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Genetic Studies Among the Sedentes and Migrant Oraons of Eastern India

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ABSTRACT A total of 334 Oraons of both sexes from two localities in eastern India were tested for 11 polymorphic and six monomorphic blood genetic markers. The sample comprised 130 sedentes from the Gumla district in Bihar and 204 migrants to the Jalpaiguri district of North Bengal. At the hemoglobin locus one example of HbAS was observed in the Gumla sample, while two cases of HbAS were found in the Jalpaiguri group. The Oraons are a distinct tribe and are characterized by a very low frequency of Hp^1, TF^{C2}, and a high frequency of Tf^{D1} and Gc^{1F} at the serum protein loci. In the red cell enzyme systems the Oraons have a higher frequency of p^a at the acid phosphatase locus and GLO^1 at the Glyoxalase I locus. Absence of red cell lactate dehydrogenase and very low Hb^S and Gd^{B-} is also characteristic of the Oraons. A probable new nondeficient slow variant of Gd has been observed in polymorphic frequency in the Oraons of Gumla. There was an excess of homozygotes at the Gc locus. No significant difference in the gene frequency between the two groups of Oraons was observed at any of the loci. Genetic distance estimates using the gene frequency data indicate that the Oraons of the two localities are genetically homogeneous and form one cluster with the Bhils. They are nearer to the Irula and Kurumba tribes of the Nilgiris rather than the other Dravidian tribes, Tamils, or Nayars.

The Oraons of eastern India are one of six large tribal groups of India having a population of more than one million (Vidyarthi, 1983). They speak the dialect "Kurukh" of Dravidian origin with close connection to Tamil and Konkoni of South India (Risley, 1891; Grierson, 1905; Howells, 1937). However, Guha (1951) considers the Oraons related to the proto-Australoid stock, which has also been described previously as "pre-Dravidian" and "Veddoid." They presently inhabit the plateau of Chota Nagpur in the state of Bihar as settled agriculturists. It is generally believed that they migrated from southern India and settled in Bihar several centuries ago and eventually moved to Chota Nagpur (Hunter, 1811; Roy, 1915). Some of the Oraons migrated to the Jalpaiguri district of North Bengal as workers in tea gardens in the middle of the last century (Grunnings, 1911; Choudhury, 1978). They form the third largest population group in the district.

Though the Oraons form one of the largest tribes of India, a limited amount of work has been carried out in the past to trace their origin. The first genetic study on the Oraons was by Sarkar (1942–43, 1949), who examined the distribution of ABO blood groups. In 1962 Kirk et al. conducted an extensive study on the Oraons, using the markers

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available at the time (ABO, MNS, Rh, Le, P, Js blood groups; Hb, Hp, Tf, and Gm types). The Oraons have characteristically high *B* and R_1, Di^{a-} and Tf^D transferrin types and an absence of abnormal haemoglobins and the Rh negative (*r*) gene. The Hp^1 was very low together with a high frequency of the $Gm^{1,2}$ allele. The authors concluded that the above characteristics suggested that the Oraons were of Southeast Asian origin rather than Dravidian stock—which is not substantiated by physical anthropometric studies. Later, Mukherjee et al. (1975), Reddy et al. (1983), and Das et al. (1983) studied the distribution of a limited number of red cell enzyme polymorphisms (AP, EsD, PGM, GLO I, LDH, MDH) in addition to serum Hp and Tf types in the Oraons of eastern India. In addition, Piplai et al. (1985) reported on the distribution of blood groups in the Oraons in the Jalpaiguri district, and Bhattacharyya et al. (1980) the distribution of a limited number of red cell enzymes among the Oraon labourers in the Andaman islands. The latter two studies on the Oraons from different locations showed some remarkable heterogeneity among the Oraons, which is consistent with the suggested diverse origin of the tribe.

Our research project studied 1) the genetic characteristics of the Oraons, 2) genetic heterogeneity among the sedente Oraons of Bihar and their migrant counterpart in North Bengal, and 3) the genetic relationship of the Oraons with other south and central Indian tribes.

MATERIALS AND METHODS

Blood samples were collected from 334 unrelated male and female Oraons of eastern India by the fingerprick method into heparinized capillary tubes and onto Whatman 3 MM filter paper strips (Saha and Kirk, 1973). Plasma was separated from the capillary tubes and used for protein polymorphisms (Hp, Tf, Alb, and Gc) while filter papers were used for hemoglobin and red cell enzyme polymorphisms. Packed cells in capillary tubes were stored as stocks for repeat experiments on haemoglobin and red cell enzymes. The sample comprised 130 sedentes, resident in the Gumla district, Bihar, and 204 migrants residing in the Birpara area of the Jalpaiguri district, North Bengal (Map—Fig. 1).

Red cell enzyme typing was carried out using techniques outlined by Saha and Kirk (1973) and Harris and Hopkinson (1976). Red cell acid phosphatase (AP) and Esterase D (EsD) were typed using fluorogenic stains and visualized under the UV lamp. Serum proteins (Hp, Tf, and Alb) were typed by PAG electrophoresis using discontinuous buffer system of pH 8.6. Tf subtypes were typed by isoelectric focusing in two ranges of pH (3.5–10 and 5–7) after treating the sample with neuraminidase using LKB ampholins. Serum group-specific component (Gc) subtypes were studied by isoelectric focusing using Pharmalytes of pH 4.0–6.5. Red cell phosphoglucomutase subtypes were determined by starch-gel electrophoresis and isoelectric focusing using LKB ampholin of pH 5–7.

The gene frequencies at the polymorphic loci were calculated by gene counting, and the Hardy-Weinberg equilibrium was estimated by the X^2 (chi-square) test.

Genetic distances among the populations were computed by the method of Cavalli-Sforza and Edwards (1967). The genetic distance D is given by

$$D = \frac{2\sqrt{2}}{\pi}\sqrt{1 - \cos\theta} \text{ where } \cos\theta = \sum_{i=1}^{n} \sqrt{p_i p_i'}$$

and the angular distance between two populations with gene frequencies P1, P2, ..., Pm and P1', P2', ..., Pm' is given by θ. The distance matrix was subjected to a cluster analysis by the minimum variance method (Ward, 1963).

RESULTS AND DISCUSSION

Phenotypic and gene frequency distributions of the polymorphic systems (11 loci) in the Oraons of Gumla, Bihar, and Jalpaiguri, North Bengal, are presented in Table 1.

Haemoglobin and G6PD

Only one instance each of haemoglobin AS and AH was observed in the 130 Oraons in Gumla and two cases of AS in the 204 Oraons of Jalpaiguri. This conforms with the reported absence of the sickle cell gene in the Oraons by earlier authors (Saha and Banerjee, 1973). Isolated cases of haemoglobin H have been reported in many diverse Indian populations including the Malayalis and Tamils (Saha and Banerjee, 1971b; 1973). The distribution of the sickle cell gene among the Indian tribes falls mainly into two categories with respect to the frequency of Hb^S—one with a high incidence such as the

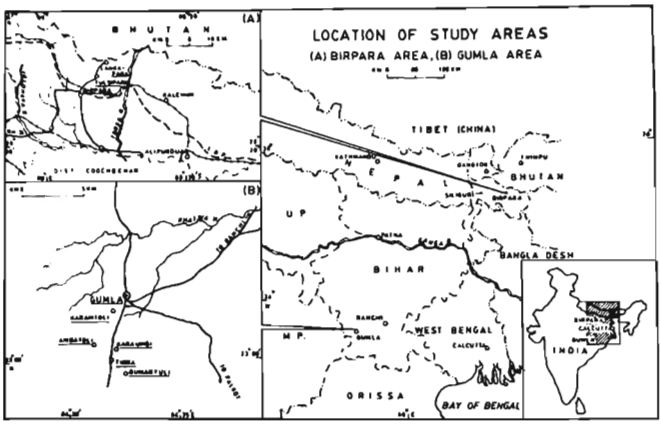

Fig. 1. Geographic locations of two groups of Oraons studied.

Bhils in central or eastern India, tribals in western India (Gamils, Mahars, Koknas, Katkaris, Sorathis, Warlis), and the Nilgiri tribes (Kurumbas, Irulas) and the others with no or low Hb^S. The Oraons, Korkus, Kota, Chenchu, and Kadars fall in the latter category.

Red cell glucose-6-phosphate dehydrogenase (G6PD) deficiency is widespread in Indian populations (Saha and Banerjee, 1971a). However, there is relatively little information available on the distribution of G6PD phenotypes in the tribal populations of India. The frequency of Gd^{B^-} in the Oraons of Bihar has been found to be very low (0.04). The sample from Jalpaiguri was not suitable for G6PD study. A probable new *Gd* allele with 95% mobility and normal enzyme activity has been found in the frequency of 0.1392 in male Oraons and 0.1087 in female Oraons. A single example of a heterozygous variant of about 50% mobility in combination with the normal GdB phenotype was encountered in a female Oraon. The phenotyping of Gd alleles was carried out using starch-gel electrophoresis in TEB buffer of pH 8.6. Further biochemical characterisation of these two probable new Gd alleles with normal activity will be needed to confirm this. It was not possible to carry out further investigations, as the samples were collected on filter paper strips and capillary tubes. The Gd (B^-) allele frequency in Irula, Korkus, and Kurumba were, respectively, 9.0, 9.8, and 4.9% in males, and 12.5 and 18.7% in females (Saha et al., 1976; Saha and Goswami, 1987). Meera Khan (1964) also reported a high frequency of G6PD deficiency (8.5%) in tribal populations of Andhra Pradesh compared to 1.2% in the nontribal populations of the same locality. Phenotyping of red cell G6PD by starch-gel electrophoresis established the absence of the African gene (Gd^A) in the tribal populations of India so far studied, including the Oraons. However, recently two cases of Gd^A have been observed among 102 Korkus of central India (Saha and Goswami, 1987). A detailed search for Gd alleles among the Indian tribal populations may exhibit the Gd^A in other tribal populations. Further heterogeneity at the Gd locus has been observed in the Oraons of Bihar as well as in the Korkus. The frequency of Gd^- and GdB^- alleles in the Oraons is similar to that reported in the Bhils ($Gd^- = 6.7\%$; $Gd^{B^-} = 8.3\%$) by Papiha et al., 1978. A low incidence of Gd (Gd^{B^-}) has been reported in the Irula and Kurumba tribes of the Nilgiris, which also carry a high frequency of the sickle cell gene. On the contrary, the Todas have no G6PD deficiency (Saha et al., 1976).

TABLE 1. Hemoglobin, serum protein and red cell enzyme polymorphisms in the Oraons from two localities

Locus	Phenotypes	Gumla, Bihar No. obs.	Gumla, Bihar No. exp.	Jalpaiguri, North Bengal No. obs.	Jalpaiguri, North Bengal No. exp.		Gene frequencies Gumla	Gene frequencies Jalpaiguri
1. Hemoglobins	A	128	128.01	202	202.00	Hb^A	.9923	.9951
	AS	1	0.98	2	1.99	Hb^S	.0038	.0049
	AH	1	0.98	0	0.00	Hb^H	.0038	.00
	Total	130		204				
2. Serum proteins a. Haptoglobin	1–1	3	2.37	0	1.83	Hp^1	.1481	.1017
	2–1	26	27.25	36	32.34	Hp^2	.8519	.8983
	2–2	79	78.38	141	142.83	Hp^0	—	.0056
	"O"	0	—	1	1.0			
	Total	108		178				
b. Transferrin subtypes (IEF)	C1-1	48	50.28	99	102.34	Tf^{C1}	.6446	.7118
	C2-1	48	44.47	77	71.52	Tf^{C2}	.2851	.2438
	C3-1	1	0.64	0	—	Tf^{C3}	.0041	.0025
	C2-2	8	9.84	9	12.50	Tf^{C4}	.00	.0049
	C3-2	0	—	1	0.72	Tf^{D1}	.0661	.0369
	C4-1	0	—	2	0.13			
	C1-D1	11	10.31	12	11.33			
	C2-D1	5	4.56	3	1.98			
	Total	121		203				
c. Group-specific component (IEF)	IF	23	16.27	24	16.83	Gc^{1F}	.3829	.2953
	IFIS	16	30.25	38	44.86	Gc^{1S}	.3559	.3839
	IS	21	14.06	37	30.16	Gc^2	.2613	.3109
	IF2	23	22.21	28	35.44			
	IS2	21	20.65	40	47.26			
	2	7	7.50	26	18.65			
	Total	111		193				
3. Red cell enzymes a. Acid phosphatase	A	10	6.62	5	3.40	p^a	.2283	.1307
	AB	38	44.75	42	44.96	p^b	.7717	.8643
	B	79	75.63	151	148.66	p^c	.00	.0050
	C	0	0	1	0.05			
	Total	127		199				
b. Esterase D	1	48	43.69	76	73.23	ESD^1	.5984	.6128
	2–1	50	58.64	87	92.54	ESD^2	.4016	.3872
	2	24	19.68	32	29.24			
	Total	122		195				
c. Phosphoglucomutase-locus 1 (IEF)	1+	52	49.62	78	71.55	PGM^{1+}	.6202	.7049
	1+1−	15	13.65	10	14.80	PGM^{1-}	.0853	.0729
	1−	1	0.94	3	0.77	PGM^{2-}	.2442	.1319
	1+2+	32	39.07	23	26.78	PGM^{2+}	.0465	.0625
	1+2−	8	7.44	9	6.34	PGM^6	.0041	.0208
	1−2+	4	5.37	3	2.77	PGM^{7*}	.00	.0069
	1−2−	1	1.02	0	0.66			
	2+	12	7.69	5	2.51			
	2+2−	3	2.77	1	2.37			
	2−	0	0.28	4	0.56			
	1−6	0	—	1	0.44			
	1+6	1	0.66	4	4.22			
	2+6	0	—	1	0.79			
	1+VS	0	—	1	1.40			
	1−VS	0	—	1	1.06			
	Total	129		144				
d. Adenylate kinase	1	111	112.84	153	152.72	AK^1	.9192	.9037
	2–1	17	19.33	32	32.55	AK^2	.0808	.0963
	2	2	0.83	2	1.39			
	Total	130		187				

(continued)

TABLE 1. Hemoglobin, serum protein and red cell enzyme polymorphisms in the Oraons from two localities (continued)

Locus	Phenotypes	Gumla, Bihar No. obs.	Gumla, Bihar No. exp.	Jalpaiguri, North Bengal No. obs.	Jalpaiguri, North Bengal No. exp.	Gene frequencies	Gumla	Jalpaiguri
e. 6-Phosphogluconate dehydrogenase	A	120	120.02	119	117.43	PGD^A	.9878	.9432
	AC	3	2.96	11	14.14	PGD^C	.0122	.0568
	C	0	0.02	2	0.43			
	Total	123		132				
f. Glyoxalase I	1	21	16.20	27	20.81	GLO^1	.3600	.3468
	2–1	48	57.60	66	78.38	GLO^2	.6400	.6532
	2	56	51.20	80	73.81			
	Total	125		173				
g. Glucose-6-phosphate dehydrogenase	Males B+	65				Gd^{B+}	.8228	—
	B−	3				$Gd^{B-(+)}$	.1392	—
	B+(S)	1				Gd^{B-}	.0380	—
	Total	79						
	Females B+	35						
	A+B+	0						
	B−	5						
	B+(S)	5						
	B+(50% mob)	1						
	Total	46						

TABLE 2. Genetic distances among the Oraons and other eight tribes and two caste populations of southern India based on ten polymorphic loci

	OR1	OR2	BH	KA	IR	KU	TO	KO	CH	TA	NA	MA
Oraons Bihar (OR1)	—											
Oraons Jalpaiguri (OR2)	0.3349	—										
Bhils (BH)	0.3403	0.3419	—									
Kadar (KA)	0.5096	0.5350	0.4864	—								
Irula (IR)	0.5648	0.4880	0.3496	0.5684	—							
Kurumba (KU)	0.4669	0.5013	0.3527	0.5075	0.3443	—						
Toda (TO)	0.5027	0.5635	0.4580	0.4367	0.5161	0.5386	—					
Kota (KO)	0.4265	0.5932	0.5130	0.5146	0.7193	0.5961	0.4955	—				
Chenchu (CH)	0.8933	0.9410	0.8585	0.9301	0.9148	0.8605	0.9180	0.9393	—			
Tamils (TA)	0.4443	0.4154	0.3113	0.4366	0.4395	0.4423	0.3431	0.4975	0.8474	—		
Nayar (NA)	0.4574	0.4277	0.3191	0.4132	0.4478	0.4281	0.3576	0.4811	0.8590	0.1349	—	
Malayarayan (MA)	0.5124	0.4569	0.4103	0.3981	0.4726	0.4073	0.4708	0.5514	0.9130	0.3333	0.2939	—

Source: Oraons: Blood groups—Kirk et al., 1962; Piplai et al., 1965; other polymorphisms—present study.
Bhils: Papiha et al., 1978.
Kadar: Saha et al., 1974.
Kota: Ghosh et al., 1977.
Chenchu: Ramesh et al., 1980.
Tamils: Saha (unpublished).
Others: Saha et al., 1976.

Serum proteins

Haptoglobins. The frequency of the Hp^1 allele in the Oraons of Gumla was 0.15 and in Jalpaiguri, 0.14. This was about the same as reported by Kirk et al. (1962). Mukherjee et al. (1975), however, have reported a much lower frequency (0.08) of Hp^1 in their series from the Ranchi district of Bihar. The difference in gene frequency of Hp^1 between the present series and that of Mukherjee et al. (1975) may be due to heterogeneity among the Oraons. However, in the present series the phenotyping of haptoglobins has been carried out by a more sensitive PAG electrophoresis. No Hp^0 or Hp^{2-1M} was encountered in the Gumla series, while only one instance of Hp^0 was found in the Jalpaiguri Oraons. A similar frequency of Hp^1 has been observed in some other tribal populations of India (Irula, Kota, and Kurumba of the Nil-

giris) and Malayrayan of Kerala (Saha et al., 1976). The Bhil tribe of Madhya Pradesh and Yanadis of Andhra Pradesh also have a low frequency of Hp^1 (0.10 and 0.08) (Papiha et al., 1978; Reddy et al., 1982). However, the Todas of Nilgiris and Kadars of the Annamalai hills have much higher frequencies of Hp^1 (0.28 and 0.30, respectively; Saha et al., 1974; 1976). The other tribes of India have frequencies of Hp^1 intermediate between these two extremes (Saha et al., 1976; Ghosh et al., 1977; Ramesh et al., 1979; 1980).

Transferrins. The frequency of Tf^{D1} in the present series of the Oraons of Bihar was 0.06, which is slightly higher ($X_1^2 = 3.6$; $P = >0.05$) than that reported by Kirk et al. (1962) but similar to that of Mukherjee et al. (1975). However, the Tf^{D1} frequency in the Jalpaiguri series was much lower (0.04). This is the highest frequency of Tf^{D1} in any of the Indian populations investigated. The Tf^{D} variant in the Oraons is definitely not the Tf^{DChs} originally described by Kirk et al. (1964). Its rate of migration was different from that of Tf^{DChs} on direct comparison on IEF gels.

On subtyping by isoelectric focusing the frequency of Tf^{C1}, Tf^{C2}, and Tf^{C3} in the Oraons was 0.6446, 0.2851, and 0.0041, respectively, in Bihar, while they were slightly different in the Jalpaiguri sample (0.7118, 0.2438, and 0.0025). There are very limited data available on the distribution of Tf^{C} subtypes in the populations of the Indian region (Saha, 1987). A low frequency of Tf^{C4} (0.0049) was observed in the Jalpaiguri sample. The frequency of Tf^{C1} in the Oraons is slightly lower than that reported in the tribes and caste populations of India (Saha and Tan, 1983; Kamboh and Kirk, 1983; Reddy et al., 1984; Walter et al., 1981, 1983; Saha, 1987). The frequency of Tf^{C1} in the Oraon is similar to that reported in the Soliga (Kamboh and Kirk, 1983) and Konda Kamera tribe (Walter et al., 1981).

Group-specific components. The frequency of Gc^{1F}, Gc^{1S}, and Gc^{2} was 0.3829, 0.3359, and 0.2613, respectively, in the Oraons of Bihar, while they were slightly different in the Jalpaiguri Oraons (0.2953, 0.3938, and 0.3109, respectively). The frequency of Gc^1 and Gc^2 in the Oraons of Gumla is in agreement with that observed by Kirk et al. (1963). The frequencies of Gc^1 and Gc^2 of the Oraons fall within the reported frequencies of these alleles in the Indian populations. However, very limited data are available on the distribution of Gc alleles in the tribal populations. Walter et al. (1972) reported similar results among the tribals of West Bengal, whereas the Irulas of Nilgiris have much lower frequencies of Gc^2 (0.10).

Only limited information is available on the distribution of Gc subtypes in Indian populations. The gene frequency of Gc^{1F} observed in the Oraons of Bihar (0.3829) and Jalpaiguri (0.2953) appears to be much higher than in the other tribal groups of South India (0.082–0.23; Walter et al., 1984; Kamboh and Kirk, 1984). However, the Mongoloid tribes of Assam and East Asia have been reported to have a similar high frequency of Gc^{1F} (Walter et al., 1986; Saha, 1988a).

It seems that the subtyping of Gc may prove to be a useful marker to trace genetic differences among Indian population groups. Unfortunately, very limited information is available in the Indian tribal groups at present. Himachal tribes and North Indians in general have a much lower frequency of Gc^{1F} (Papiha et al., 1983). Tamil Hindus sampled in Singapore have a frequency of 0.305 for Gc^{1F} (Saha, unpublished). A high frequency of Gd^{1F} is, in general, typical of mongoloid and negroid populations (Saha, 1988a). There is an excess of homozygotes at the Gc locus in both the samples of Oraons ($X_1^2 = 3.335$; $P = >0.05$ and 5.24; $P = <0.025$ respectively).

Red cell enzyme systems

Acid phosphatase. The frequencies of p^a and p^b in the Oraons of Bihar were 0.23 and 0.77, respectively, compared to a frequency of 0.13 and 0.86 in the Jalpaiguri sample. A similar low frequency of p^a (0.14) has been reported in the Oraons in Andamans and Ranchi by Bhattacharyya et al. (1980) and Das et al. (1983), respectively. Similar frequencies of the acid-phosphatase alleles have been reported in the Bhils of Madhya Pradesh, tribals of Andhra Pradesh, and the Kurumba of Nilgiris (Papiha et al., 1978; Saha et al., 1976; Rao et al., 1978). A higher frequency of p^a has been reported in the Chenchu tribe of Andhra Pradesh (0.38) and the Kotas of the Nilgiris (0.46) by Ramesh et al. (1980) and Ghosh et al. (1977), respectively. The Kadar, Irula, and Toda of the Nilgiris and Yanadi tribe of Andhra Pradesh have a lower frequency of p^a (Saha et al., 1974, 1976; Reddy et al., 1982). There are wide variations of the frequency of acid phosphatase alleles

among the different caste and tribal groups of the Indian population.

Esterase D. Very limited information is available on the distribution of this enzyme system in Indian populations. The frequency of EsD^1 has been found to range from 0.69 to 0.76 in various populations of Indian regions (Ghosh, 1977a). The Oraons of the present series have a frequency of EsD^1 of 0.5984 and 0.6128 in Bihar and Jalpaiguri, respectively. This is not very different from that reported in the Oraon series of Das et al. (1983) (0.67) or in some tribal groups like Chenchu (0.62), Kolams (0.56), Konda Kamera (0.64) of Andhra Pradesh (Ramesh et al., 1979, 1980; Reddy et al., 1982; Veerraju et al., 1982). The mongoloid populations have been reported to have a lower frequency of EsD^1 compared to various Indian populations (Papiha and Nahar, 1977). The Bhils of Madhya Pradesh and Koya Doras of Andhra (Papiha et al., 1978, Veerraju et al., 1982) and the Kotas of the Nilgiris have a slightly higher frequency of EsD^1 (0.71–0.74; Ghosh et al., 1977).

Phosphoglucomutase (locus 1). The frequencies of PGM^1 and PGM^2 for the Oraons of Bihar were 0.70 and 0.29, respectively; in the Jalpaiguri samples frequencies were 0.77 and 0.20. Similar gene frequencies at the PGM_1 locus have been reported in the Oraons of Ranchi and Andaman islands by Mukherjee et al. (1975) and Bhattacharyya et al. (1980), respectively, and in Bhils of Madhya Pradesh and other south Indian tribes, excepting the Kadars (Papiha et al., 1978). An uncommon allele (PGM^6) has been reported in low frequency in the Kadar, Malayalaram, and Koya Dora. The Kadar variant of PGM^6 has been found to be a private allele with slightly different electrophoretic mobility from that of PGM^6 (Saha et al., 1974). In the present group of Oraons a solitary example of PGM^6 has been observed.

The frequencies of PGM^1 subtypes of the present group of Oraons have been observed as follows: PGM^{1+}—0.6202; PGM^{1-}—0.0853, PGM^{2+}—0.2442; PGM^{2-}—0.0462; PGM^6—0.004 in Bihar as compared to 0.7049, 0.0729, 0.1319, 0.0625, and 0.0208 in the Jalpaiguri sample. However, the gene frequencies of the PGM alleles in a group of 76 Oraons investigated by Das et al. (1983) are somewhat different from the present series in the Jalpaiguri sample. Mukherjee et al. (1975) and Bhattacharyya et al. (1980) reported a PGM^2 frequency of 0.316, and 0.33 in their Oraon samples from Ranchi and Andamans, respectively. The Korkus of Madhya Pradesh have a similar frequency of PGM (subtype) alleles (Saha and Goswami, 1987). The tribal populations of south India have similar frequencies of PGM, subtypes, while Tamil Hindus and the Soliga tribe of Andhra Pradesh and Himachal populations have a much lower frequency of PGM^{1+} (Papiha et al., 1981; Saha, 1983, 1988b; Kamboh and Kirk, 1984). In general, the caste groups of Andhra, Kerala, and Karnataka have similar frequency of PGM^{1+}.

Adenylate kinase. The frequency of AK^2 in the present population is 0.08, which is similar to that reported in the Irula, Kurumba of the Nilgiris. A lower frequency of AK^2 has been reported in tribes like the Bhils, Toda, and Kota of Nilgiris and Kolams of Andhra Pradesh. The overall distribution of AK alleles is similar in tribal and nontribal populations of India.

6-Phosphogluconate dehydrogenase. A lower frequency of PGD^c (0.0122) has been observed in the Oraons of Bihar compared to that in Jalpaiguri (0.0568). Similar frequencies of PGD^c have been reported in some of the Indian tribes investigated (Bhils, Irula, Toda, Kurumba, Chenchu, Kolams, Koya Dora, Konda, and Kota).

Glyoxalase I. Very little information is available on the distribution of GLO I in the tribal populations of India. The frequency of GLO^1 and GLO^2 in the present Oraon population was 0.36 and 0.64 in the Bihar sample, and 0.35 and 0.65 in Jalpaiguri, respectively. Reddy et al. (1983) reported a frequency of 0.23 for GLO^1 in a sample of 71 Oraons ($\chi_1^2 = 4.7$; $P = <0.01$). A lower frequency of GLO^1 has also been reported in the Koya Dora and Konda tribes of Andhra Pradesh (Veerraju et al., 1982) and Mundas of Bihar (Reddy et al., 1983). The frequency of GLO^1 in different Indian population groups has been reported to vary from 0.1471 to 0.2799 (Ghosh, 1977b).

Lactate dehydrogenase. The widespread prevalence of the variant forms of LDH is a unique feature of the populations of India. All the caste-groups investigated have been found to have LDH variant in polymorphic frequency. No LDH variant was observed in the present series of 334 Oraons, although Mukherjee et al. (1975) reported the presence of three heterozygotes of the LDH-Calcutta-1 variant in their series of Oraons. Das et al. (1983) also failed to detect any LDH

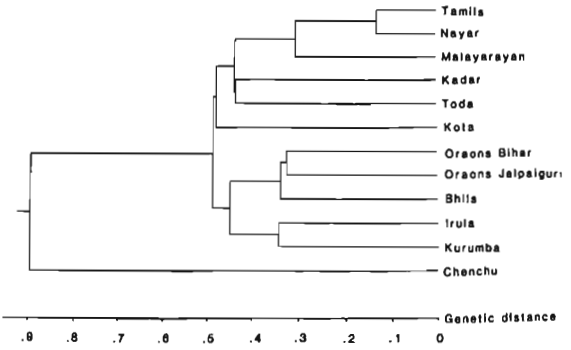

Fig. 2. Dendrogram for sedente (Bihar) and migrant (Jalpaiguri) Oraons; other eight tribal and caste populations of south India based on ten polymorphic loci controlling 33 alleles.

variant in their series of Oraons. Most of the tribal populations of India lack LDH variant.

Monomorphic systems. No variation at the loci for albumin, malate dehydrogenase, phosphohexose isomerase, phosphoglucomutase (locus 2), and superoxide dismutase has been observed in the present Oraons. Only rarely have variant forms of PHI been reported in tribal populations of India.

Genetic distance of the Oraons

The genetic relationships of the Oraons with eight other Australoid tribes of central and southern India and Tamils and Nayar (caste Hindus) of southern India were studied by genetic distance analysis. The genetic distances between the tribes and two caste populations have been computed using ten polymorphic loci controlling 33 alleles: ABO (p, q, r), MN (M, N), Rhesus (Rz, $R1$, $R2$, Ro, r'', r, r') blood groups; haemoglobin (Hb^A, Hb^H, Hb^S), haptoglobin (Hp^1, Hp^2), transferrin (Tf^C, Tf^B, Tf^D); red cell acid phosphatase (p^a, p^b, p^c), phosphoglucomutase-1 (PGM^1, PGM^2, PGM^3, PGM^7, PGM^{sn}), adenylate kinase (AK^1, AK^2), and 6-phosphogluconate dehydrogenase (PGD^A, PGD^C, PGD^K). The distance matrix is computed by using the formula of Cavalli-Sforza and Edwards (1967). The distance matrix is presented in Table 2. The dendrogram was derived from the distance matrix, using the cluster and tree procedures employing Ward's minimum variance method (Ward, 1963) on the IBM 3081 (Fig. 2).

The results show that the Oraons are nearest to the Bhils of Madhya Pradesh with whom it forms one cluster. The Oraons and Bhils are nearer to the Kurumba and Irula tribes of the Nilgiri Hills rather than the Toda of the Nilgiri Hills and Malayaram and Kadar of the Annamallni Hill region. The Kota of the Nilgiri and the Chenchu of south India are the most distant tribes, and they formed two separate arms unrelated to all the other tribes.

Genetic heterogeneity of the Oraons

There are some appreciable differences in gene frequencies between the Oraons of Bihar and the Jalpaiguri area at the Hp, Gc, and AP loci. Heterogeneity at the Hp locus has also been observed between the series of Mukherjee et al. (1975) and Kirk et al. (1962), both from Bihar and in the frequency

of p^* and $G10^1$ in the Oraons of Bihar and Andamans (Das et al., 1983; Reddy et al., 1983) (X_1^2 3.36–4.79; P = <0.05). Similar heterogeneity in the distribution of blood groups has been observed betwen the Orsons sampled by Kirk et al. (1962) and Sarkar (1942–43); and between the Oraons of Duars (North Bengal) and Ranchi (Bihar) (Piplai et al., 1985).

However, a detailed genetic distance analysis of the Oraons of Bihar and Jalpaiguri of the present study in relation to other tribes and caste groups of southern India failed to delineate much heterogeneity between the Oraons of these two localities.

It may therefore be concluded that the Orsons are genetically homogeneous in spite of differences in gene frequencies at some of the loci. They are most closely related to the Bhils of central India and nearer to the Irula and Kurumba of the Nilgiris. They are characterized by very low or absence of Hb^S, low Hp^1, absence of LDH variant, and a high frequency of TF^{D1} and Gc^{1F}. The earlier studies demonstrated their having high B, R_1 and Di^{a*} at the blood group loci.

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LITERATURE CITED

Bhattacharyya SK, Ghosh AK, Bharti P, and Dey B (1980) Red-cell enzyme study among some migrant tribal populations in the Andaman islands. Z. Morph. Anthropol. *71*:336–340.

Cavalli-Sforza L, and Edwards AWF (1967) Phylogenetic analysis: Models and estimation procedures. Am. J. Hum. Genet. *19*:234–257.

Choudhury MR (1978) The Tea Industry in India. A Diagnostic Analysis of its Geoeconomic studies. Calcutta: Oxford Book and Stationary Company.

Das SK, Reddy AP, Dey B, Chatterjee Sikha, Sarkar JM, and Basu A (1983) Red cell enzyme polymorphisms among the Oraon. Hum. Sci. (Anth. Survey India) *32*:57–59.

Ghose B (1971) Census of India: Series 22 West Bengal Part IIA: General population tables Delhi, 1973.

Ghosh AK (1977a) The distribution of genetic variants of Glyoxalase I, Esterase D and Carbonic anhydrase I and II in Indian populations. Indian J. Phys. Anthrop. Hum. Genet. *3*:73–83.

Ghosh AK (1977b) Polymorphism of red cell glyoxalase I. With special reference to South and Southeast Asia and Oceania. Hum. Genet. *39*:91–96.

Ghosh AK, Kirk RL, Joshi SR, and Bhatia HM (1977) A population genetic study of the Kota in the Nilgiri Hills, South India. Hum. Hered. *27*:225–241.

Grierson GA (1905) Linguistic Survey of India. Vol. IV. Calcutta.

Guha BS (1951) The Indian Aborigines and their Administration. Delhi.

Grunnings JF (1911) Eastern Bengal and Assam District Gazetteers. Allahalad: Allahalad Press.

Harris H, and Hopkinson DA (1976) Handbook of Enzyme Electrophoresis in Human Genetics. Amsterdam: North Holland Publishing Company.

Howells WW (1937) Anthropometry of the natives of Arnhem Land and the Australian race problem. Pap. Peabody. Mus. Am. Arch. Ethn. XXI.

Hunter WW (1811) A statistical Accounts of Bihar. Vol. 17—Concept, Delhi.

Kamboh MI, and Kirk RL (1983) Distribution of Transferrin (Tf) subtypes in Asian, Pacific and Australian aboriginal populations: Evidence for the existence of a new subtype TF^{C8}. Hum. Hered. *33*:237–243.

Kamboh MI, and Kirk RL (1984) Genetic studies of PGM1 subtypes: Population data from the Asian-Pacific area. Ann. Hum. Biol. *11*:211–219.

Kirk RL, Cleve H, and Bearn AG (1963) The distribution of the group specific component (Gc) in selected populations in South and South East Asia and Oceania. Acta Genet. Stat. Med. *13*:140–149.

Kirk RL, Lai LYC, Vos GH, and Vidyarthi LP (1962) A genetical study of the Oraons of the Chota Nagpur Plateau (Bihar, India). Am. J. Phys. Anthropol. *20*:375–385.

Kirk RL, Parker WC, and Bearn AG (1964) The distribution of the transferrin variants D1 and Dchi in various populations. Acta Genet. Stat. Med. *14*:41–51.

Meera Khan P (1964) Glucose-6-phosphate-dehydrogenase deficiency in an Indian rural area. J. Genet. *59*:14–18.

Mukherjee BN, Das SK, and Dash Sharma P (1975) Serum protein and red cell enzyme polymorphisms in Oraon tribe, India. Ann. Hum. Biol. *2*:201–204.

Papiha SS, and Nahar A (1977) The world distribution of the electrophoretic variants of the red cell enzyme Esterase D. Hum. Hered. *27*:424–432.

Papiha SS, Roberts DF, Mukherjee DP, Singh SD, and Malhotra M (1978) A genetic survey in the Bhil tribe of Madhya Pradesh, Central India. Am. J. Phys. Anthropol. *49*:179–185.

Papiha SS, White I, and Chahal SM (1981) Study of phosphoglucomutase polymorphism by isoelectric focusing: Gene frequencies in the Gaddi tribe of Himachal Pradesh, India. Ann. Hum. Biol. *8*:379–382.

Papiha SS, White I, and Roberts DF (1983) Some genetic implications of isoelectric focusing of human red cell phosphoglucomutase (PGM1) and serum protein group-specific component (Gc): Genetic diversity—in the populations of Himachal Pradesh, India. Hum. Genet. *63*:67–72.

Piplai C, Vasantha K, Gorakshaker AC, Bhatia HM, and Bhattacharyya SK (1985) A note on ABO, MN, Rh and In(a) blood groups of Tamang and Oraon tea-labourers of the Jalpaiguri district West Bengal. J. Indian Anthrop. Soc. *20*:68–70.

Ramesh A, Blake NM, Vijaykumar M, and Murthy JS (1990) Genetic studies on the Chenchu tribe of Andhra Pradesh. Hum. Hered. *30*:291–298.

Ramesh A, Murthy J, and Blake NM (1979) Genetic studies on the Kolams of Andhra Pradesh, India. Hum. Hered. *29*:147–153.

Rao PM, Blake NM, and Veerraju P (1978) Genetic studies on the Savara and Jatapu tribes of Andhra Pradesh, India. Hum. Hered. *29*:122–131.

Reddy AP, Mukherjee BN, Malhotra KC, Walter H, Sauber P (1984) Transferrin subtypes by isoelectrofocussing in three West Bengal populations. Z. Morphol. Anthropol. *74*:345–349.

Reddy AP, Mukherjee BN, Malhotra KC, Das SK, and Ramachandriah T (1982) A serological and biochemical genetic study among the coastal and plateau Yanadis: A tribal population of Andhra Pradesh. Homo. *33*:174–185.

Reddy AP, Mukherjee BN, and Basu A (1983) Glyoxalase 1 Polymorphism among three tribes of Eastern India. J. Indian Anthropol. Soc. *18*:195–196.

Risley HH (1891) Tribes and castes of Bengal: Ethnographic Glossary Vol. I. Calcutta: Bengal Secretariat Book Depot.

Roy SC (1915) The Oraons of Chotanagpur: History, Economic Life and Social Organization. Ranchi: Man in India Press.

Saha N (1987) Distribution of transferrin (Tf) subtypes in several mongoloid populations of East Asia. Ann. Hum. Biol. *14*:349–357.

Saha N (1988a) Distribution of group-specific component (Gc) subtypes in several Mongoloid populations of East Asia. Ann. Hum. Biol. IN PRESS.

Saha N (1988b) Distribution of red cell phosphoglucomutase (PGM1) subtypes in several Mongoloid populations of East Asia. Am. J. Phys. Anthropol. IN PRESS.

Saha N, and Banerjee B (1971a) Incidence of erythrocyte glucose-6-phosphate dehydrogenase deficiency among different ethnic groups of India. Hum. Hered. *21*:78–82.

Saha N, and Banerjee B (1971b) Incidence of abnormal haemoglobins in different ethnic groups of Indiana. Hum. Genet. *11*:300–303.

Saha N, and Banerjee B (1973) Haemoglobinopathies in the Indian subcontinent. Acta Genet. Med. Gemell. *22*:117–138.

Saha, N (1983) Red cell phosphoglucomutase (PGM_1) subtypes in three ethnic groups of Singapore. Proc. 15th Int. Congr. Genet., New Dehli p. 776.

Saha N, and Goswami HK (1987) Some blood genetic markers in the Korkus of Central India. Hum. Hered. *37*:272–277.

Saha N, and Kirk RL (1973) A simple technique for collecting blood for population studies of enzyme polymorphisms and haemoglobins. Hum. Hered. *23*:182–187.

Saha N, Kirk RL, Shanbhag S, Joshi SH, and Bhatia HM (1974) Genetic studies among the Kadar of Kerala. Hum. Hered. *26*:175–197.

Saha N, Kirk RL, Shanbhag S, Joshi SR, and Bhatia HM (1976) Population genetic studies in Kerala and the Nilgiris (South West India). Hum. Hered. *26*:175–197.

Saha N, and Tan PY (1983) Transferrin C subtypes among some populations of the Indian subcontinent. Abstract Ann. Hum. Biol. *10*:84–85.

Sarkar SS (1942–43) Analysis of Indian blood group data with special reference to Santal Parganas, Bihar. Trans. Bose Res. Inst. *15*:1–3.

Sarkar SS (1949) ABO blood groups from Palamau, Bihar, India. Am. J. Phys. Anthropol. *7*:559–563.

Veerraju P, Sudhaker Babu M, Jailkishan G, Naidu JM, and Blake NM (1982) Genetic study on the Koya Dora and Konda Kammara tribe of Andhra Pradesh, India. Hum. Hered. *32*:240–245.

Vidyarthi LP (1983) Tribes of India. In "Peoples of India." XV International Congress of Genetics, New Delhi, 1983. Indian Council of Medical Research, pp. 85–103.

Walter H, Dannewitz A, Veerraju P, and Goud JD (1984) Gc subtyping in South Indian tribal and caste populations. Hum. Hered. *34*:250–254.

Walter H, Kellermann G, Bajatzadeh M, Kruger J, and Chakravartti MR (1972) Hp, Gc, Cp, Tf, Bg and Fi phenotypes in leprosy patients and healthy controls from West Bengal (India). Humangenetik *14*:314–325.

Walter H, Mukherjee BN, Gilbert K, Lindenbery P, Dannewitz A, Malhotra K, Das BM, and Deka R (1986) Investigations on the variability of Haptoglobin, Transferrin and Gc polymorphisms in Assam, India. Hum. Hered. *36*:388–396.

Walter H, Pahl KP, Hilling M, Goud JD, Naidu JM, Sudhakar BM, and Jai Kishan G (1981) Genetic markers in eight endogamous population groups of Andhra Pradesh (South India). Z. Morp. Anthropol. *72*:325–338.

Walter H, Stach M, Singh IP, and Bhasin MK (1983) Transferrin subtypes in four Northwest Indian tribal populations and some remarks on the anthropological value of this new polymorphism. Am. J. Phys. Anthropol. *61*:423–428.

Walter H, Stroditmann H, Hilling M, Singh IP, Bhasin MK, and Veerraju P (1981) Transferrin subtypes in six Indian population samples. Hum. Hered. *31*:152–155.

Ward JH (1963) Hierarchical grouping to optimize an objective function. J. Am. Stat. Assn. *58*:236–244.