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With regards
from Urmila

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Morphological and Genetic Composition of the Gonds of Central India: A Statistical Study

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ABSTRACT Various multivariate statistical techniques were used to determine the morphological and genetic relationship between five Gond populations living in Adilabad District (Andhra Pradesh) and Chanda District (Maharashtra). The analysis revealed the Gonds to be a heterogenous group being morphologically and genetically different from each other, forming separate endogomous entities. The morphological and genetic distances between these five Gond populations when projected graphically revealed that the spatial distribution of these populations generally corresponded to their present geographical distribution. The Manne lie intermediate forming the connecting link between the other four populations such as Kolams, Raj Gonds, Koyas and Maria Gonds. The Raj Gonds and Maria Gonds lie farthest away from each other at two opposite poles.

The Gonds of this study were also compared morphologically with other tribal populations of peninsular India. These tribals also clustered according to the geographical regions they belong and formed three main clusters : (1) Central Indian group (including Gonds of the present study) ; (2) Orissa and Chotanagpur group ; and (3) South Indian group (South of Krishna river).

The Gonds lie in close proximity to the main Central Indian cluster showing morphological closeness to Bhils, Korkus and Gonds (Madhya Pradesh). These findings do not substantiate the contention made by Russel and Hiralal (1916), that the Gonds who speak a Dravidian language might have migrated from South India to Central India sometime between 9th century to 13th century A.D. The Central Indian group and Orissa and Chotanagpur group are however relatively close to each other than to the more distant South Indian tribal group. The South Indian group is separated from the rest of the tribal people of peninsular India by the Krishna and Godavari deltas.

The Gonds are one of the largest tribal populations of Central India, roughly 4 million in number amounting to about 13 per cent of the total tribal population of India. 'Gondwana,' the area of their distribution stretches into Madhya Pradesh, Maharashtra and Andhra Pradesh States. The Gondi language belongs to the Dravidian group of languages. The Gonds had kingdoms in Deogarh on the foothills of Satpura at Mandla (Madhya Pradesh) and Chanda (Maharashtra) from the 14th—18th century A.D until they were defeated by the Marathas. The social anthropological aspects of the Gonds of Andhra Pradesh have been studied over a period of forty years by Furer—Haimendorf (1979) who considers the Gonds as being neither racially, culturally nor linguistically a homogenous group. There have been various divergent views on the relationship of Gonds to other tribal group of Central India.

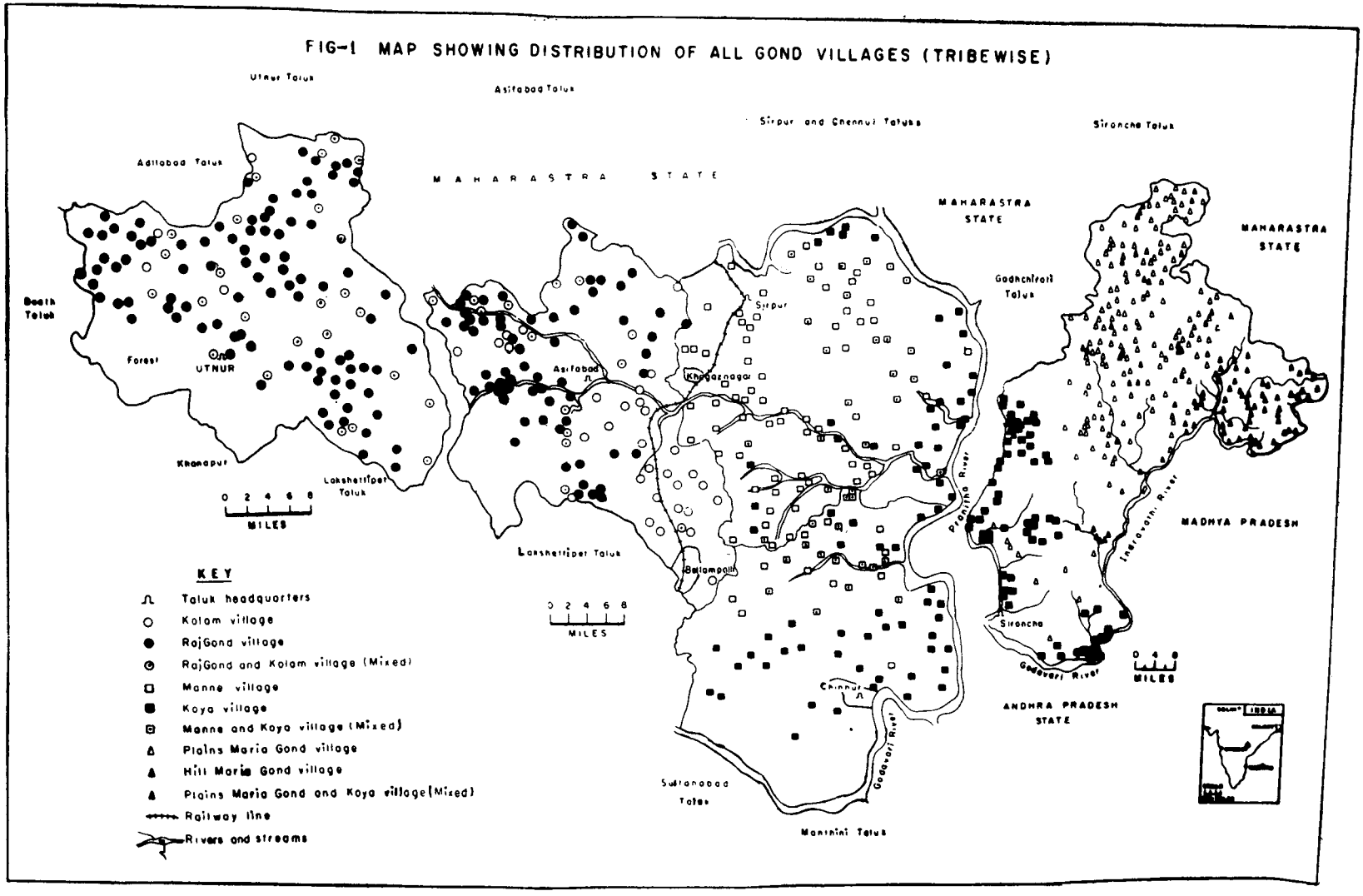

Fig. 1. Map showing the distribution of all Gond villages (tribewise).

to Chinnur taluka (Andhra Pradesh) were selected for study. These two groups are also located each to a distinct geomorphological territory which has determined the different means of production they have adopted. The Koya villages are present in clay soils found along rivers, especially the Pranitha river which necessitates the practice of settled cultivation and the use of plough technology. The Manne are located to sandy soils (Gondwana sandstones) on gently sloping terraine suitable only for shifting cultivation. The Manne extend into eastern part of Asifabad taluka from where the area rises up into hills on the west and is the area of Kolams and Raj Gonds. East of the river Pranitha and mainly in the valley of Indravathi river live the main sub-group of Gonds—the Marias, Murias and Bisonhorn Marias. The geology is mainly of metamorphic and Gneiss rocks. This is a country of dense forests, of plains and hills. The sample population selected are the Maria Gonds living mainly in the Sironcha taluka of Chanda district (Maharashtra). This group is divided into two sub-groups, the Plains Maria and Hill Maria Gonds. The Plain Marias occupy a major portion of the north-eastern area of the taluka and practice settled rice cultivation (rainfed) whereas the Hill Marias live on the Abhumjer hills which lies on the extreme east of Sironcha taluka practising shifting cultivation.

MATERIALS AND METHODS

Data on anthropometric measurements and blood samples were collected on 100 individuals consisting of 50 males and 50 females from each of the five Gond populations. In addition, extra 50 male samples for each of the above five groups was collected for the purposes of screening for G6PD deficiency, Haemoglobin and Transferrin variants. Villages were selected to represent as far as possible the different areas of distribution of the tribe. Since most of the villages were situated along the main streams, villages were selected so as to represent each of the main stream thus covering a representative proportion of the tribal groups in the area selected for study. All available adult population in the villages were covered avoiding as far as possible (as consanguinity was high in these groups) relatives and rejecting members of the same family. Information on age, marital status, relatendness of spouse, place of birth of spouses etc., were also collected on each of the individuals. On each selected individual after the measurements were taken, blood samples were collected by means of finger prick method into heparnised micro-capillary tubes.

Biochemical Methods Followed

Micro-techniques were followed for blood grouping in ABO, MN and $Rh_{(0)}D$ systems. The antisera was got from Haffkine Institute, Bombay

and the techniques followed were those advocated by this Institute. Screening for G6PD deficiency was done by Brilliant Cresyl Blue (BLB) Dye decolourisation technique of Motulsky and Campbell-Kraut (1960). Separation of serum proteins like Haptoglobin, Transferrin, Albumin and Haemoglobin were achieved by polyacrylamide electrophoresis. The method of Clark (1964) was adopted for separation of serum proteins on a 7% acrylamide gel. A 5.5% polyocrylamide gel was used with a buffer system of Dietz *et al.* (1971) for Haemoglobin separation. Sickle cell test was carried out using 2% sodium metabisulphite solution and then observing the red cells under a microscope for sickling after 15-20 minutes.

Anthropometric Techniques Followed

Sixteen anthropometric measurements were taken and the methods followed were according to Human Biology, I.B.P. Handbook No. 9 (Weiner and Lourie, 1969) : (1) stature (St), (2) upper arm length (UAL), (3) fore arm length (LAL), (4) bigonial diameter (BgB), (5) Morphological face height (TFG), (6) Nose height (NL), (7) Nose breadth (NB), (8) Head length, (HL), (9) Head breadth (HB), (10) Biacromial diameter (BAB), (11) Bi-iliac diameter (BIB), (12) Right upper arm circumference (MAC), (13) Right triceps skinfold (TFF), (14) Right subscapular skinfold (SFF), and (15) Weight (Wt). Bizygomatic breadth (BZB) however was measured as the maximum diameter between zygomatic arches which was different from that followed in I.B.P. Handbook.

Statistical Methods

Scrutiny of data : The scrutiny of raw data for the presence of 'outliers' that is, observations which appear to be inconsistent with the remainder of that set of data, is an important and essential step to valid analysis of data. Since the presence of these outliers is likely to distort the inference process, as a first step, in order to detect the outlier a "descriptive analysis" of the data was carried out. This involves (1) frequency distribution in narrow class intervals in drawing histograms, (2) computing measures of location like mean, mode, median and measures of dispersion, (3) recording maximum and minimum values and (4) computing measures of skewness and kurtosis. Outliers were suspected if, (a) there are gaps in the histogram and the extreme observations are far removed from the nearest neighbours, (b) if the variation in some samples is larger than in the others for the same character, and (c) if there is a general consistency in measures of skewness and kurtosis but in some cases the values are discordant.

A number of outliers were detected in the data and their presence produced a deviation in the normal distribution increasing skewness and kurtosis significantly. The removal of outliers in many cases brought back the distribution to normality. In the cases of skinfold thickness measurements and weight, the distribution to start with is not normal, the skewed distribution being due to inherent variability. These measurements were not used for multivariate analysis.

Preliminary Analysis

Anthropometric data

Out of the 16 measurements only 10 were selected for further analysis. Out of the six that were rejected, the upper arm and forearm length are highly correlated with stature and hence redundant whereas the rest consisting of of soft tissue measurements like mid-arm circumference, triceps skinfold, subcapular skinfold and weight showed a skewed distribution and therefore were not suitable for multivariate analysis. Also, they are highly affected by environmental factors and not suitable for comparative analysis. The following tests were carried out on all measurements :

(a) Variances within tribes and tests of homogeneity for both females and males.

(b) Tests for homogeneity of a set of correlation co-efficients (Rao, 1965).

(c) Equality of variances and co-variances for males and females by likelihood ratio test and using χ^2 approximation according to Box (1949). Only ten measurements mentioned above were found to have nearly the same variances for all the groups, a similar correlation matrix and the co-variance matrices were found to be equal both within male and female groups. Hence only these measurements were used for multivariate analysis.

Analysis of variance was carried out on each of the selected measurements between female groups and male groups and for sexual dimorphism.

Genetic data

The gene frequency and tests of homogeneity and consistency were applied for seven biochemical markers. In the case of Albumin protein which was found to be invariant, it was not used for comparative analysis. The gene frequency for ABO system was estimated by maximum likelihood method and tests for departure from Hardy-Weinberg equilibrium and heterogeneity

were carried out according to Rao (1965). The test for consistency and homogeneity was also carried out on MN system according to Rao (1965). χ^2 test for heterogeneity of gene frequencies between the five Gond populations was carried out in the other genetic markers.

Multivariate Analysis

Different distance measures and clustering algorithms stress different aspects of the similarity or dissimilarity of groups. There is nothing like which is an appropriate measure of distance and a method of cluster analysis unless the problem is posed in a narrow but a definite way. For exploratory studies, it would be useful to try different methods and interpret the results and also to see whether different methods give nearly consistent results.

Distance measures used

(a) *Mahalanobis' D^2* : This is the best measure for metric data provided that some assumptions are satisfied, the two most important being homogeneity of the variances, and correlations and normality of the multivariate distribution.

(b) *Nei's distance* : Nei (1972) taking into account the effect of genetic polymorphism within populations defined the normalised identity of genes between populations as equivalent to protein identity. He then related it to the accumulated number of gene differences per locus which was now called genetic distance. This measure of genetic distance, according to Nei, has several advantages over those proposed by Cavalli-Sforza and Edwards (1967), Balakrishnan and Sanghvi (1968) and others.

(c) *G^2c (Balakrishnan and Sanghvi)* : The same fundamental assumption in Mahalanobis's D^2 is followed, that is while the populations may differ in their mean gene frequencies all of them have the same dispersion matrices.

The two clustering techniques used in this study are (i) Single linkage (Sneath and Sokal, 1973) or minimum method by Johnson (1967), and (ii) Complete linkage or maximum method (Johnson, 1967).

Ordination techniques : Suppose that on each individual, we have taken p measurements. In such a case the mean values of the tribes under study can be represented as points in a p-dimensional Euclidean space. If $p = 3$ we can have a physical representation of the points using three space co-ordinates. If $p > 3$, it may be possible to represent the points

approximately in a 3-dimensional space. The method of obtaining the co-ordinates in three dimensions is as follows :

Let $X_1, \ldots\ldots, X_p$ be the original measurements. Then we difine the the first canonical variate as a linear function.

$$Y_1 = a_1\ x_1 + \ldots\ldots + a_p\ X_p$$

The co-efficient $a_1, \ldots, a_p$ are obtained in such a way that the sum of all possible D^2 values based on Y_1 alone is maximised. The second variate $Y_2 = b_1 x_1 + \cdots + b_p\ X_p$ is obtained in such a way that the sum of all possible D_2's based on Y_1 and Y_2 is maximised. The basis for obtaining a third variate, fourth variate etc., is now clear. Theoretically, we can have p canonical variates $Y_1, \ldots, Y_p$ which are obtained by a linear transformation of the original variates $X_1, \ldots, X_p$. The best three dimensional representation is represented by y_1, y_2 and y_3 (Rao, 1971). It is also possible to obtain canonical co-ordinates directly from D^2 values using a technique by Torgerson (1958), Rao (1965) and Gower (1966 a, b).

Clustering versus Ordination : Both methods may differ greatly in the taxonomic results to which they lead. Cluster methods will yield clusters of some kind, whatever the structure of the data, even if the populations are randomly distributed. Attempts are being made to put them on firmer scientific basis (Gower, 1967). Oridination too has its disadvantages, for clusters produced by it may overlap in two or three spaces though they are quite distinct in hyperspace and also final differences between populations within a cluster may not be accurate. Hence a combination of both clustering and ordination have been used in this study in order to get a clearer picture of the relationship between the populations.

RESULTS

Analysis on Gonds

(a) *Morphology* : The mean values for various measurements in male and female groups are given in Tables 1 and 2. Analysis of variance showed F values were high for 8 of the 11 measurements showing significant differences between the five tribal groups, both for the females as well as for the males (Table 3). There was also a significant difference between sexes within each tribal group for each of the 11 measurements. Except for head breadth all other measurements showed no difference in sexual dimorphism between the five tribal groups.

TABLE 1. *Male tribals : mean* ($\bar{X}$) *and standard error* ($\pm SE$) *of anthropometric measurements after omitting outliers (number indicated in bracket)*

Character	Kolam (52)		Koya (51)		Manne (56)		Plains Maria (54)		Raj Gond (54)	
	$\bar{X}$	±SE	$\bar{X}$	±SE	$\bar{X}$	±SE	$\bar{X}$	±SE	$\bar{X}$	±SE
HB	137.308	0.781	141.843	0.606	141.073 (−1)	0.602	142.185	0.664	139.481	0.491
HL	184.173	0.726	186.922	0.793	184.839	0.889	186.241	0.834	187.148	0.647
BzB	118.481	0.691	118.647	0.787	120.018	0.767	118.019	0.747	119.259	0.726
BgB	103.314 (−1)	0.709	101.900	0.871	103.115 (−1)	0.729	104.906	0.698	102.096	0.750
TFL	109.442	0.818	108.843	0.815	111.673	0.819	110.963	0.917	110.736	0.799
NL	49.288	0.620	47.529	0.571	49.607	0.624	47.944	0.419	47.815	0.510
St	1613.038	7.719	1593.118	8.554	1607.607	7.633	1606.648	7.873	1628.278	8.757
UAL	315.058	2.257	306.608	2.354	311.018	2.835	305.778	2.185	313.630	2.126
LAL	262.510 (−1)	1.746	255.961	2.317	264.500	2.226	256.778	1.799	265.241	1.944
BAB	351.615	2.307	357.078	2.313	353.607	2.127	351.111	2.115	355.759	2.067
BIB	252.471 (−1)	1.722	256.569	1.677	258.036	1.934	264.481	2.011	254.333	1.699
MAC	226.308	2.350	236.000	1.978	228.071	2.065	243.741	2.577	238.444	2.282
TFF	46.731	0.970	49.118	1.109	49.286	1.542	58.113 (−1)	2.061	48.148	1.615
SFF	75.481	1.977	75.588	1.983	70.625	1.978	86.226 (−1)	3.230	78.333	2.368
Wt	96.771	1.612	98.708	1.364	94.852	1.362	105.509	1.795	103.170	1.828
NB	39.308	0.442	38.196	0.364	38.054	0.324	39.185	0.401	37.481	0.415

TABLE 2. Female tribals : mean ($\bar{X}$) and standard error ($\pm SE$) of anthropometric measurements after omitting outliers (number indicated in bracket)

Character	Kolam (50)		Koya (50)		Manne (49)		Plains Maria (48)		Raj Gond (37)	
	$\bar{X}$	±SE	$\bar{X}$	±SE	$\bar{X}$	±SE	$\bar{X}$	±SE	$\bar{X}$	±SE
HB	135.260	0.763	137.160	0.609	136.479 (−1)	0.650	135.125	0.725	134.459	0.618
HL	177.340	0.884	180.660	0.779	177.167 (−1)	0.745	180.042	0.892	181.054	0.954
BzB	113.280	0.682	111.440	0.855	113.204	0.662	111.396	0.725	115.297	0.872
BgB	96.043	0.696	94.042	0.862	95.596 (−1)	0.688	96.721 (−1)	0.728	94.118	0.936
TFL	103.120	0.707	101.553	0.817	105.522	1.014	104.128	0.910	104.056	0.883
NL	44.560	0.476	42.760	0.436	45.878	0.499	43.271	0.471	44.946	0.520
NB	36.580	0.301	35.160	0.369	35.388	0.342	35.875	0.407	36.027	0.424
St	1490.500	6.646	1505.540	8.521	1503.551	6.614	1500.833	9.201	1515.216	7.164
UAL	287.938 (−2)	2.102	293.840	2.113	289.479 (−1)	1.848	286.813	1.883	287.784	2.479
LAL	235.959 (−1)	1.880	240.040	2.073	238.306	2.080	233.958	1.804	238.432	1.684
BAB	311.380	1.811	321.000	1.727	320.490	1.751	317.478 (−2)	2.135	312.081	2.923
BIB	245.420	1.803	247.000	1.929	250.755	2.117	254.688	1.870	247.838	2.168
MAC	210.660	2.195	215.000	2.141	223.347	2.281	225.146	2.535	222.622	2.920
TFF	66.400	2.914	62.200	2.997	58.673	2.019	80.000	3.332	75.676	3.520
SFF	70.400	2.511	69.260	2.815	69.898	2.140	87.500	2.600	78.514	4.132
Wt	83.653	1.310	82.531	1.580	81.449	1.483	88.479	1.680	87.943	1.669

TABLE 3. *Analysis of variance (individual anthropometric characters)*

Characters	Between male tribals	Between female tribals	Sex difference within tribals	Sexual dimorphism
	F(4,482)	F(4,482)	F(5,482)	F(4,482)
HB	9.3106**	2.5778*	29.0532**	3.8416**
HL	2.5922*	4.8178**	33.4196**	0.2814
BzB	1.0165	3.8753**	34.4140**	1.6832
BgB	2.8285*	2.0975	50.4718**	0.2658
TFL	1.6866	2.4057*	31.3000**	0.1042
NL	3.4251**	5.3792**	31.6999**	1.2634
NB	4.6603**	2.0819	25.7829**	1.6448
St	2.6680*	1.0683	89.6933**	1.3948
BAB	1.4555	4.2209**	181.9257**	2.0438
BIB	6.0459**	3.3935**	9.6177**	0.2774
Wt	7.7744**	4.3188**	46.0932**	0.3535

* $p < .05$; ** $p < .01$

χ^2 test for homogeneity on D^2 matrix (Tables 4) on males and female Gonds was calculated. D^2 values were significantly different in both female as well as male tribal groups (Table 5).

TABLE 4. χ^2 *values : homogeneity of* D^2 *values (above the diagonal females below males)*

Gond groups	Kolam	Koya	Manne	Plains Maria Gonds	Raj Gond
Kolam	—	47.08	21.78	37.38	25.66
Koya	63.59	—	39.50	32.13	46.89
Manne	41.22	22.96	—	34.78	46.14
Plains Maria Gond	78.10	40.34	36.62	—	48.22
Raj Gond	37.16	35.93	34.49	75.49	—

TAFLE 5. D^2 matrix based on anthropometrics in Gonds (above the diagonal females and below males)

Gond groups	Kolam	Koya	Manne	Plains Maria Gonds	Raj Gond
Kolam	×	1.8831	0.8991	1.5741	1.2068
Koya	2.5188	×	1.6306	1.3567	2.2054
Manne	1.5878	0.8756	×	1.5132	2.2286
Plains Maria Gond	3.0084	1.5379	1.3564	×	X
Raj Gond	1.4313	1.3700	1.2776	2.7960	

Two clustering techniques, the single linkage and complete linkage methods were carried out on D^2 values and showed a near correspondence in relationship in both males and in females (Figs. 2 and 3). However, the

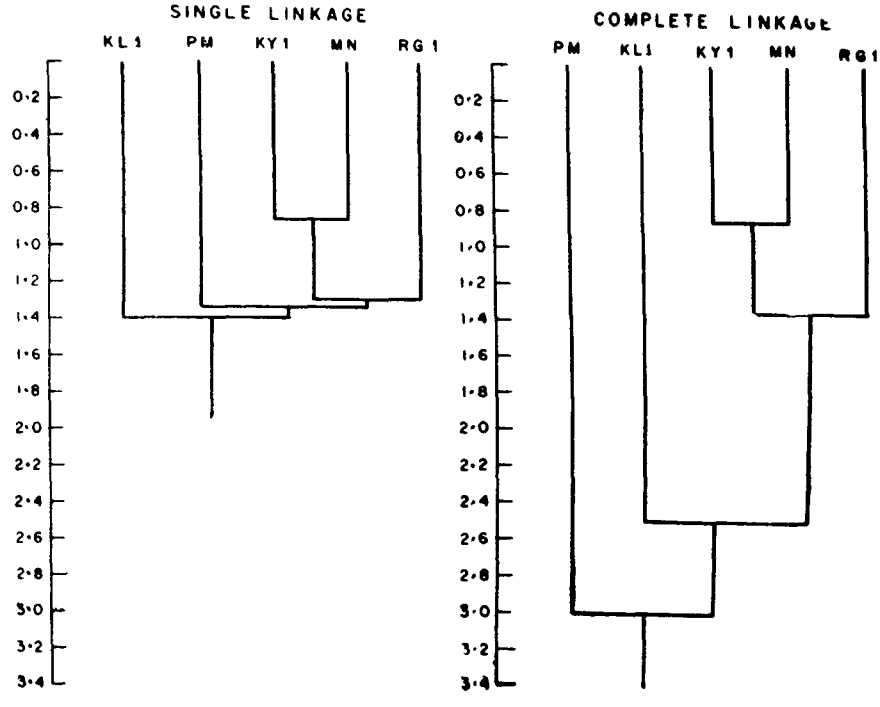

Fig. 2. Anthropometric relationship between Gond males as revealed by cluster analysis.

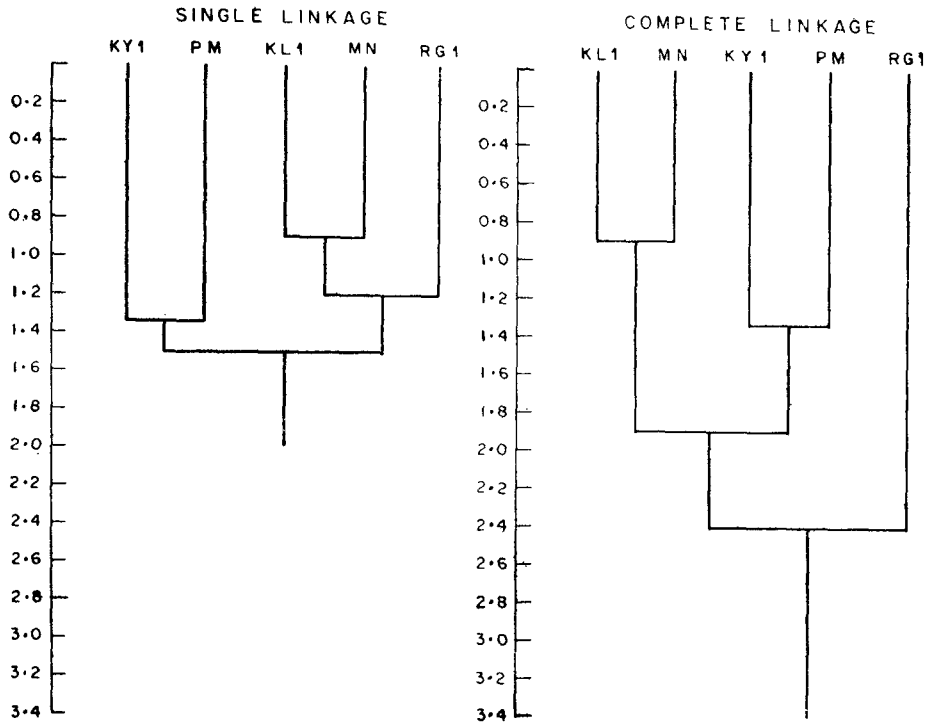

Fig. 3. Anthropometric relationships between Gond females as revealed by cluster analysis.

relationship between males and females did not show close correspondence or consistency when either of the clustering techniques were followed. In the males, the Koyas cluster with Manne and Raj Gonds, the Kolams and Plains Maria Gonds joining separately in that order. Whereas in the females two clusters are formed, one consisting of Kolams and Manne and the other of Koyas with Plains Maria Gonds. After these two clusters join each other, the Raj Gonds join separately.

Sub-graphs at various levels of clustering based on complete linkage method were drawn for both males and females separately (Fig. 4 and 5). These help in showing the spatial distribution of these groups. The graphs for males and females generally correspond with geographical distribution of groups. The Manne (MN) lie intermediate, connecting the Kolams (KL1) and the Raj Gonds (RG1) and Koyas (KY1) and Plains Maria Gonds (PM). The position of Koyas (KY1) however, is different in the two sexes shifting nearer to Manne (MN) in the males and away from Manne towards Plains Maria Gonds (PM) in the females.

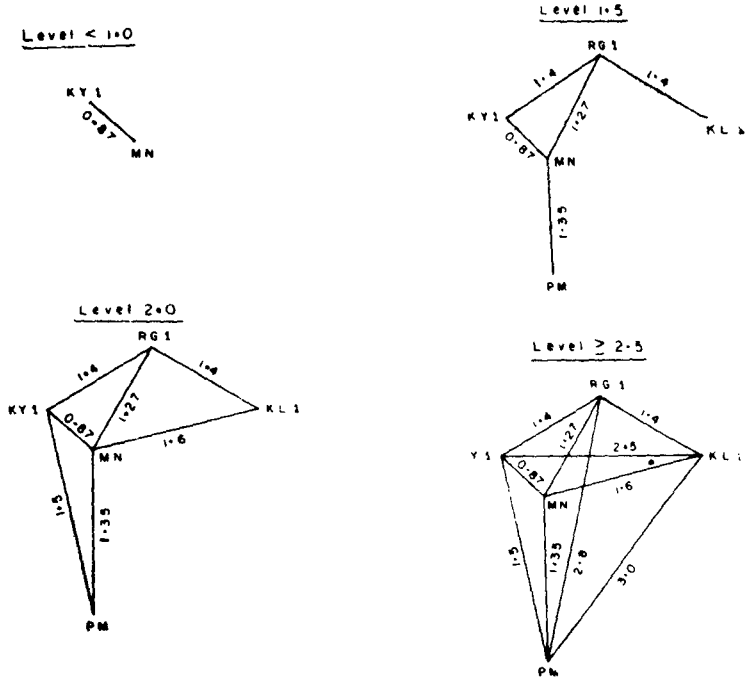

Fig. 4. Anthropometric relationship between Gond males based on complete subgraphs.

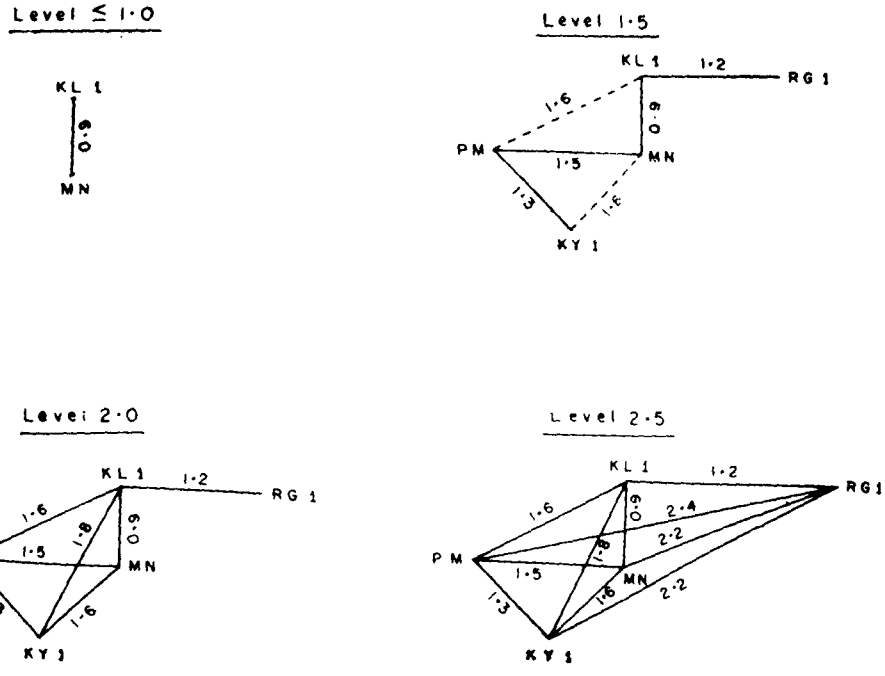

Fig. 5. Anthropometric relationship between Gond females based on complete subgraphs.

(b) *Genetic Analysis*: The phenotype and gene frequencies of the seven genetic polymorphisms studied are given in Table 6 and 7. All the

TABLE 6. Distribution of seven genetic characters among the five Gond populations

Genetic character	Phenotype frequency				
	Kolams	Koyas	Manne	Plains Maria Gond	Raj Gond
ABO blood groups					
A	17	56	32	28	24
B	44	39	36	26	34
O	25	57	30	40	21
AB	16	17	7	9	12
Total	102	169	105	103	91
Rh blood groups					
D	96	168	103	101	83
d	6	1	2	2	7
Total	102	169	105	103	90
MN blood groups					
M	62	75	80	86	61
MN	30	29	18	13	27
N	6	5	3	4	3
Total	98	109	101	103	91
Haemoglobin type					
AA	132	213	151	140	120
AS	10	15	4	27	20
Total	142	228	155	167	140
G6PD types					
Normal	—	125	—	106	92
Deficient	—	6	—	7	13
Total	—	131	—	113	105
Haptoglobin types					
Hp 2—1	13	20	15	18	14
Hp 2—2	76	135	83	78	63
Total	89	155	98	96	77
Transferrin types					
Tf C—C	137	187	136	159	135
Tf C—D	12	4	6	3	8
Total	149	191	142	162	143

TABLE 7. Gene frequencies for biochemical markers in the tribal populations

Character	Kolams	Koyas	Manne	Plains Maria Gond	Raj Gond
ABO					
p	0.1748	0.2452	0.2099	0.1985	0.2226
q	0.3527	0.1814	0.2347	0.1865	0.2968
r	0.4725	0.5734	0.5554	0.6150	0.4806
Rh					
D	0.7575	0.9231	0.8620	0.8606	0.7211
d	0.2425	0.0769	0.1380	0.1393	0.2789
MN					
m	0.7857	0.8211	0.8812	0.8981	0.8187
n	0.2143	0.1789	0.1188	0.1091	0.1813
Hb					
A	0.9648	0.9671	0.9870	0.9191	0.9286
S	0.0352	0.0329	0.0130	0.0808	0.0714
Hp					
Hp1	0.0730	0.0645	0.0573	0.0937	0.0909
Hp2	0.9270	0.9355	0.9427	0.9063	0.9091
Transferrin					
C	0.9597	0.9895	0.9789	0.9907	0.9720
D	0.0403	0.0105	0.0211	0.0093	0.0280
G6PD					
Deficient	0.0000	0.0076	0.0000	0.0619	0.0659

groups are significantly different from each other in the ABO gene frequency distribution. The B gene frequency is highest in Kolams, Raj Gonds, and Manne. Rh negative allele is highest in Raj Gonds and Kolams and lowest in Koyas. All groups show heterogeneity between each other for MN system ($P < 0.05$ level). The N gene frequency is lowest in the Manne and Plains Maria Gonds. The Gond populations were significantly heterogenous for both Haemoglobin and G6PD deficiency. The Haemoglobin S gene freuqency was highest in Plains Maria Gonds and Raj Gonds. The highest G6PD deficiency is found among the Raj Gonds and Plains Maria Gonds. These groups also have a high Haemoglobin S gene frequency which is consistent with the fact that the groups were and are in areas hyperendemic for Falciparum malarial infection. These groups are however homogenous for Haptoglobin protein. The Hp^1 gene frequency is low in these populations ranging from 0.06—0.13 comparable to most Indian populations where it is very low.

χ^2 test showed significant heterogeneity for Transferrin types between all Gond populations at $P < 0.05$ level. The slow vairant D Transferrin which is rare in other populations in India is highest in Kolams, Manne, Raj Gonds and Koyas. It is low or absent in Plains Maria Gonds. This is an interesting finding as it differentiates this group from the rest of the other Gondi-speaking groups. Another Dravidian-speaking group, the Oraons have also been found to have a high D gene frequency (Kirk *et al.*, 1962 ;

Mukherjee *et al.*, 1975). The gene D may prove a useful marker in differentiating the Dravidian speaking tribals from the Munda-speaking as well as South Indian tribals where the frequency of D gene is found to be very low.

Nei's and Sanghvi's distance measures were computed based on gene frequencies of 7 biochemical characters (Table 8). Both methods of clustering

TABLE 8. Genetic distances among the five populations of Gonds (above the diagonal Sanghvi's distance and below Nei's distance)

Gond population	Kolam	Koya	Manne	Plains Maria Gond	Raj Gond
Kolam	X	0.5375	0.2837	0.4559	0.0886
Koya	0.0641	X	0.0956	0.1877	0.6238
Manne	0.0365	0.0119	X	0.1457	0.3536
Plains Maria Gond	0.0548	0.0182	0.0088	X	0.3537
Raj Gond	0.0095	0.0604	0.0325	0.0388	X

based on Nei's and Sanghvi's genetic distance matrices showed close correspondence in the relationship between the five tribal groups (Figs. 6 and 7).

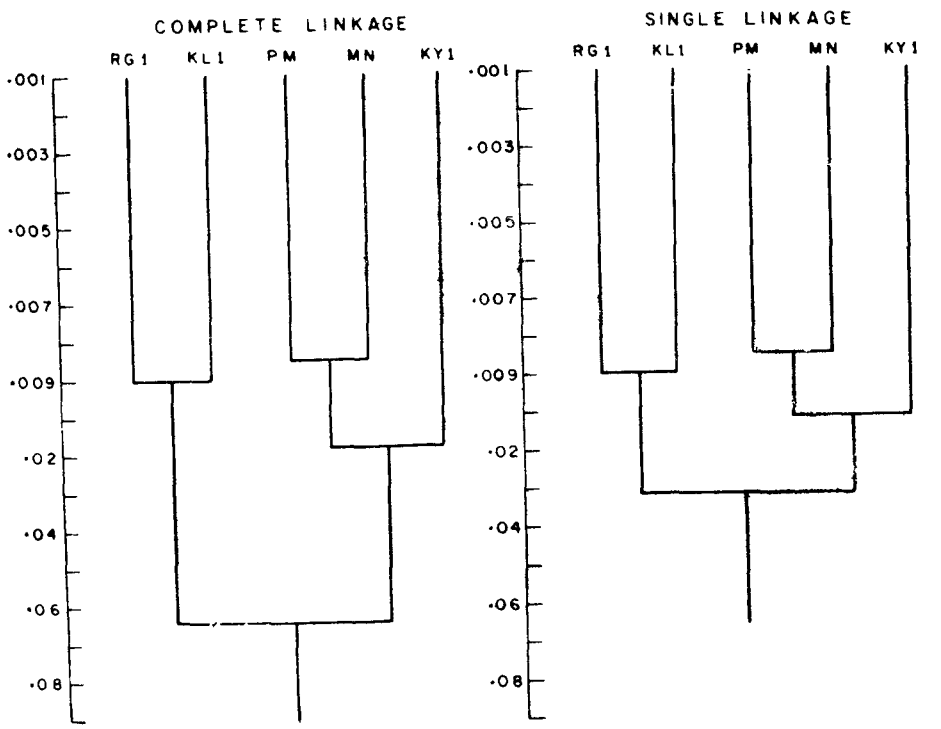

Fig. 6. Genetic relationship between Gonds based on Nei's distance as revealed by cluster analysis.

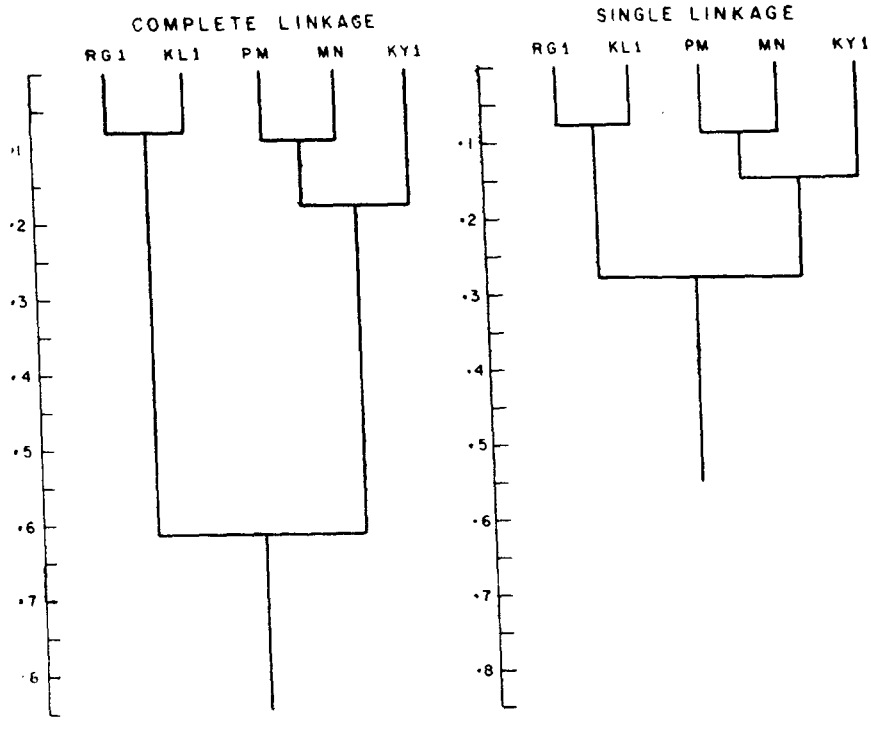

Fig. 7. Genetic relationship between Gonds based on Sanghvi's distance as revealed by cluster analysis.

The Raj Gonds (RG1) and Kolams (KL1) cluster together whereas the other three, the Plains Maria Gonds (PM), Manne (MN) and Koya (KY1) form a separate cluster.

Complete sub-graphs based on both these distance measures also showed a close correspondence in the relationship and spatial distribution of the five groups. The Manne are an intermediate group connecting the Koyas and Plains Maria Gonds with Kolams and Raj Gonds (Figs. 8 and 9). The Manne are closer to Koyas and Plain Maria Gonds than to Kolams and Raj Gonds.

Comparison of Gonds With Other Tribal Populations Based on Anthropometric Data

The 46 populations which were selected were mostly tribal groups belonging to three main regions—central India, Orissa and Chota Nagpur and South India—which were identified because of geographical and cultural differences (Table 9). These populations were given code names for convenience.

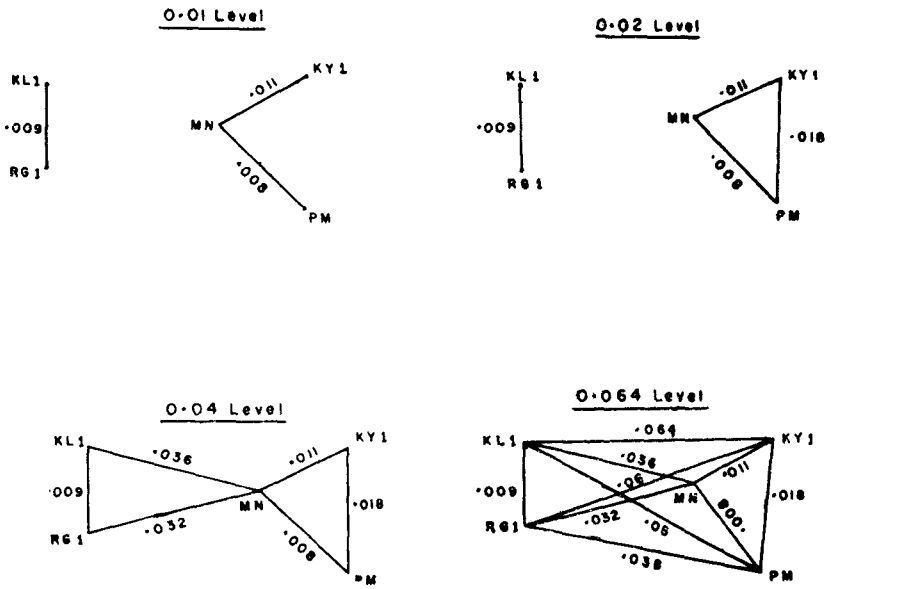

Fig. 8. Genetic relationship between Gonds based on Nei's distance as revealed by complete subgraphs.

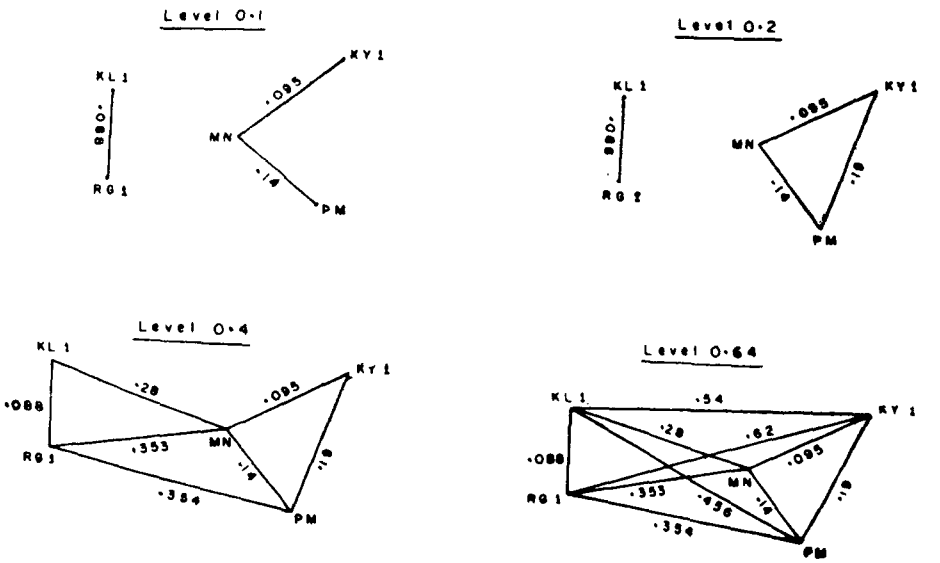

Fig. 9. Genetic relationship between Gonds based on Sanghvi's distance as revealed by complete subgraphs.

TABLE 9. Source material for comparison with Gonds on basis of anthropometric data

Population	Population code	Region[1]	Data source
Maratha	M1	C P and Berar, MH	Karve and Dandekar, 1951
Maratha	M2	W. Khandesh, MH	Karve and Dandekar, 1951
Maratha	M3	E. Khandesh, MH	Karve and Dandekar, 1951
Maratha	M4	Nizam's Dominions, MH	Karve and Dandekar, 1951
Koli Malhar	K1	Thana Dist., MH	Karve and Dandekar, 1951
Koraku	KR1	C P and Berar, MH	Karve and Dandekar, 1951
Kunbi Mane	KM	C P and Berar, MH	Karve and Dandekar, 1951
Kunbi Tirole	KT	C P and Berar, MH	Karve and Dandekar, 1951
Mahar	MH1	Des, MH	Karve and Dandekar, 1951
Warli	WR	Thana Dt, MH	Karve and Dandekar, 1951
Dhangar Hatkar	DH	Des, MH	Karve and Dandekar, 1951
Dhangar Kutekar	DK	Des, MH	Karve and Dandekar, 1951
Gonds	G1	CP and Berar, MH	Karve and Dandekar, 1951
Gujar	GJ	East Khandesh, MH	Karve and Dandekar, 1951
Halbi	HL	C P and Berar, MH	Karve and Dandekar, 1951
Kolam	KL2	C P and Berar, MH	Karve and Dandekar, 1951
Jenu Kuruba	JK	Coorg, Karnataka	Karve and Dandekar, 1951
Bette Kuruba	BK	Coorg, Karnataka	Karve and Dandekar, 1951
Sholega	SO	Biligiri Rangan Hills, Mysore	Karve and Dandekar, 1951
Andhs	A	Bombay, MH	Karve and Dandekar, 1951
Bhils Mavachi	BM	West Khandesh, MH	Karve and Dandekar, 1951
Bhils Tadvi	BT	West Khandesh, MH	Karve and Dandekar, 1951
Gonds	G2	C P & Berar, MH	Karve, 1954

TABLE 9 (*Contd.*). *Source material for comparison with Gonds on the basis of anthropometric data*

Population	Population code	Region	Data source
Juang	JA	Keonjghar, Orissa	Karve, 1954
Khond	KN	Koraput, Orissa	Karve, 1954
Koya	KY2	Koraput, Orissa	Karve, 1954
Savara	SV	Sambalpur and Cuttack, Orissa	Karve, 1954
Oraons	O2	Sundergarh, Orissa	Karve, 1954
Bondos	BN	Koraput, South Orissa	Karve, 1954
Gadaba	GD1	Jeypore, Orissa	Karve, 1954
Koraku	KR2	Amraoti Dt., MH	Chattopadhyay, 1952
Mundas	MD1	Sundergarh, Orissa	Karve, 1954
Bhatra	BA	Bastar, MP	Rakshit, 1962
Kodakus	KD	Surguja, Chota Nagpur, MP	Ahmed, 1976
Pardhans	PR1	Mandla Dt., MP	Ahmed, 1971a
Korwa	KW	Surguja Dt., MP	Ahmed, 1971b
Muria	MR	Bastar, MP	Rakshit, 1962
Hill Maria Gonds	HM1	Bastar, MP	Roy, 1938
Bison Hill Marias	BH	Bastar, MP	Roy, 1938
Dorla	DR	Bastar, MP	Rakshit, 1974
Dhurwas	DU	Bastar, MP	Rakshit, 1974
Kolam	KL1	Adilabad, Dt., AP	Pingle, Present study
Koya	KY1	Adilabad Dt., AP	Pingle, Present Study
Manno	MN	Adilabad Dt., AP	Pingle, Present study
Plains Maria Gonds	PM	Chanda Dt., MH	Pingle, Present study
Raj Gonds	RG1	Adilabad Dt., AP	Pingle, present study

1. CP = Central Provinces ; MH = Maharashtra State ; AP = Andhra Pradesh

Cluster Analysis : The complete linkage method gave more compact and biologically meaningful clusters separating out according to geographical regions. The single linkage method also produced clustering according to geographical regions ; but unlike the complete linkage method, formed long straggly clusters which included morphologically diverse groups within the same clusters. Complete linkage method clearly separates out at level 5.8 the following clusters :

TABLE 10. *Canonical coordinates based on 7 anthropometric measurements*

Populations[1]	$\lambda_1 = 0.6329$	$\lambda_2 = 0.5719$	$\lambda_3 = 0.3302$	$\lambda_4 = 0.1830$	$\lambda_5 = 0.1775$	$\lambda_6 = 0.1072$	$\lambda_7 = 0.0534$
M1	25.2352	10.7752	22.2870	6.9892	0.8703	29.2169	4.2703
M2	25.1898	11.2112	21.7492	6.5691	1.4134	28.8122	4.4715
M3	24.7327	11.0915	21.7245	6.7794	1.2746	28.7894	4.1447
M4	24.9795	10.1764	21.8414	6.6724	1.0515	28.8609	4.0552
K1	23.4790	9.2063	21.7830	6.9660	0.8164	28.9397	3.8362
KR1	23.7236	10.0307	21.7504	6.1760	0.2379	29.8283	4.2494
KM	23.6162	9.8109	22.0816	7.1720	0.8128	28.5483	4.4816
KT	24.8923	10.3034	22.3889	7.0342	0.6423	28.9675	4.4096
MH	25.0393	9.8267	22.3311	6.6599	0.8038	28.9775	4.3134
WR	23.3776	9.5952	21.4165	6.9763	0.6843	28.9754	4.2175
DH	25.1497	10.2608	22.3116	6.9104	0.9352	29.0806	4.8044
DK	24.3871	9.9521	21.6185	6.9013	1.0490	28.7432	4.4981
G1	23.9709	9.9764	22.2304	6.6905	0.3831	28.9782	4.4965
GJ	24.8607	10.3433	22.4531	7.4538	0.6967	29.0351	4.3268
HL	23.7813	9.7981	22.5491	6.4529	0.5250	28.7974	4.6282
KL2	23.6008	9.8446	21.9525	6.8735	0.3966	29.3989	4.3109
JK	22.8843	8.8453	21.7599	6.8411	0.1327	28.7123	4.5706
BK	23.3019	8.7919	21.9108	6.1643	0.9958	28.0787	4.2747
SO	22.8525	9.4786	22.0944	7.4288	0.8110	28.9901	3.7804
A	24.5496	10.1834	21.6516	6.3309	0.8509	28.9327	4.3314
BM	24.0454	9.1796	21.7551	6.5849	0.4438	28.9231	4.4655
BT	23.8677	9.9379	21.3901	6.9301	0.7413	29.1041	4.2144
G2	23.6754	9.4852	22.8460	6.6041	0.9170	29.5364	4.1434

TABLE 10 (*Contd.*). *Canonical coordinates based on* 7 *anthropometric measurements*

Populations	λ_1 =0.6329	λ_2 =0.5719	λ_3 =0.3302	λ_4 =0.1830	λ_5 =0.1775	λ_6 =0.1072	λ_7 =0.0534
JA	22.7819	9.7521	23.1068	6.2480	1.5220	28.6070	4.3277
KN	23.5232	9.9657	23.0933	6.6314	1.3275	28.6090	4.5164
KY2	23.2974	9.4023	22.1598	6.2708	0.7257	29.3672	4.4941
SV	23.5575	9.3197	23.4340	6.9774	0.7247	29.3249	4.3315
01	22.9202	10.9432	22.9727	7.7072	0.6604	28.6868	4.4825
02	23.6683	9.0688	22.5050	6.7076	0.5817	28.8897	4.5026
	23.4808	11.0501	21.5993	7.2398	0.5219	28.8606	4.2947
BN	23.2509	9.6599	22.5782	6.1928	1.4789	29.3152	4.3399
GD1	23.5096	9.8318	22.9930	6.5419	0.9891	29.3176	4.2587
KR2	22.8729	11.2269	21.1503	6.9296	0.1146	29.3606	4.8396
MD1	23.7087	9.0707	23.2854	7.5620	0.2133	29.1254	4.5353
MD2	22.9082	11.2751	22.7983	6.3756	0.4980	28.8532	4.5316
BA	23.3057	10.9003	21.9259	6.1457	0.6068	29.3696	4.4651
KD	22.8815	11.4795	22.8695	6.3952	1.2811	28.9983	4.4808
PR	23.3954	11.5220	22.9651	7.5341	1.0505	28.9054	3.9990
KW	23.0212	10.5473	22.8853	6.1693	0.7478	29.0088	4.0401
KR3	23.8472	10.2629	21.9672	6.5150	1.4185	29.6420	4.1756
MR	23.1200	11.1719	22.7243	6.6750	0.1096	29.3015	4.3390
HM1	23.3256	11.3023	22.2604	6.7975	0.4113	29.2845	4.3421
BH	23.4819	11.2622	21.6645	6.3579	0.1109	29.1079	4.3638
DR	23.5988	9.9564	21.9637	6.1834	0.2113	29.0774	4.3759
DU	23.5641	10.5718	21.8970	6.1770	0.7126	29.5365	4.2945
KA	21.9759	11.2747	21.5032	6.2297	0.3431	28.3679	4.1558
DM	22.2642	10.4757	21.3542	7.0736	1.7255	29.1704	4.6220
HM2	22.2561	10.7287	21.9149	7.5350	1.5350	29.4353	4.4955
KL1	23.8260	11.1978	22.4610	6.4263	0.1397	28.8509	3.7740
KY1	24.2118	10.7005	22.8674	6.4028	0.4880	28.6831	4.7381
MN	24.3232	11.1422	22.3815	6.4500	0.6708	28.7561	4.2951
PM	24.3017	10.7658	22.7679	6.1288	0.6389	29.2085	4.3219
RG1	24.0911	10.7044	22.7443	7.1821	0.3176	28.8242	4.2401

1. For details see Table 9

(1) Gonds of this study ; (2) Central Indian tribal group ; (3) Central Indian non-tribal groups ; and (4) Orissa and Chotanagpur group including South Indian populations within the same clusters.

A three dimensional model based on the first three canonical co-ordinates (Table 10) giving about 75 per cent of the variation between populations was constructed (Fig. 10).

The sticks representing the population were drawn in such a way that they represented the geographical area from which they were sampled. The model brought out clearly a clustering of groups according to geographical areas (Fig. 10). The clustering in three dimensional space also helped to separate more clearly the populations overlapping between any two main clusters. The presence of outliers like PR 1 and KD were easily observed in three dimensional epace. The Central Indian tribal Groups lie between the Gonds of present study and Orissa group with non-tribal Central Indian group lying apart from these other clusters.

The comparison of the main clusters in the three dimensional model were more similar to that of the complete linkage method of clustering than in the single linkage technique. There were no differences in the composition within main clusters between the two methods. Due to this close correspondence between these methods, interpretation of the results was based on a combination of these two.

CONCLUSION AND GENERAL DISCUSSION

Morphological and genetic relationship between the Gonds : Statistical analysis showed that the Gonds are a heterogenous group being morphologically and genetically different from each other, forming separate endogamous entities. In addition, this tribal endogamy has a territorial basis, each of these populations being located to distinct geomorphological areas (Fig. 1).

The morphological and genetic distances between these groups when projected graphically revealed that the spatial distribution of these Gond populations generally correspond to their present geographical distribution. The Manne lie intermediate forming the connecting link between the other four populations. The Raj Gonds and Plains Maria Gonds lie fartherest away from each other at two opposite poles. However, the actual relationship between each of the Gond populations show differences when based on these two different biological variables. The morphological relationships hows a greater variability, the clustering pattern differing between male and female Gonds. The Koyas move nearer the Manne and Raj Gonds and away from

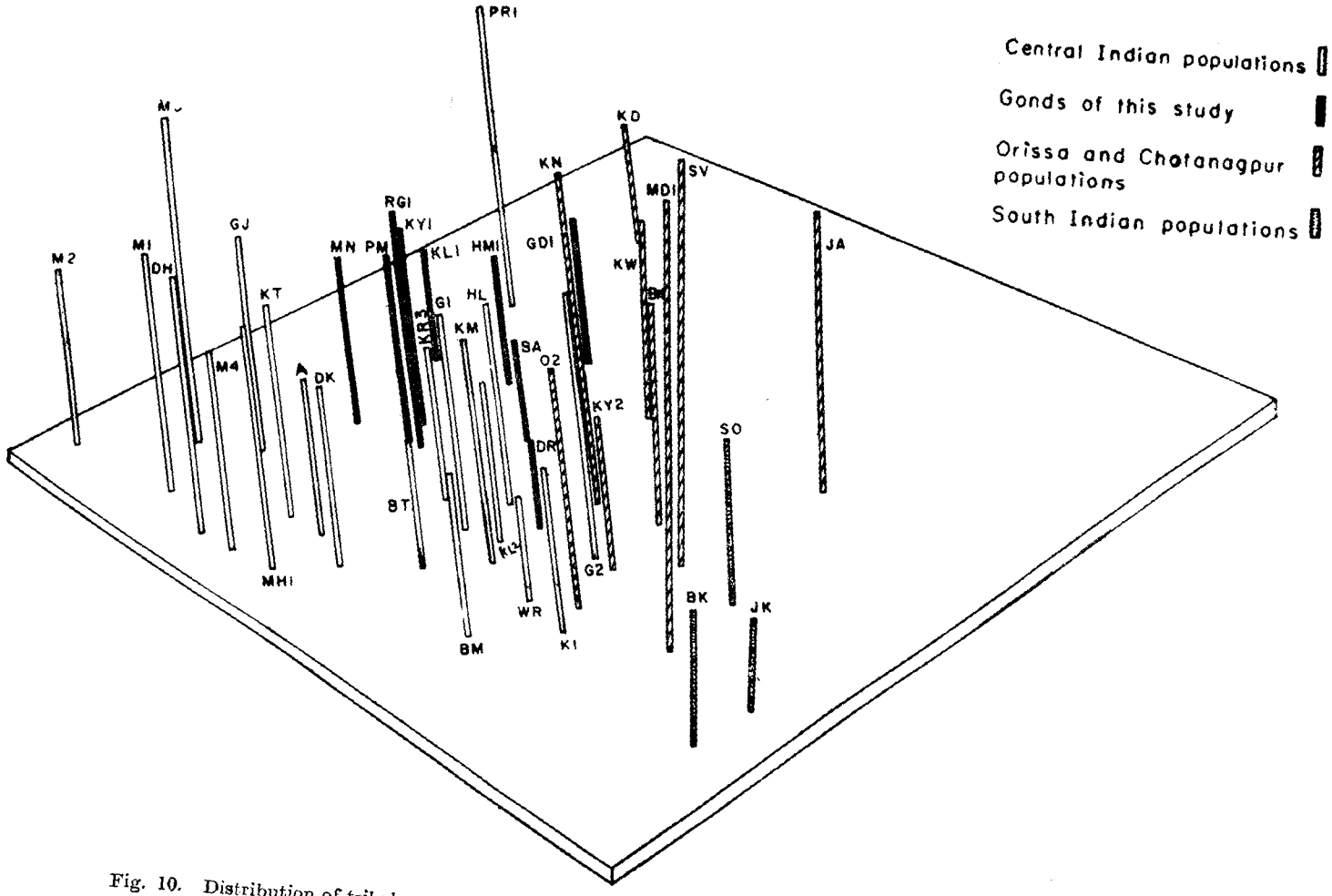

Fig. 10. Distribution of tribal populations in 3-dimensional space based on anthropometric measurements

the Plains Maria Gonds in the males and away from the rest but nearer the Plains Maria Gonds in the females. The Kolams too show a variability in their position between sexes being far removed from all the groups in the males but moving very close to the Manne in the females. This variability in morphological rlationship between sexes is difficult to interpret and may be, in part, due to differences in sex dimorphism and the greater degree of environmental influence on morphological characters.

The relationship based on genetic characters, however, is different from the morphological relationship and closely corresponds to the degree of geographical contiguity between the populations. The Raj Gonds and Kolams form a close cluster with Manne, Koyas and Plains Maria Gonds forming a second cluster. The Raj Gonds and Kolams live in close proximity to each other on the highlands consisting of black cotton soil which are contiguous with Marathwada whereas the Manne, Koyas and Plains Maria Gonds lie on the east in the valley of Pranitha-Godavari and Indravathi rivers which is predominantly influenced by Telugu culture. The genetic characters unlike morphology are purely heritable and not influenced by environment and hence perhaps reflect more closely the effect of geographical proximity in producing a greater genetic similarity within these two clusters of Gond populations.

Interpretation based on morphological relationship between tribal groups
The tribals clustered according to the geographical regions they belong (Fig. 10) and formed three main clusters : (1) Central Indian groups (including Gonds of present study) ; (2) Orissa and Chota Nagpur group; and (3) South Indian group (south of Krishna river).

The Gonds of this study fall very close to the main Central Indian cluster showing morphological closeness to those populations such as Bhils, Korkus and Gonds (of Madhya Pradesh). This is substantiated by the fact that there was a contiguous belt of Gond culture extending from Garha (Madhya Pradesh State) in the north to Chanda in the south (Maharashtra State) from at least the 14th century to the 18th century A.D when the Gond Kingdoms were overthrown by the Marathas.

The Central Indian group and Orissa and Chota Nagpur group each form a distinct cluster with a small degree of overlap between them. The eastern area consists of Munda-speaking tribal populations and is ecologically different from Central India consisting of Sal forests (Shorea *robusta*) with an extensive rice cultivation in constrast to the Teak forest, Jowar (Sorghum *vulgare*) and cotton cultivation of Central Indian tribes. The difference between

these two clusters may be also due to the possibility of inclusion of Mongoloid element in Chota Nagpur tribals due to admixture in the past. In addition, geographical factors may have helped in cultural and probably genetic diffusion from eastern India into the Chotanagpur plateau, the centre of Munda culture. The plateau is steep and inaccessible on the west and south whereas it slopes down to the east becoming accessible for easy communication.

This is also substantiated by linguists who consider Munda languages to be distantly related to Mon-Khmer languages (which includes Khasi) spoken by the Mongoloid populations of Eastern India, both belonging to Austro-Asiatic branch of Austric language family.

The Central Indian group and Orissa and Chota Nagpur group are, however, closer to each other relatively than to the more distant South Indian tribal group. The South Indian group is separated from the rest of the the rest of the tribal people of Peninsular India by the Krishna and Godavari deltas occupied by economically better off plains people. The South Indian tribal populations are mostly food gatherers, a mode of living which is determined by the rugged and hilly terrain of Western and Eastern Ghats which they inhabit, whereas the Central Indian and Orissa and Chota Nagpur tribals have adopted agriculture due to greater availability of cultivable land. These findings do not substantiate the contention made by Russel and Hiralal (1916) that the Gonds who speak a Dravidian language might have migrated from South India to Central India sometime between 9th century and 13th century A.D. This is also criticised by Furer-Haimendorf (1979) on the basis that this is not supported by ethnological evidence. It is perhaps more reasonable to postulate that the Dravidian culture and languages were widespread even among tribes of Central India who may have been in the past speaking their own languages.

Another interesting finding obtained from the study is the distinct separation of Central Indian tribal cluster from the non-tribal cluster which confirms the morphological distinctness of tribals from non-tribals in spite of the fact that they may belong to the same geographical area.

The emphasis of the present study based on quantitative techniques is on the importance of geographical proximity in producing morphological and genetic similarity between populations. This is revealed in the smaller Gond study as well as in the case of the larger tribal study. Geographical proximity between populations being brought about by a closer distance as well as similar geographical factors (such as soil, terrain, flora etc.) drawing these

populations together under a common eco-cultural umbrella. The closer the geographical distance between populations the closer the genetic as well as morphological similarity between them. This is more so in populations such as these who due to having adopted a settled agricultural occupation are less mobile. This low moblity in turn produces a smaller marriage distance (distance between place of birth of spouses) thus restricting the spatial distribution of genes to a smaller area.

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