIRD, G.W.G. and P. KRISHNASWAMI (1946) Cited in Bhalla (1966).

BIRD, G.W.G. and P. KRISHNASWAMI (1955) The ABO blood groups of Kumaonis, Curr. Sci. 24. 162-163.

BIRD, G.W.G., E.W. IKIN, A.E. MOURANT and H. LEHMANN(1956) The blood groups and haemoglobins of the Sikhs. Heredity 10. 425-429.

BIRD, G W G , E W IKIN, A.E. MOURANT and H. LEHMANN (1962) The blood groups and the haemoglobin of the Malayalis. In Indian Anthropology, (Eds. T N MADAN and GOPALA SARANA) Asia Publishing House, Bombay. pp. 221-226.

BISHNOI, S (1969) Delhi University expedition report, 1969.

BISWAS, K.C. (1955) Blood groups from Cooch-Behar. Sci. and Cult. 21. 265.

BOSE, U. (1952a) Blood groups of the Bhils. Bull. Dept. Anthrop. (Govt. of India) 1. 14-18.

BOSE, U. (1952b) Blood groups of the tribes of Travancore. Bull. Dept. Anthrop. (Govt. of India) 1. 19-24.

BOWLES, G.T. (1977) People of Asia, Widenfeld and Nicolson, London.

BOYD, W.C. and L.G. BOYD (1954) Cited in Bhalla (1966)

BRITISH RESEARCH ASSOCIATION COMMITTEE On Blood Groups Among the Primitive Peoples (1939). Blood groups among the primitive peoples. Nature 144. 714.

BÜCHI, E.C (1952) Blood groups of Tibetans, Bull. Dept. Anthrop. (Govt of India) 1. 71-78.

BÜCHI, E.C (1953a) Frequency of ABO blood groups and secretor factor in Bengal. Bull. Dept. Anthrop. (Govt. of India) 2. 49-54.

BÜCHI, E.C. (1953b) ABO, MN, Rh blood groups and secretor factor in Kanikkar: A genetical survey in South Travancore and a contribution to the race problem in India. Bull. Dept. Anthrop. (Govt. of India) 2. 83-98.

BÜCHI, E.C. (1955a) Blood, secretion and taste among the Pallar - a south Indian community. The Anthropologist 1. 1-8.

BÜCHI, E.C. (1955b) A genetic survey among the Malapantaram - a hill tribe of Travancore. The Anthropologist 2.

BÜCHI, E.C. (1954) Blut, Ausscheiderstatus und Geschmack bei den Ulladan, einem Dschugelvolk in Sudindien. Bull. schweiz Ges. Anthrop. 34.5-7.

BÜCHI, E.C. (1958) Genfrequenzen von MalaVedan (Sudindien). (Blut, Ausscheider-status und Geschmack). Bull. scheweiz. Ges. Anthrop. 35.6-9.

BÜCHI, E.C. (1959) Cited in Bhalla (1966)

BÜCHI, E.C. (1960) Cited in Bhalla (1966)

BÜCHI, E.C (1961) Cited in Bhalla (1966)

CHAKRABORTY, R., S.R. DAS, B.N. MUKHERJEE, S.K. DAS and M. ROY (1975) Personal communication.

CHAKRABORTTY, M. (1965) A note on the ABO blood groups of the Thadou Kuki of Nagaland Sci. and Cult. 31.264.

CHAKRAVORTTY, M. (1965) ABO blood groups of the Zeliang Naga. Man in India 45.311-315.

CHATTERJEE, C. (1959) Delhi University expedition report, 1959.

CHATTERJEE, J.B. (1963) Cited in Bhalla (1966)

CHATTERJEE, S. and D.P. MUKHERJEE (1979) Distribution of blood groups in the Bengali speaking populations - A critical review. J. Ind. Anthrop. Soc. 14.65-88.

CHATTERJI, B.K. and A.K. MITRA (1941-'42) Blood group distributions of Bengalis and their comparison with other Indian races and castes. Indian Culture 8.197-217.

CHATTOPADHYAY, P.K. (1969) A genetic study of the Jats of New Delhi and Punjab. Ph.D. Thesis, Delhi University, Delhi. (unpublished)

CHAUDHURI, A. (1931) Blood groups and heredity. Ind. Med. Gazette 66.193-195.

CHAUDHURI, A. (1936) Cited in Bhalla (1966)

CHAUDHRI., I.M., E.W. IKIN, A.E. MOURANT and J.A.E. WALBY (1952) The blood groups of the people of North-West Pakistan. Man 52 . 168-169.

CHAUDHURI, S., M.R. CHAKRAVARTTI, B. MUKHERJEE, S.N. SEN, J. GHOSH and A. MAITRA (1964) Study of haematological factors, blood groups, anthropometric measures and genetics of some of the tribal and caste groups of :

1. South India - Kerala, Nilgiris and Andhra Pradesh
2. North Eastern India (Indo-Bhutan Border) - Totopara.

Proc. 9th Congr. Int. Soc. Blood Transf., Mexico, pp.196-205.

CHAUDHURI, S., J. GHOSH, B. MUKHERJEE, and A.K. ROYCHOUDHURY (1967) Study of blood groups and haemoglobin variants among the Santal tribe in Midnapore district of West Bengal, India. Amer. J. Phys. Anthrop. 26 . 307-312.

CHAUDHURI, S., B. MUKHERJEE, J. GHOSH and A.K. ROYCHOUDHURY (1969) Study of blood groups, ABH secretors and haemoglobin variants in three upper castes of West Bengal, India Amer. J. Phys. Anthrop. 30 . 129-132.

CHHABRA, N. (1970) Delhi University expedition report, 1970.

CHOPRA, S.R.K. and L.S. SIDHU (1970) Distribution of ABO blood groups in Lahaulis. Eastern Anthrop. 23 . 11-16.

CORREIA, A.C.G. da S. (1934) Les groupes-sanguines des Maharattas de l' Inde Portugaise. Congress Internat. des Sciences Anthropologiques et Ethnologiques. Compte-rendu de la premiere session, Londres. pp.86-87. (Cited in Aiyappan, 1936).

Crooke, W. (1896) Tribes and castes of North-Western provinces and Oudh. Calcutta: Govt. Printing Press.

DAS, B.M. (1958) Blood groups of the Rabhas. Man in India 38 . 213-215.

DAS, B.M. (1969) ABO blood groups in the tribal populations of North-East India with special reference to the Khasi. The Anthropologist. Special volume. pp. 85-92.

DAS, B.M., K.K. AGARWAL, P GUPTA, A. BANERJEE, A. BOSE and B. MUKHERJEE (1953) Blood groups from Calcutta. Sci. and Cult. 19 . 164.

DAS B.M., P. DAS and R. DAS (1973) Genetic distances in respect of ABO blood groups among four castes of Assam, India. Humangenetik 20 . 179-181.

DAS, F.A. (1974) A comparison of the Assamese Muslims with the Assamese Hindu and the Muslims of some other states of India in respect of ABO blood groups. In Contemporary Anthropological Research in North East India (Ed. B.M. Das), Dept. of Anthropology, Dibrugarh University, Dibrugarh, Assam, pp.79-81.

DAS, S.K., B.N. MUKHERJEE, K.C. MALHOTRA and P.P. MAJUMDER (1978) Serological and biochemical investigations among five endogamous groups of Delhi, India. Ann. Hum. Biol. 5 . 25-31.

DAS, S.R., P.N. BHATTACHARJEE, D.B. SASTRY and D.P. MUKHERJEE (1963) Blood groups (ABO, MN, Rh), ABH secretion, sickle-cell trait and colour blindness in the Bado Gadaba and the Bareng Paroja of Koraput district in Orissa. Bull.Anthrop. Surv. India 11 . 145-151.

DAS, S.R., and P.N. BHATTACHARJEE (1963) Blood groups (A_1A_2BO) ABH secretion, P.T.C. taste and colour blindness in the Rajbanshi of Midnapur district, West Bengal. Bull.Anthrop. Survey of India 12 . 1-6.

DAS, S.R., and L. GHOSH (1954) A genetic survey among the Paniyan - a South Indian aboriginal tribe (ABO, MN blood groups, secretor factor and taste ability). Bull. Dept. Anthrop. (Govt. of India) 3 . 65-72.

DAS, S.R., N. KUMAR, P.N. BHATTACHARJEE and D.B. SASTRY (1961) Blood groups (ABO, MN and Rh), ABH secretion, sickle-cell, PTC taste and colour blindness in the Mahar of Nagpur. J. Roy. Anthrop. Inst. 91 . 345-355.

DAS, S.R., B.N. MUKHERJEE, S.K. DAS, M. ROY and S.S. CHHATUI (1974) Blood groups, serum proteins, haemoglobin and some serum and red cell enzymes among the Kaoras of 24 Parganas in West Bengal (India) Hum. Hered. 24 . 24-31.

DAS, S.R., D.P. MUKHERJEE and P.N. BHATTACHARJEE (1967) Survey of the blood groups and PTC taste among the Rajbanshi caste of West Bengal (ABO, MNS, Rh, Duffy and Diego). Acta genet. (Basel) 17 . 433-445.

DAS, S.R. and D.B. SASTRY (1960) Simplified maximum likelihood estimation of the A-B-O gene frequencies: results for a few Indian peoples surveyed. Bull. Anthrop. Surv. India 9 . 1-8.

DAS, S.R , D.B. SASTRY and D.P. MUKHERJEE (1966) Blood groups (A_1A_2BO, MN, Rh) and ABH secretion in the Pareng Gadaba, the Ollaro Gadaba and the Konda Paroja of Koraput district in Orissa. Acta genet. (Basel) 16 . 169-183.

DASGUPTA, P. and J.B.CHATTERJEE (1955) Cited in Bhalla (1966).

DASH-SHARMA, P. (1972) Personal communication

DASH SHARMA, P. (1973) A study on the ABO blood groups, PTC tasting ability, anthropometric and dermatoglyphic characteristics among the Oraons of Banari. Ranchi Univ. Anthrop. Study (unpublished).

DASH-SHARMA (1974) Personal communication.

DEKA, U. (1974) Personal communication.

DEKA, U. (1977) Genetic variation among the population of Koraput. Paper presented at the Seminar on Human Variation in India, A.S.I., Calcutta.

DEKA, U. and S.K. GHOSHMAULIK (1973) Personal communication.

DEKA, U. and P.K. PATOJOSHI (1974) Personal communication

DELHI UNIVERSITY (1951) Expedition report

DELHI UNIVERSITY (1958) Expedition report

DELHI UNIVERSITY (1960) Expedition report

DELHI UNIVERSITY (1962) Expedition report

DRONAMRAJU, K.R., E.A. MURPHY and J. SCHULZE (1967) ABO blood group frequencies in Andhra Pradesh (1955-1960). Acta genet. Stat. med. 17 , 446-453.

ELWIN,,V. (Ed.) (1969) The Nagas in the Nineteenth Century. Oxford Univ. Press.

Enthoven, R.E. (1920) Tribes and castes of Bombay. Bombay. Govt. Printing Press.

FIGUERIEDO, P. de (1935) Cited in Bhalla (1966)

FISHER, R.A. and R. TAYLOR (1940) Cited in Race and Sanger (1970)

FRANCIS, W. (1901) Madras Census Report

GAIT, E.A. (1892) Census of Assam, 1891, Vol.1. Report Pt.II.

GATES, R.R (1936) Tibetan blood groups. Man 36 . 147-148.

GHEI, S.K. (1968) Delhi University expedition report, 1968

GHOSH, A.K. (1957) Cited in Bhalla (1966)

GHOSH, A.K. (1964) ABO blood groups from Singhbhum, Bihar. Sci. and Cult. 30 . 49-50.

GHOSH, A.K. (1973) ABO blood groups and PTC taste sensitivity among the Kota of Nilgiri Hills. Hum. Hered. 23.78-82.

GHOSH, A.K., R.L. KIRK, S.R. JOSHI and H.M. BHATIA (1977) A population genetic study of the Kota in the Nilgiri Hills, South India. Hum. Hered. 27.225-241.

R.11

GHOSHMAULIK, S.K. (1973) Personal communication

GHOSHMAULIK, S.K. and B. PATNAIK (1971) ABO blood groups in three castes of Orissa. Proc. India. Sc. Cong. Assocn. Abstracts, pt. 3.

GLASGOW, B.G., M.J. GOODWIN, F. JACKSON, A.C. KOPEĆ, H. LEHMANN, A.E. MOURANT, D. TILLS, R.W.D. TURNER and M.P. WARD (1968) The blood groups, serum groups and haemoglobins of the inhabitants of Lunana and Thimbu, Bhutan, Vox Sang.14.31-42.

GOLLAREDDY, G. (1973) An anthropogenetic study of Bagathas. Ph.D. thesis, Andhra University, Waltair (unpublished).

GOYAL, R.K. and B.R. ANAND (1955) Cited in Bhalla (1966)

GREENE, R. (1929) Cited in Bhalla (1966)

GREVAL, S.D.S. and S.N. CHANDRA (1940) Blood groups of communities in Calcutta Ind. J. Med. Res. 27.1109-1116

GULATI, R.K and S. SRINIVASAN (1973) An analysis of ABO blood groups of the Bhil of West Khandesh (Maharastra). Eastern Anthrop. 26.79-85.

GULATI, V. (1971) Delhi University expedition report, 1971.

GUPTA, B.P. (1968) ABO blood group distribution in the population of Bihar. Patna J. Med., January 1968. (Cited in Sharan, 1970).

GUPTA, S.P .(1958) ABO blood groups in Tripura (North East India) J. Roy. Anthrop. Inst. 88.109-111.

GUPTA, S.P. (1962) Cited in Bhalla (1966).

GUPTA, S.P. and P. DASH SHARMA (1973) A genetic survey of the Car-Nicobarese of Nicobar Islands. Man in India 53.315-320.

HANURAV, T.V. (1964) Estimation of O-A-B blood group frequencies - A sample survey. A.I.S.I. dissertation, Indian Statistical Institute, Calcutta. (Unpublished).

HARGRAVE, D.C. (1963) Cited in Mourant et al. (1976).

HEINRICH, S. (1966) Unpublished observations (Cited in Mourant et al., 1976).

R.12

HILL, W.C.O. (1937) Cited in Bhalla (1966)

HIRSCHFELD, L. and H. HIRSCHFELD (1919) Serological differences between the blood of different races: The result of researches on the Macedonian front. Lancet ii.675-679.

HORROBIN, D.F., J.S. BLACKBURNE, J.P. GARLICK, E.W. IKIN, A.C. KOPEĆ and A.E. MOURANT (1963) Unpublished observations (Cited in Mourant et al., 1976)

HOUSE, R.J. and P.C MAHALANOBIS (1939) Cited in Bhalla (1966).

IYER, L.A.K. (1946) Cited in Bhalla (1966).

JLA DEVI (1956) Delhi University expedition report, 1956.

JOSH, A.M. (1966) Delhi University expedition report, 1966.

KALRA, S.L. (1947) Blood groups of Punjabis and Maldividians. Curr. Sci. 16.92.

KARUNAKARAN, K. (1939) Cited In Bhalla (1966).

KARVE, I. (1948) Anthropometric measurements of Marathas. Deccan College Monograph No.2, Poona.

KARVE, I. and V.M. DANDEKAR (1951) Anthropometric Measurements of Maharashtra. Deccan College, Poona.

KAUL, S.K. (1953) A short study of blood groups among Rajputs of sub-Himalayan hills. Man in India 33.67-72.

KAUL, S.L., M.N. BHAN and B.R. ANAND (1962) Distribution of A,B,O and AB blood groups in Kashmir Valley. Ind. Practitioner 15.1009-1010.

KAUR, T. (1967) Delhi University expedition report, 1967.

KAUR, H., P.K SEHAJPAL and P.K. SHRIVASTAVA (1977) Distribution of some genetic traits in Punjab. Paper presented at the Seminar on Human Variation in India, A.S.I., Calcutta.

KHAN, A.M. (1952) Blood group frequencies in the Punjab, The Medicus (Karachi), 5.29-30.

KHERUMIAN, R. and P. NIOGUY (1960) Note sur les groupes sanguins ABO des Brahmanes de Pondichery. Bull. Soc. Anthrop. Paris, S.11, 1:241-244.

KHULLER, P. (1964) Delhi University expedition report, 1964.

KHURANA, B.K. (1956) ABO blood group investigation among the Jats of Rohtak (Punjab). Man in India 36:224-227.

KIRK, R.L., L.Y.C. LAI, G.H. VOS and L.P. VIDYARTHI (1962) A genetical study of the Oroans of Chota Nagpur Plateau (Bihar, India) Amer. J. Phys. Anthrop. 20 : 375-385.

KIRK, R.L., L.Y.C. LAI, G.H. VOS, R.L. WICKREMASINGHE and D.J.B. PEREVA (1962) The blood and serum groups of selected populations in South India and Ceylon. Amer. J. Phys. Anth. 20:485-497.

KOCH, A.C.E. and C.E.S. WEERATUNGA (1953) Cited in Bhalla (1966).

KOPEĆ, ADA C. (1970) Distribution of the Blood Groups in the United Kingdom. Oxford Univ. Press, London.

KULKARNI, V.S. (1973) The ABO blood groups of Madia Gonds. Project Report, University of Poona, Poona. (Unpublished)

KUMAR, N. (1954) Blood group and secretor frequency among the Galong. Bull. Dept. Anthrop. (Govt. of India) 3:55-64.

KUMAR, N. (1957) A genetic survey among the Tentulia Bagdi and the Duley of Hooghly District in West Bengal. Bull. Dept. Anthrop. (Govt. of India) 6:81-88.

KUMAR, N. (1960) ABO blood groups and secretor factor distribution among the Noatia : A Mongoloid tribe of Tripura State. The Anthropologist 5:42-46.

KUMAR, N. (1965) ABO blood groups and sickle-cell trait investigations in Madhya Pradesh; Ratlam and the adjacent districts. Bull. Anthrop. Survey of India 14:40-44.

KUMAR, N. (1966) ABO blood group and sickle-cell trait distributions in Malwa, Western Madhya Pradesh. J. Ind. Anthrop. Soc. 1:129-139.

R.14

KUMAR, N. (1968) A genetic survey among the Rana Tharu of Nainital Dist. in Uttar Pradesh. J. Ind. Anthrop. Soc. 3:39-55.

KUMAR, N. and A.K. GHOSH (1967) ABO blood groups and sickle-cell trait investigations in Madhya Pradesh: Ujjain and Dewas districts. Acta Genet. (Basel), 17:55-61.

KUMAR, N. and D.P. MUKHERJEE (1969): A genetic survey among the Desi Bhumij of Chota Nagpur in Bihar. The Anthropologist Special volume, pp.75-84.

KUMAR, N. and D.P. MUKHERJEE (1975) Genetic distances among the Ho tribe and other groups of Central Indians. Amer. J. Phys. Anthrop. 42:489-494.

KUMAR, N., and D.B. SASTRY (1961) A genetic survey among the Riang: A Mongoloid tribe of Tripura, Z. Morph. Anthrop. 51:346-355.

LEHMANN,M., and M. CUTBUSH (1952) Subdivision of some of Southern Indian Communities according to the incidence of sickle cell trait and blood groups. Trans. Roy. Soc. Trop. Med. Hyg. 46:382-383.

LI, C.C. (1955) Population Genetics, Chicago Univ. Press.

LUCKNOW UNIVERSITY (1974) Expedition Report (Cited in Tyagi et al., 1977).

MACFARLANE, E.W.E. (1935) Cited in Bhalla (1966)

MACFARLANE, E.W.E. (1936) Preliminary note on the blood groups of some Cochin castes. Curr. Sci. 4:653.

MACFARLANE, E.W.E. (1937) Eastern Himalayan Blood Groups Man 37:159.

MACFARLANE, E.W.E. (1938) Blood group distribution in India with special reference to Bengal. J. Genet. 36:225-237.

MACFARLANE, E.W.E. (1940) Blood grouping in the Deccan and Eastern Ghats. J. Roy. Asiatic Soc. Bengal 6:39-49.

MACFARLANE, E.W.E. (1941) Tibetan and Bhotia blood groups distributions. J. Roy. Asiatic Soc. Bengal 7:4.

R.15

MACFARLANE, E.W.E. (1941) Blood groups among Balahis (weavers), Bhils, Korkus and Mundas, with a note on Pardhis and Aboriginal Blood types. J. Roy. Asiatic. Soc. Bengal 7:15-24.

MACFARLANE, E.W.E. (1942) Amer. Nat. 76:520-525. (cited in Mourant et al., 1958).

MACFARLANE, E.W.E. and S.S. SARKAR (1941) Blood groups in India. Amer. J. Phys. Anthrop. 28:397-410.

MAHALANOBIS, P.C. (1958) Preface to Bengal Anthropometric Survey, 1945: A statistical study. Sankhyā 19:203-408.

MAHAPATRA, M. (1972) M.Sc. dissertation, Dept. of Anthropology, Utkal University, Orissa. (Unpublished)

MAHAPATRA, M. and P.K. MISRA (1971) Personal communication.

MAJUMDAR, D.N. (1943) Blood groups of the tribes and castes of the U.P. with special reference to the Korwas. J. Roy. Asiatic Soc. Bengal 9:81-94.

MAJUMDAR, D.N. (1949) Cited in Bhalla (1966)

MAJUMDAR, D.N. (1950) Cited in Bhalla (1966)

MAJUMDAR, D.N. (1950) ABO blood among the Garos of Eastern Pakistan. Man in India 30:32-35.

MAJUMDAR, D.N. (1950-'51) Sankha Banik of Dacca (Anthropometric and Serological Status) Eastern Anthrop 4:98-103.

MAJUMDAR, D.N. (1952) Cited in Bhalla (1966)

MAJUMDAR, D.N. (1958) Blood groups of the tribes and castes of Bengal. Chapter 9 of Bengal Anthropometric Survey, 1945: A statistical study (by D.N. Majumdar and C.R. Rao) Sankhya 19:319-323.

MAJUMDAR, D.N. and S. BAHADUR (1951-'52) ABO blood in India. Eastern Anthrop. 5:101-122.

MAJUMDAR, D.N. and K. KISHEN (1947) Blood groups' distribution in the United provinces: Report on the serological survey of the U.P. -.Census operations, 1941 Eastern Anthrop. 1:8-15.

R.16

MAJUMDAR, D.N. and K. KISHEN (1948) Serological status of castes and tribes of cultural Gujarat. Eastern Anthrop. 2:92-97.

MAJUMDAR, D.N. and C.R. RAO (1958) Bengal Anthropometric Survey, 1945: A Statistical Study. Sankhyā 19:203-408.

MALHOTRA, K.C. (1966) Anthropometric measurements and blood groups among the Brahmins of Maharashtra. Ph.D. Thesis, Poona University, Poona. (Unpublished)

MALHOTRA, K.C. (1971) Population biology of the three split Gavda groups of Goa. Proc. First Internat. Symp. Hum. Genet., Andhra University, Waltair. (Ed. M.R. Chakravartti) pp.204-232.

MALHOTRA, K.C. (1978) Morphological composition of the people of India. J. Hum. Evol. 7:45-63.

MALHOTRA, K.C., S.K. DAS, B.N. MUKHERJEE, J.V. UNDEVIA, B.V. BHANU, S. YEE and P.P. MAJUMDAR (1976) Distribution of blood groups among 21 Dhangar castes of Maharashtra. (Personal communication. Now published in Ind. J. Phys. Anthrop. Hum. Genet. 3:141-159, 1977)

MALHOTRA, K.C., G.S. MUTALIK, S.L. KATE and M.A. PHADKE (1974) Serological and biochemical investigations among the Nandiwallahs of Mahrashtra. (Personal communication)

MALLESWARA RAO, P. (1971) M.A. dissertation. Department of Anthropology, Andhra University, Waltair. (Unpublished)

MALONE, R.H. and M.N. LAHIRI (1929) Distribution of blood groups in certain races and castes of India. Ind. J. Med. Res. 16:963-968.

MARANJIAN, G. (1952) Cited in Bhalla (1966)

MATHEW, N.T. (1959) Relation between stature and blood group among Indian soldiers. Sankhyā 21:1-12.

MAVALWALA, G.D. (1967) Delhi University expedition report, 1967.

MIKI, T., T. TANAKA and T. FURUHATA (1960) On the distribution of ABO blood groups and the taste ability for phenylthiocarbamide (P.T.C.) of the Lepchas and the Khasis. Proc. Japan Acad. 36:78-80.

MITRA, P.N. (1933) The influence of blood group in certain pathological states. Ind. J. Med. Res. 20:995-1004.

MITRA, P.N. (1935) Blood groups and heredity. Ind. J. Med. Res. 22:496-497.

MITRA, P.N. (1936) Blood groups of the Angami Naga and the Lushai Tribes. Ind. J. Med. Res. 23:685-686.

MOURANT, A.E. (1954) Distribution of the Human Blood Groups. Oxford, Blackwell.

MOURANT, A.E. (1959) Blood groups and anthropology. British Med. Bull. 15:140-142.

MOURANT, A.E. (1961) Blood groups. In Genetical Variation in Human Populations. Pergamon Press, London. pp. 1-15.

MOURANT, A.E., M.J. GOBBER, A.C. KOPEĆ, H. LEHMANN, P.R. STEELE and D. TILLS (1969) The hereditary blood factors of some populations in Bhutan. The Anthropologist, Special volume, pp. 29-43.

MOURANT, A.E., ADA C. KOPEĆ and K. DOMANIEWSKA-SOBCZAK (1958) The ABO blood groups: Comprehensive tables and maps of world distribution, Blackwell Scientific Publications, Oxford.

MOURANT, A.E., A.C. KOPEĆ and K. DOMANIEWSKA-SOBCZAK (1978) Blood groups and Diseases: A Study of the associations of Diseases with Blood groups and other polymorphisms. Oxford Univ. Press.

MOURANT, A.E., A.C. KOPEĆ and K. DOMANIEWSKA-SOBCZAK (1976) The distribution of the human blood groups and other polymorphisms. Oxford University Press, New York.

MUKHERJEE, B.N., S.K. DAS, M. ROY (1977) Personal communication.

MUKHERJEE, B.N., K.C. MALHOTRA, S.K. DAS, P.P. MAZUMDER, M. ROY, S.L. KATE, G.S. SAINANI (1977) Genetic polymorphism analysis among Nine endogamous population groups of Maharashtra, India. (Personal Communication). [Now published in J. Hum. Evol. 8:555-566, 1979]

MUKHERJEE, B.N., U. PINGLE and S.K. DAS (1977) Personal communication.

MURTY, J.S. and T. RAJYA LAKSHMI (1971) Distribution of ABO blood groups among Brahmins and Non-Brahmins of coastal Andhra and Tamilnadu, Proc. First. International Symp. Human Genet. (Ed. M.R. Chakravartti) pp. 245-258.

MUTALIK, G.S., K.C. MALHOTRA, M.A. PHADKE and S.L. KATE (1974) Population genetics of an endogamous group - the Parsis. Paper presented at the First Annual Conference of the Indian Society of Human Genetics, Bombay.

NAIDU and NATHAN (1938) Cited in Bhalla (1966)

NAYAK, G. (1974) Personal communication.

NEGI, R.S. (1963) ABO blood groups, sickle-cell trait and colour blindness in the Maria of Bastar; and Gond and Kanwar of Bilaspur. Bull. Anthrop. Survey of India 12:149-153.

NEGI, R.S. (1977) Regional round-up: N.W. Region - Paper presented at the Seminar on Human Variation in India, A.S.I., Calcutta.

NEGI, R.S. and S.H. AHMED (1962) The Bhatra, Muria and Mahara of Bastar: a blood group genetic study. Bull. Dept. Anthrop. (Govt. of India) 3-4:201-209.

NEGI, R.S. and S.H. AHMED (1963) A study of A_1A_2BO, MN, Rh blood groups; ABH secretion in saliva and colour blindness in the Dorla and Dhurwa of Bastar. Bull. Anthrop. Survey of India 12:21-29.

NEGI, R.S. and S.H. AHMED (1971) ABO blood groups and ABH secretion in saliva of Bade Bhinjhwars of Chhattisgarh Proc. Internat. Symp. Hum. Genet. (Andhra University, Waltair. (Ed. M.R. Chakravartti) pp. 277-283.

NEGI, R.S. and A. DAS (1958) A genetic survey among the Rajputs in U.P. and Rajasthan - Unpublished. (cited in Das and Sastry, 1960).

NEGI, R.S. and A. MAITRA (1974) ABO blood groups in some western and southern Indian tribes. (Personal communication).

R.19

NEGI, R.S., A.C. SRIVASTAVA and B.R. BHATNAGAR (1975) Distribution of ABO blood groups and Central and Western Himalayan populations. (in Press) (Cited in Tyagi et al., 1977).

NIOGUY, P. and R, OLIVIER (1961) Cited in Bhalla (1966)

PADMA, T. and J.S. MURTY (1974) Distribution of ABO blood groups in Hyderabad Population. Ind. J. Med. Res. 62: 745-748.

PANDIT, S.R. (1934) Blood groups distribution in the Todas. Ind. J. Med. Res. 21:613-615.

PARIKH, N.P., A.J. BAXI and H.I. JHALA (1969) Blood groups, abnormal haemoglobins and other genetical characters in three Gujrati-speaking groups. Hum. Hered. 19:486-498.

PUNJAB UNIVERSITY (1962) Expedition report.

PALKAR, K. (1974) Blood groups of the people of Karnataka M.Sc. dissertation, Poona University, Poona. (Unpublished)

PATEL, S. (1971) ABO blood groups, PTC tasting and dermatoghyphics of Tibetans at Chandragiri, Orissa. Amer. J. Phys. Anthrop. 35:149-150.

PATNAIK, G. (1973) M.Sc. dissertation, Dept. of Anthropology. Utkal University, Orissa. (Unpublished)

PATOJOSHI, P.K. (1975) Genetic survey of the Sistha Karami Proc. 62nd Ind. Sc. Cong. Asscon. pt. 3 (Abstract).

POORNIMA, W. (1971) M.A. dissertation, Department of Anthropology, Andhra University, Waltair. (Unpublished)

RACE, R.R. and R. SANGER (1970) Blood groups in Man. F.A. Davis Co., Philadelphia.

RAMACHANDRAIAH, T. (1967) A genetic study of the Lambadis of Andhra Pradesh. Ph.D. Thesis, Delhi University, Delhi. (Unpublished)

RAO, A.K. (1952) Blood group characteristics in South Indians. Curr. Sci. 21:188.

R.20

RAO, C.R. (1952) Advanced Statistical Methods for Biometric Research. John Wiley and Sons, New York.

RAO, C.R. (1958) A statistical assessment of some of the existing data on A-B-O blood groups of Bengalees. Sankhya 19:323-330.

RAO, C.R. (1977) Cluster analysis applied to a study of race mixture in human populations. In Classification and Clustering (Ed. J. Van Ryzin), Academic Press, NewYork. pp. 175-197.

RAO, M.B. (1964) Delhi University expedition report, 1964.

RAO, R.S. (1961) Delhi University expedition report, 1961.

RAO, T.V. and G. GOLLAREDDY (1973) A Population Genetic Survey of the Bagatha and Valmiki Tribes of Visakhapatnam District (A.P.), India. Jap. J. Hum. Genet. 18:226

RAY, P. (1962) ABO blood groups from Nazat, 24-Parganas, West Bengal. Sci. and Cult. 28:243-244.

REDDI, A.P. (1974) Personal communication

REDDI, A.R. (1943a) Distribution of blood groups among some donors to the Madras Blood Bank: with a discussion on the relationship between neuropathic conditions and blood groups. Ind. J. Med. Res. 31:193-195.

REDDI, A.R. (1943b) Distribution of blood groups among different communities in the Government mental hospital, Madras, Ind. J. Med. Res. 31:189-192.

REDDY, A.R. (1945) Physical anthropology of the Yenadis. Proc. 32nd Ind. Sc. Cong. Assocn., Nagpur, 32(3):49 (Abstract).

RIFE, D.C. (1956) Cited in Bhalla (1966)

RISLEY, H.H. (1908) People of India. Calcutta; Thacker Spink Co.

RISLEY, H.H. (1915) The People of India, Calcutta.

ROBERTS, D.F., C.K. CREEN and K.P. ABEYARATNE (1972) Blood groups of the Sinhalese. Man 7:122-127.

ROY, M. and S.R. DAS (1973) Blood groups genetic survey among the Poundra Kshatriya caste of 24-Parganas district in West Bengal. J. Ind. Anthrop. Soc. 8:83-86.

ROY, S. (1955) Distribution of ABO, MN blood groups and the ABH secretor among the tribes of central and northern Travancore. Mar in India 35:57-65.

ROYCHOUDHURY, A.K. (1976) Incidence of inbreeding in different States of India. Demography India 5:108-119.

RUSSELL, R.V. (1916) Tribes and castes of the Central Provinces of India. London: Macmillan.

SAHA, N., R.L. KIRK, S. SHANBHAG, S.R. JOSHI and H.M. BHATIA (1974) Genetic studies among the Kadar of Kerala. Hum. Hered. 24:198-218.

SAHA, N., R.L. KIRK, S. SHANBHAG, S.R. JOSHI and H.M. BHATIA (1976) Population genetic studies in Kerala and the Nilgiris (south West India). Hum. Hered. 26:175-197.

SAHU, P.N. (1977) Variability in a small population. Paper presented at the Seminar on Human Variation in India, A.S.I., Calcutta.

SANGHVI, L.D. (1954) Genetic diversity in the people of Western India. Eugen. Quartly. 1:235-239.

SANGHVI, L.D., and V.R. KHANOLKAR (1949) Data relating to seven genetical characters in six endogamous groups in Bombay. Ann. Eugen. 15:52-75.

SARKAR, S.S. (1936) Cited in Bhalla (1966)

SARKAR, S.S. (1937) Blood grouping investigations in India, with special reference to Santal Parganas, Bihar. Trans. Bose Res. Inst. 12:89-101.

SARKAR, S.S. (1938) Preliminary note on the Blood groups of the aboriginals of Bihar and a supplementary note on the Bagdi blood groups by E.W.E. MACFARLANE. Curr. Sci. 6:283-284.

SARKAR, S.S. (1940) Blood groups of the Angami Nagas. Nature 145:261.

SARKAR, S.S. (1942) Analysis of blood group data, with special reference to the Oraons. Trans. Bose Res. Inst. 15:1-15.

SARKAR, S.S. (1949) ABO blood groups from Palamau, Bihar, India. Amer. J. Phys. Anthrop. 7:559.

SARKAR, S.S. (1950) Cited in Bhalla (1966)

SARKAR, S.S. (1952) Blood groups from the Andaman and Nicobar Islands. Bull. Dept. Anthrop. (Govt. of India) 1:25-30.

SARKAR, S.S. (1954) Blood groups in India, Chapter 6 of The Aboriginal Races of India (by S.S. Sarkar), Bookland Ltd., Calcutta, pp.104-125.

SARKAR, S.S. (1956) Blood groups from Orissa. Sci. and Cult. 22:180-181.

SARKAR, S.S. (1959) Blood groups and colour blindness among the Kotas of Nilgiri Hills. Sci. and Cult. 25:379-380.

SARKAR, S.S. and A.R. BANERJEE (1959) ABO blood groups. Chapter 6 of A Physical Survey of the Kadar of Kerala, (by S.S. Sarkar, G. Ray, M.R. Chakravartti, A.R. Banerjee and Papia Bhattacharjee) Dept. of Anthropology, Govt. of India, Calcutta. pp.71-78.

SARKAR, S.S., A.R. BANERJEE, P. BHATTACHARJEE and A.K. ROY (1960) Further studies on ABO blood groups from Orissa. Sci. and Cult. 25:694-695.

SARKAR, S.S., B.M. DAS and K.K. AGARWAL (1953) The Anglo-Indians of Calcutta, Man in India 33:93-103.

SARKAR, S.S. and D.K. SEN (1952) Further blood group investigations in the Santal Parganas. Bull. Dept. Anthrop. (Govt. of India) 1:8-13.

SASTRY, D.B. (1955) Delhi University expedition report, 1955.

SEN, D.K. (1954) Blood group investigation in the 24 Parganas District, West Bengal. Man in India 34:50-60.

SEN, D.K. (1960) Blood groups and haemoglobin variants in some upper castes of Bengal. J. Roy. Anthrop. Inst. 90:161-172.

SENEVIRATNE, R.D. (1944) Cited in Bhalla (1966)

SERAH, P. (1965) Cited in Negi (1977).

SESHADRINATHAN, N. and R. TIMOTHY (1942) Distribution of blood groups in a Madras population. Ind. J. Med. Res. 30:445-447.

SETH, P.K., and S. SETH (1973) Genetical study of Angami Nagas (Nagaland, India): A_1A_2BO, MN, Rh Blood groups, ABO (H) Secretion, PTC taste sensitivity and colour blindness. Hum. Biol. 45:457-468.

SETH, P.K., S. SETH, M.B. RAO and S.B. MANI (1969) Genetical study of the Gujars: A_1A_2BO blood groups, PTC, Somatametry, Mid-phalangeal hair, Ear lobes, Hand clasping, Arm folding and Leg folding. Hum. Hered. 19:190-197.

SETH, S. (1967) Blood and Secretion: A Genetical Survey in the Population of Rourkela (Orissa, India). J. Genetique Humaine 16:97-105.

SETH, S. (1968) A study of the A_1A_2BO blood group system and ABO (H) secretion insix endogamous groups of Punjab. Amer. J Phys. Anthrop. 29:387-396.

SHAH, P. (1968) Delhi University expeiditon report, 1968.

SHARAN, J. (1970) Statistical analysis of ABO blood group data from Bihar. Sankhyā 32 (Ser.B):27-30.

SHARMA, J.C. (1959) Cited in Bhalla (1966).

SHARMA, J.C. (1969) Personal communication.

SHIVARAMAN, E.K., R.K. SARAN and H.M. BHATIA (1971) The distribution of ABO and Rh blood groups in North Indian populations. Hum. Hered. 21:326-333.

SHUKLA, B.R.K. and D. TYAGI (1973) Rajputs and their ABO blood groups. Z. Morph. Anthrop. 65:237-244.

SIBSON, R. (1972) Order invariant methods for data analysis. Jour. Roy. Stat. Soc. (B) 34:311-349.

SILVA, E.M. da (1953) Cited in Bhalla (1966)

SINGH, I.P. and D. SINGH (1960) The study of ABO blood groups of Sainis of Punjab. Amer. J. Phys. Anth. 19:223-225.

SINGH, L., P. GUPTA and K.V. GOEL (1974) Distribution of ABO and Rh blood groups among the Tibetans. Hum. Hered. 24:387-388.

SINGH, U., A.K. KALLA and Y.R. AHUJA (1969) A Genetic investigation of the Gujars. I: Blood groups and ABH secretion. The Anthropologist 16:57-61.

SOLANKI, B.R., R.N. SHUKLA and J.J. SOOD (1960) Study of blood groups of Mahars and Marathas showing presence of sickle-cell trait at Nagpur. Ind. J. Med. Res. 48:146-148.

SRIVASTAVA, L.R.N. (1962) The Gallongs Research Dept., Adviser's Secretariate, Shillong.

SRIVASTAVA, R.P. (1965) Blood groups in Tharus of Uttar Pradesh and their bearing on ethnic and genetic relationships. Hum. Biol. 37:1-12.

SRIVASTAVA, S. (1965) Ph.D. thesis, Delhi University (Unpublished).

SUNDARARAJAN, N. (1956) Cited in Mourant et al. (1976).

TALWAR, C.L. and C.P. SAWHNEY (1958) ABO and AB blood groups in Punjab. Ind. J. Med. Sci. 12:942-944.

THURSTON, E. (190) Castes and tribes of Southern India. Madras: Govt. Press.

TIWARI, S.C. (1952) The distribution of blood groups among the Bhotias of Almora district, U.P. Man in India 32:148-151.

TIWARI, S.C. (1954) The blood groups of the Kumaonis. The Anthropologist 1:50-52.

TIWARI, S.C. (1966) The blood groups of the Tibetans. Proceedings of the Symposium on Human adaptability to environments and physical fitness. (Ed. M.S. Malhotra) pp. 281-289.

TIWARI, S.C., and M.K. BHASIN (1968) The blood groups of the Brahmins and Rajputs of Garhwal. Hum. Biol. 40:386-395.

TYAGI, D. (1969) Personal communication.

TYAGI, D. (1972) Personal communication.

TYAGI, D., S.K. GARG and R.S. NEGI (1977) Blood group variation among the Bhoksas of DehraDun. Paper presented at the Seminar on Human Variation in India, A.S.I. Calcutta.

UNDEVIA, J.V. (1969) Personal communication.

VEERRAJU, P. (1973) A genetic study of the Konda Reddis. Unpublished Ph.D. thesis, Andhra University, Waltair.

VYAS, G.N., H.M. BHATIA, D.D. BANKER and N.M. PURANDARE (1958) Study of blood groups and other genetical characters in six Gujerati endogamous groups in Western India. Ann.Hum. Genet. 22:185-199.

VYAS, G.N., H.M. BHATIA, P.K. SUKUMARAN, V. BALAKRISHNAN and L.D. SANGHVI (1962) Study of blood groups, abnormal haemoglobins and other genetical characters in some tribes of Gujarat. Amer. J. Phys. Anthrop. 20:255-265.

WICKRAMASINGHE, R.L., E.W. IKIN, A.E. MOURANT and H. LEHMANN (1963) The blood groups and haemoglobins of the Veddahs of Ceylon. J.R. Anthrop. Inst. 93:117-125.

WICKRAMASINGHE, R.L. and N.E.L. PONNUSWAMY (1963) Blood groups and haemoglobin types of Ceylonese. Spolia zeylan., 30(i): 149-154.

WORKMAN, P.L. and J.D. NISWANDER (1970) Population studies on Southwestern Indian tribes. II Local genetic differentiation in the Papago. Amer. J. Hum. Genet. 22:24-49.

WRIGHT, S. (1931): Evolution in Mendelian populations. Genetics 16:97-159.

WRIGHT, S. (1940) The statistical consequences of Mendelian heredity in relation to speciation. In The New Systematics (Ed. J.S. Huxley), Oxford.