Genetic studies among the Siddis of Karnataka, India: A migrant population from Africa

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With 5 figures and 26 tables in the text

Summary: 18 polymorphic systems of the blood — A1A2BO, MNSs, Rhesus (C,c,D,E,e), Duffy, Diego; Haptoglobin (Hp), Ceruloplasmin (Cp), Transferrin subtypes (Tf), Gc subtypes (Gc), Gm (1,2,5), Km (1); red cell acid phosphatase (aP), phosphoglucomutase subtypes (PGM1), adenylate kinase (AK), adenosine deaminase (ADA), esterase D (EsD), lactate dehydrogenase (LDH), and haemoglobin variants — were typed on 237 Siddis from Karnataka (South India), a Negroid population of African descent, which came to India at various periods, starting as early as 1100 A.D. They were mainly imported as slaves. The typing results were compared with that of two other population groups of Karnataka: Havig Brahmins (n = 140) and Muslims (n = 27) as well as with pooled samples of Ethiopia. It is seen that the genetic pattern of the Siddis is much more similar to that of Ethiopians than to Havig Brahmins or Muslims. One can assume that this is due to the genetic isolation of the Siddis, though some gene flow from Indian side cannot be ruled out completely.

Zusammenfassung: 18 polymorphe Systeme des Blutes — A1A2BO, MNSs, Rhesus (C,c,D,E,e), Duffy, Diego; Haptoglobin (Hp), Coeruloplasmin (Cp), Transferrin subtypes (Tf), Gc subtypes (Gc), Gm (1,2,5), Km (1); saure Erythrozytenphosphatase (aP), Phosphoglucomutase subtypes (PGM1), Adenylatkinase (AK), Adenosindesaminase (ADA), Esterase D (EsD), Lactatdehydrogenase (LDH) und Hämoglobin-Varianten — wurden an 237 Siddis aus Karnataka (Süd-Indien) untersucht. Bei den Siddis handelt es sich um eine negride Population afrikanischer Herkunft, die zu verschiedenen Zeiten seit 1100 n. Chr. nach Indien kam, vorwiegend als Sklaven. Die Untersuchungsergebnisse wurden mit denen an zwei anderen Populationen aus Karnataka gewonnenen verglichen: Havig Brahmins (n = 140) und Muslims (n = 27), darüberhinaus mit gepoolten Stichproben aus Äthiopien. Es zeigte sich, daß das »genetic pattern« der Siddis dem der äthiopischen Populationen deutlich ähnlicher ist als dem der Havig Brahmins oder Muslims. Man kann vermuten, daß das durch die genetische Isolation der Siddis bedingt ist, obwohl ein gewisser Genfluß von indischer Seite nicht völlig ausgeschlossen werden kann.

Introduction

The *Siddis*, a Negroid population in India, are of African descent and were brought into various parts of the country at various periods, starting as early as 1100 A.D. as evident from historical records (Enthoven 1922). They were mainly imported as slaves by the Arab and Portuguese traders (Sorley 1931) mostly from East African countries like Ethiopia, Kenya, Uganda, Mozambique, etc. They are also known as «Hubshi», this name being a deformation of the Arabic word, «El-habish», the Arabic name for the

former Abessynian empire, currently known as Ethiopia (Russel & Hiralal 1916). The word «Siddi» is derived from «Sayyid», meaning one, who has descended from the Prophet (Russel & Hiralal 1916).

Currently, the Siddi population in India is concentrated in the Western Ghat forests of the North Kanara district of Karnataka (Fig. 1 and 2), in the Gir forest of Junagadh district, Gujarat, and to a small extent in the city of Hyderabad, the capital of the South Indian State of Andhra Pradesh.

The Karnataka Siddis, who were studied for the present investigation, number about 5000 individuals (Vijayakumar & Malhotra 1983). They work mostly as forest and agricultural labourers, occasionally cultivating small patches of encroached land in the forests. Very few of them have their own lands. They follow the local social and cultural practices including consanguineous marriages (Vijayakumar & Malhotra 1983) and

Fig. 1. Location of Karnataka (black). BH = Bhutan, B.D. = Bangla Desh.

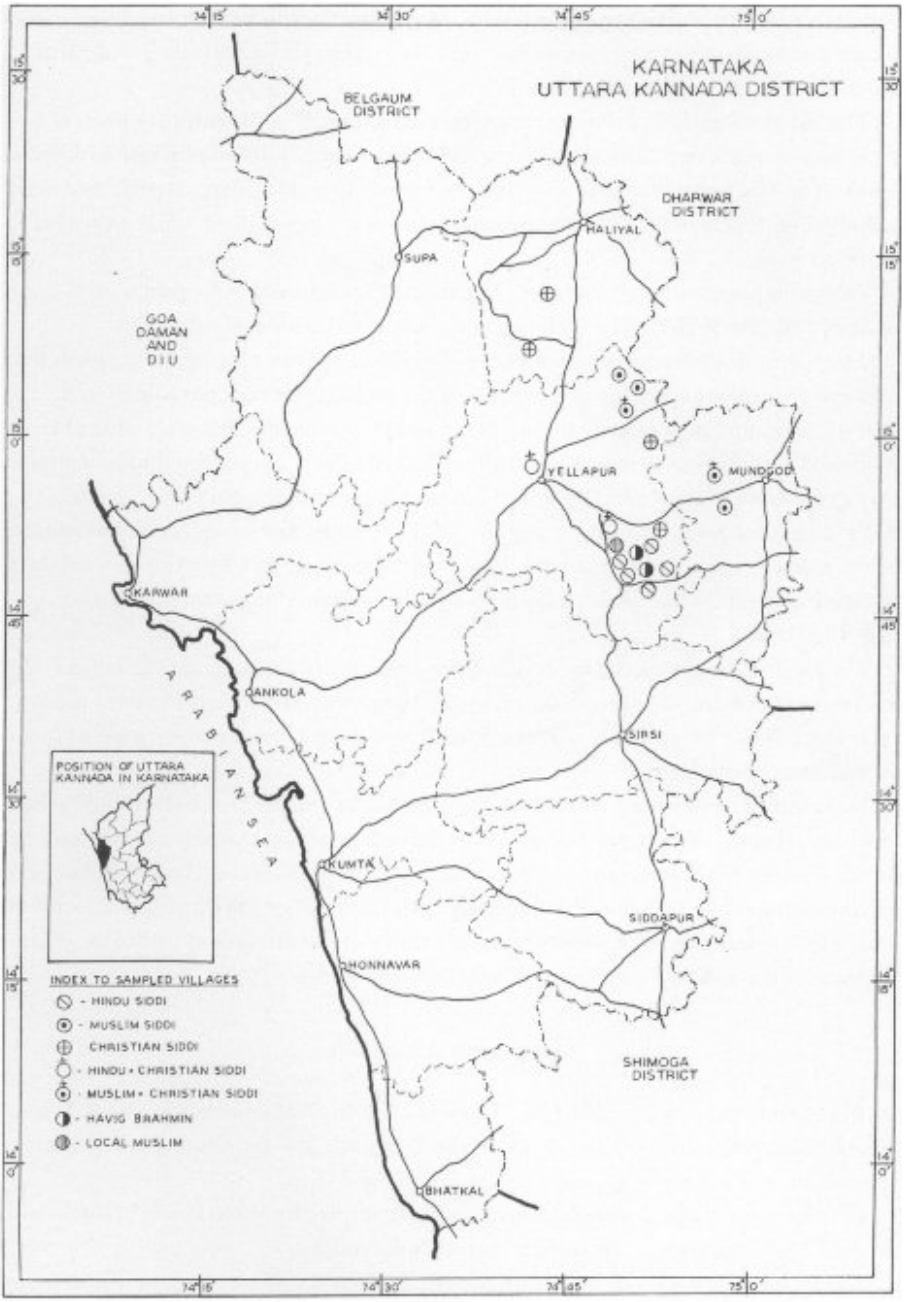

Fig. 2. Position of the North Kanara district of Karnataka, from where the samples were collected.

linguistic patterns, with Kannada, Konkini, Marathi and Urdu being spoken by various sections of Siddis. The Siddis are divided into three religious isolates: the *Hindu Siddis*, the *Muslim Siddis* and the *Christian Siddis*.

The Siddis are endowed with typical Negroid features (Fig. 3), having in general medium height, thick lips, broad nose, long and narrow head, scanty body hair with thick kinky to woolly hair on the head and dark complexion (Vijayakumar, unpublished data; Indo-Soviet Collaborative Anthropological Project, unpublished data; Abe 1983; Roychowdhury 1957).

The other populations of the North Kanara district, studied for the purposes of comparison with the Siddis, are the *Havig Brahmins* and the local *Muslims*.

The *Havig Brahmins* occupy a supreme position in the caste hierarchy in North Kanara and are expert horticulturists, cultivating the areca nut or betal nut palms (Areca catechu), cardamon, pepper and other spices in addition to paddy. A section of the Havig Brahmins also officiate as priests for the local Hindu castes. They are said to be a migratory group from North India (Bombay Gazetteer-Kanara 1883), but follow the local social and cultural practices. They are of brown to relatively fair complexion, medium to below medium in height, broad head, long to medium nose, thin lipped with wavy hair and medium to thick body hair (Indo-Soviet Collaborative Anthropological Project, unpublished data).

The local *Muslims* sampled in this study are numerically a small group, living in small pockets in towns and villages of North Kanara. They are mostly traders but some practise agriculture. They are probably of a mixed stock of Muslims from northern parts of India as well as converts from the local areas.

In view of the interesting ethno-history of the Siddis and the fact that serological and biochemical markers have great potentiality for understanding the genetic make up of a population like the Siddis, have prompted this study in 1983—84. To facilitate the comparison of the Siddis with the other local populations, the Havig Brahmins and the Muslims of the same region were also studied. This study was undertaken as part of the «Siddi Project» of the Indian Statistical Institute, Calcutta, India.

Materials and methods

Blood samples from 237 Siddis (125 Christian Siddis, 72 Muslim Siddis and 40 Hindu Siddis) were collected by finger prick method to study the distribution of 18 genetic systems for red cell antigens, isozymes and serum proteins.

In addition to the Siddi sample, blood was also collected from 140 Havig Brahmin and 27 local Muslim subjects, for comparison with the Siddis.

All the samples were collected from the North Kanara district of Karnataka in India (Fig. 2).

Following serological and biochemical markers were studied; *Blood group antigens:* ABO, MNSs, Rh complex, Duffy, Diego; *Isozymes:* red cell acid phosphatase (aP), phosphoglucomutase 1 (PGM1), adenylate kinase (AK), esterase D (EsD), adenosine deaminase (ADA) and lactate dehydrogenase (LDH); *Serum proteins:* Haptoglobin (Hp),

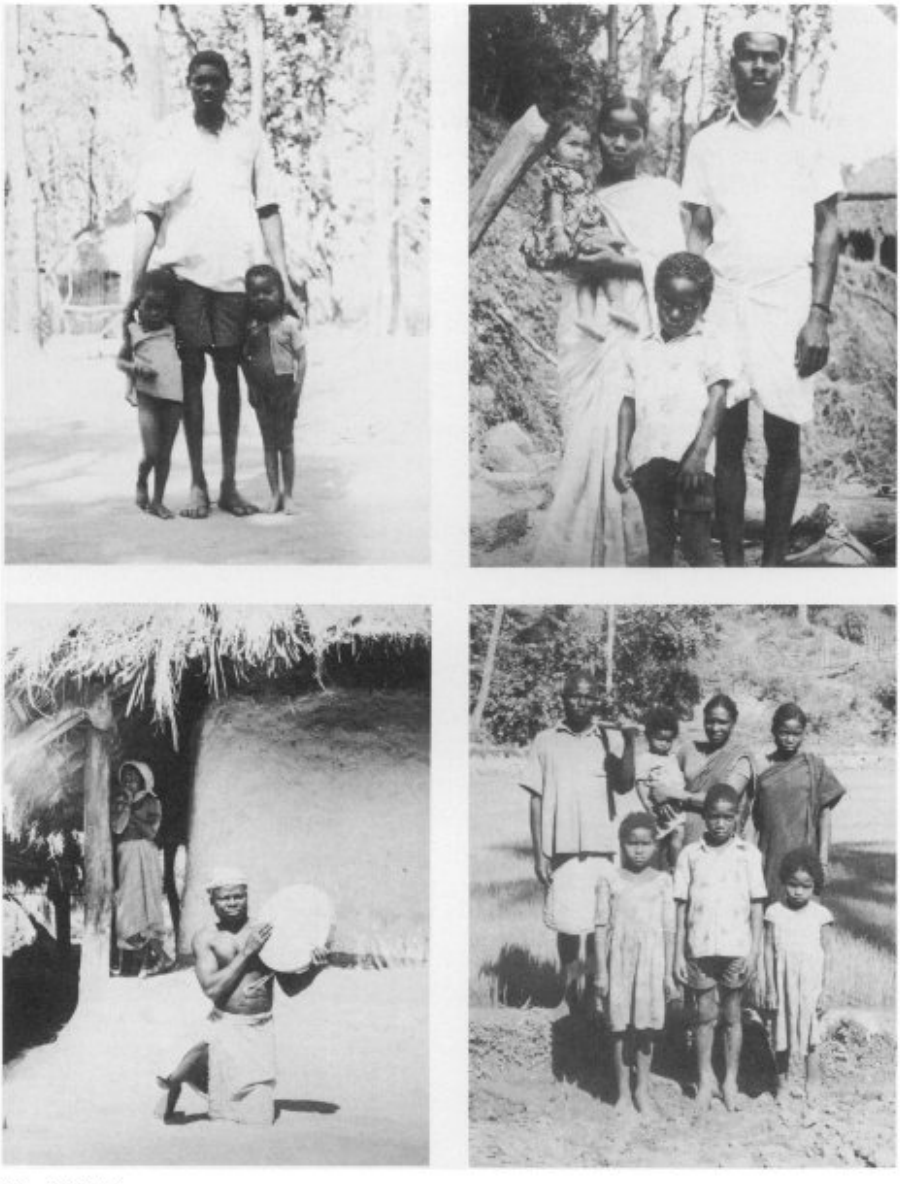

Fig. 3. Siddis.

Transferrin (Tf), Ceruloplasmin (Cp), group specific component (Gc), Gm and Km allotypes, and *haemoglobin variants* (Hb). Blood groups were tested by the technique and following the instructions in case of Rh complex as per RACE & SANGER (1975); the antisera were received from Ortho Diagnostic System Inc., Raritan, N.J. (USA), the Rh system was typed using five antisera as anti-C, -c, -D, -E and -e; the MNSs system was tested for anti-M, -N, -S and -s sera, while the Duffy and Diego system were screened with anti-

Fy(a) and anti-Di(a)-antisera, respectively. For ABO blood grouping, anti-A_1 serum was used for further sub-typing. Gm and Km typing were done according to STEINBERG (1980) using anti-Gm(1), -Gm(2) and -Gm(5) and anti-Km(1) sera obtained from the Molter Diagnostic, Heidelberg (W. Germany). Blood samples were tested for Tf and Gc subtypes by isoelectric focusing technique (IEF) following the technique described by DANNEWITZ (1985). Hp and Cp were done by starch gel electrophoresis as per ASHTON & BRADEN (1961); aP, EsD, AK, ADA and LDH were tested by starch gel electrophoresis following the methods described by HARRIS & HOPKINSON (1977) and PGM1 subtyping was performed by IEF according to MUKHERJEE et al. (1982). The Hb pattern were detected by starch gel electrophoresis using TEB buffer at pH 8.6. The blood samples were kept in the refrigerating temperature immediately after collection and were despatched to the Anthropometry and Human Genetics Laboratory in Indian Statistical Institute, Calcutta, where all the tests were performed, except Gm, Km and subtyping of Tf and Gc, which were done in the Department of Human Biology/Anthropology, University of Bremen, Bremen, W. Germany.

The maximum likelihood estimates of allele frequencies together with tests of Hardy-Weinberg equilibrium of phenotype frequencies were computed following the computer programme of REED & SCHULL (1968).

Results

The distribution of phenotypes with the Chi-square values for Hardy-Weinberg equilibrium tests and the allele frequencies with standard error of the 18 markers studied in the five population groups are given in Tables 1 to 25. The allele frequencies of these markers in the population group studied and the Ethiopians of Africa are given in Table 26. The

Table 1. ABO phenotype frequencies among the Siddis and other populations of Karnataka.

Population		Phenotypes						Total	χ^2	d.f.	P
		A_1	A_2	B	A_1B	A_2B	0				
PS	Obs.	43	9	69	8	1	107	237			
	Exp.	41.3	8.0	66.4	9.9	2.1	109.3	237.0	1.28	2	ns
HS	Obs.	4	6	9	1	0	20	40			
	Exp.	4.3	5.1	8.4	0.7	0.9	20.6	40.0	1.27	2	ns
MS	Obs.	19	2	20	0	0	31	72			
	Exp.	16.1	1.7	16.8	3.2	0.3	33.9	72.0	4.99	2	ns
CS	Obs.	20	1	40	7	1	56	125			
	Exp.	20.8	1.5	41.2	6.1	0.5	54.9	125.0	0.94	2	ns
HB	Obs.	36	2	13	1	1	87	140			
	Exp.	34.9	2.8	12.6	2.2	0.2	87.3	140.0	4.26	2	ns
MU	Obs.	9	2	6	3	0	7	27			
	Exp.	9.4	1.5	6.0	2.5	0.5	7.1	27.0	0.80	2	ns

Note: Population names in Tables 1 to 25 are abbreviated as: PS = Pooled Siddis; HS = Hindu Siddis; MS = Muslim Siddis; CS = Christian Siddis; HB = Having Brahmins; and MU = Local Muslims.

Table 2. Allele frequencies for ABO locus among the Siddis and other populations of Karnataka.

Population	Allele frequencies			
	A_1	A_2	B	O
PS	0.114 ± 0.015	0.024 ± 0.008	0.182 ± 0.019	0.680 ± 0.023
HS	0.064 ± 0.028	0.084 ± 0.033	0.135 ± 0.040	0.717 ± 0.053
MS	0.144 ± 0.030	0.017 ± 0.012	0.153 ± 0.031	0.686 ± 0.041
CS	0.114 ± 0.021	0.009 ± 0.006	0.214 ± 0.028	0.662 ± 0.032
HB	0.143 ± 0.022	0.013 ± 0.007	0.055 ± 0.014	0.789 ± 0.025
MU	0.253 ± 0.064	0.051 ± 0.035	0.183 ± 0.055	0.513 ± 0.076

Table 3. Phenotype frequencies for MNSs locus among the Siddis and other populations of Karnataka.

Population		Phenotype frequencies									
		MSS	MSs	Mss	MNSS	MNSs	MNss	NSS	NSs	Nss	Total	χ^2
PS	Obs.	4	5	28	7	22	82	6	6	42	202	
	Exp.	1.2	11.9	29.3	2.8	27.8	69.7	1.6	16.2	41.5	202.0	39.1^{+}
HS	Obs.	0	1	7	0	5	18	2	1	6	40	
	Exp.	0.0	0.8	8.7	0.2	5.0	14.8	0.5	3.7	6.3	40.0	7.2
MS	Obs.	0	2	5	4	4	18	2	2	14	51	
	Exp.	0.3	2.5	5.0	0.9	7.7	15.7	0.7	5.0	12.3	51.0	17.7^{+}
CS	Obs.	4	2	16	3	13	46	2	3	22	111	
	Exp.	1.0	8.1	16.2	1.4	15.3	38.7	0.5	6.7	23.1	111.0	23.7^{+}
HB	Obs.	1	1	16	2	8	14	1	2	2	47	
	Exp.	0.2	3.6	15.3	0.9	8.7	12.2	0.8	2.9	2.4	47.0	7.1
MU	Obs.	3	0	6	5	5	5	1	1	1	27	
	Exp.	1.5	4.8	3.8	2.6	6.5	3.7	1.2	2.0	0.9	27.0	11.0

All χ^2 values are with 5 degrees of freedom: $^{+}P < 0.01$; $^{++}P < 0.001$

Table 4. Allele frequencies for MNSs locus among the Siddis and other populations of Karnataka.

Population	Allele frequencies			
	MS	Ms	NS	Ns
PS	0.077 ± 0.016	0.381 ± 0.026	0.089 ± 0.017	0.453 ± 0.026
HS	0.021 ± 0.021	0.467 ± 0.057	0.117 ± 0.038	0.395 ± 0.056
MS	0.079 ± 0.033	0.313 ± 0.050	0.117 ± 0.037	0.491 ± 0.053
CS	0.095 ± 0.023	0.382 ± 0.035	0.067 ± 0.021	0.456 ± 0.035
HB	0.067 ± 0.030	0.571 ± 0.053	0.135 ± 0.038	0.227 ± 0.046
MU	0.237 ± 0.066	0.374 ± 0.073	0.208 ± 0.063	0.181 ± 0.061

Table 5. Phenotype frequencies for Rh locus among the Siddis and other populations of Karnataka.

	Population											
	PS		HS		MS		CS		HB		MU	
Phenotype	O	E	O	E	O	E	O	E	O	E	O	E
CCD.EE	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
CCD.Ee	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
CCD.ee	23	21.3	5	4.6	9	10.4	9	7.5	20	19.1	8	9.5
CcD.EE	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
CcD.Ee	13	11.0	0	3.8	3	3.2	10	8.9	6	3.8	4	3.5
CcD.ee	72	77.5	17	14.0	25	22.1	30	34.0	14	17.9	12	9.5
ccD.EE	0	0.0	7	0.0	2	0.2	12	2.6	0	0.2	1	0.3
ccD.Ee	21	16.8	0	5.8	0	3.3	0	19.9	0	1.8	0	1.8
ccD.ee	69	68.8	11	10.9	11	10.8	47	35.8	3	1.8	1	1.2
CCddEE	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
CCddEe	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
CCddee	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
CcddEE	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
CcddEe	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Ccddee	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
ccddEE	0	1.4	0	0.8	0	0.0	0	0.0	0	0.0	0	0.0
ccddEe	0	3.3	0	0.1	0	0.0	0	0.0	0	0.0	0	0.0
ccddee	4	1.9	0	0.0	1	1.0	3	2.3	4	2.4	1	1.2
Total	202	202.0	40	40.0	51	51.0	111	111.0	47	47.0	27	27.0
χ^2	8.93		5.51		16.83		58.43^{+++}		6.01		4.13	

$^{+++}$ $P < 0.0001$

Table 6. Haplotype frequencies for Rh locus among the Siddis and other population groups of Karnataka.

Population	CDE	CDe	cDE	cDe	CdE	Cdc	cdE	cde
PS	0.0	0.324 ±0.023	0.0	0.494 ±0.035	0.0	0.0	0.084 ±0.014	0.098 ±0.029
HS	0.0	0.337 ±0.066	0.0	0.517 ±0.096	0.0	0.0	0.140 ±0.035	0.006 ±0.005
MS	0.0	0.451 ±0.049	0.068 ±0.025	0.342 ±0.076	0.0	0.0	0.0	0.139 ±0.069
CS	0.0	0.261 ±0.029	0.153 ±0.024	0.442 ±0.052	0.0	0.0	0.0	0.144 ±0.047
HB	0.0	0.638 ±0.050	0.064 ±0.025	0.073 ±0.049	0.0	0.0	0.0	0.225 ±0.060
MU	0.0	0.593 ±0.067	0.111 ±0.043	0.087 ±0.070	0.0	0.0	0.0	0.209 ±0.081

Table 7. Phenotype and allele frequencies for Duffy locus among the Siddis and other populations of Karnataka.

Population	Phenotypes			Allele frequencies	
	Fy(a+)	Fy(a–)	Total	Fy^a	Fy^b
PS	57	145	202	0.153 ± 0.019	0.847 ± 0.019
HS	16	24	40	0.225 ± 0.050	0.775 ± 0.050
MS	14	37	51	0.148 ± 0.037	0.852 ± 0.037
CS	27	84	111	0.130 ± 0.023	0.870 ± 0.023
HB	42	5	47	0.674 ± 0.069	0.326 ± 0.069
MU	22	5	27	0.570 ± 0.087	0.430 ± 0.087

Table 8. Phenotype and allele frequencies for Diego locus among the Siddis and other populations of Karnataka.

Population	Phenotypes			Allele frequencies	
	Di(a+)	Di(a–)	Total	Di^a	Di^b
PS	0	202	202	0.0	1.0
HS	0	40	40	0.0	1.0
MS	0	51	51	0.0	1.0
CS	0	111	111	0.0	1.0
HB	0	47	47	0.0	1.0
MU	1	26	27	0.019 ± 0.019	0.981 ± 0.019

Table 9. Phenotype and allele frequencies for Haptoglobin locus among the Siddis and other populations of Karnataka.

Population		Phenotype frequencies							Allele frequencies	
		1 1	2-1	2 2	Total	χ^2	df	Prob.	Hp^1	Hp^2
PS	Obs.	27	103	92	222	0.05	1	0.824	0.354	0.646
	Exp.	27.8	101.5	92.7	222.0				±0.023	±0.023
HS	Obs.	5	22	36	63	0.39	1	0.533	0.254	0.746
	Exp.	4.1	23.9	35.0	63.0				±0.039	±0.039
MS	Obs.	2	30	14	46	7.34+	1	0.007	0.370	0.630
	Exp.	6.3	21.4	18.3	46.0				±0.050	±0.050
CS	Obs.	20	51	42	113	0.43	1	0.511	0.403	0.597
	Exp.	18.3	54.4	40.3	113.0				±0.033	±0.033
HB	Obs.	3	30	102	135	0.20	1	0.655	0.133	±0.867
	Exp.	2.4	31.2	101.4	135.0				±0.021	±0.021
MU	Obs.	1	1	12	16	1.34	1	0.248	0.156	0.844
	Exp.	0.4	4.2	11.4	16.0				±0.064	±0.064

+Significant at 0.01 level.

Table 10. Phenotype and allele frequencies for Cp locus among the Siddis and other populations of Karnataka.

Population	Phenotype frequencies				Allele frequencies	
	A	AB	B	Total	Cp^A	Cp^B
PS	0	0	132	132	0.0	1.0
HS	0	0	33	33	0.0	1.0
MS	0	0	26	26	0.0	1.0
CS	0	0	73	73	0.0	1.0
HB	0	0	110	110	0.0	1.0
MU	0	0	11	11	0.0	1.0

Table 11. Phenotype frequencies for Tf locus among the Siddis and other populations of Karnataka.

Phenotype	Population											
	PS		HS		MS		CS		HB		MU	
	O	E	O	E	O	E	O	E	O	E	O	E
C1	14	15.2	2	3.9	5	4.2	7	7.1			4	3.8
C2-1	49	47.9	18	14.9	10	12.1	21	20.8	–	–	6	6.4
C2	38	37.9	13	14.2	10	8.7	15	15.1			3	2.8
C1-D	2	0.8	1	0.3	1	0.4	0	0.0	–	–	0	0.0
C2-D	0	1.2	0	0.7	0	0.6	0	0.0	–	–	0	0.0
D	0	0.0	0	0.0	0	0.0	0	0.0	–	–	0	0.0
Total	103	103.0	34	34.0	26	26.0	43	43.0	–	–	13	13.0
χ^2	3.30		3.62		2.15		0.01				0.07	

Note: All χ^2 values with 3 d.f. None of them are significant.

Table 12. Allele frequencies for Tf locus among the Siddis and other populations of Karnataka.

Population	Allele frequencies		
	Tf^{C1}	Tf^{C2}	Tf^{D}
PS	0.383 ± 0.034	0.607 ± 0.034	0.010 ± 0.007
HS	0.338 ± 0.057	0.647 ± 0.058	0.015 ± 0.015
MS	0.404 ± 0.068	0.577 ± 0.069	0.019 ± 0.019
CS	0.407 ± 0.053	0.593 ± 0.053	0.0
HB		–	–
MU	0.539 ± 0.098	0.461 ± 0.098	0.0

Table 13. Phenotype frequencies for Gc locus among the Siddis and other populations of Karnataka.

	Population											
	PS		HS		MS		CS		HB		MU	
Phenotype	O	E	O	E	O	E	O	E	O	E	O	E
1F	53	55.1	12	14.2	6	8.0	35	33.8	2	1.3	1	0.7
1F–1S	51	44.6	14	10.8	10	6.6	27	27.8	10	9.7	4	3.5
1S	5	9.0	0	2.1	0	1.4	5	5.7	17	18.5	3	4.2
2–1F	26	28.3	9	7.8	12	11.3	5	6.7	1	2.7	1	2.1
2–1S	13	11.4	4	3.0	4	4.7	5	2.7	13	10.4	7	5.0
2	4	3.6	0	1.1	4	4.0	0	0.3	1	1.4	1	1.5
Total	152	152.0	39	39.0	36	36.0	77	77.0	44	44.0	17	17.0
χ^2	3.23		4.91		3.75		2.78		2.44		2.04	

Note: All χ^2 values are with 3 d.f. None of them are significant.

Table 14. Allele frequencies for Gc locus among the Siddis and other populations of Karnataka.

	Allele frequencies		
Population	Gc^{1S}	Gc^{1F}	Gc^{2}
PS	0.243 ± 0.025	0.602 ± 0.028	0.155 ± 0.021
HS	0.231 ± 0.048	0.603 ± 0.055	0.166 ± 0.042
MS	0.194 ± 0.047	0.472 ± 0.059	0.333 ± 0.056
CS	0.273 ± 0.036	0.662 ± 0.038	0.065 ± 0.020
HB	0.648 ± 0.051	0.170 ± 0.040	0.182 ± 0.041
MU	0.500 ± 0.086	0.206 ± 0.069	0.294 ± 0.078

Table 15. Phenotype frequencies for Gm locus among the Siddis and other populations of Karnataka.

	Population											
	PS		HS		MS		CS		HB		MU	
Phenotype	O	E	O	E	O	E	O	E	O	E	O	E
I	24	20.1	0	0.0	10	9.2	14	11.0	8	3.5	–	–
1, 2	1	6.6	0	0.0	0	1.0	1	5.3	3	4.4	–	–
1, 5	71	75.1	7	7.0	20	20.9	44	47.4	19	23.0	–	–
1, 2, 5	13	7.2	0	0.0	2	0.9	11	6.3	11	9.7	–	–
5	0	0.0	0	0.0	0	0.0	0	1.0	2	2.4	–	–
Total	109	109.0	7	7.0	32	32.0	70	70.0	43	43.0	–	–
χ^2	10.44^{+}		0.00		2.69		8.17^{+}		6.83^{+}		–	

Note: All χ^2 values are with 1 d.f. + $P < 0.01$

Table 16. Haplotype frequencies for Gm locus among the Siddis and other populations of Karnataka.

Population	Haplotype frequencies			
	Gm^1	$Gm^{1,2}$	Gm^5	$Gm^{1,5}$
PS	0.430 ± 0.041	0.065 ± 0.017	0.003 ± 0.048	0.502 ± 0.063
HS	0.0	0.0	0.0	1.0
MS	0.535 ± 0.073	0.031 ± 0.022	0.001 ± 0.088	0.433 ± 0.115
CS	0.397 ± 0.052	0.086 ± 0.024	0.012 ± 0.060	0.515 ± 0.079
HB	0.474 ± 0.051	0.097 ± 0.021	0.236 ± 0.064	0.193 ± 0.070
MU	–	–	–	–

Table 17. Phenotype and allele frequencies for Km locus among the Siddis and othe populations of Karnataka.

Population	Phenotype frequencies			Allele frequencies	
	Km(1+)	Km(1–)	Total	Km^1	Km^{-1}
PS	34	75	109	0.171 ± 0.027	0.829 ± 0.027
HS	3	4	7	0.244 ± 0.143	0.756 ± 0.143
MS	11	21	32	0.190 ± 0.052	0.810 ± 0.052
CS	20	50	70	0.155 ± 0.032	0.845 ± 0.032
HB	3	40	43	0.035 ± 0.020	0.965 ± 0.020
MU	–	–	–	–	–

Table 18. Phenotype and allele frequencies for aP locus among the Siddis and other populations of Karnataka.

Population		Phenotype frequencies							Allele frequencies	
		A	AB	B	Total	x^2	d.f.	Prob.	p^a	p^b
PS	Obs.	13	75	209	297	3.29	1	0.070	0.170	0.830
	Exp.	8.6	83.8	204.6	297.0				±0.015	±0.015
HS	Obs.	3	24	55	82	0.04	1	0.850	0.183	0.817
	Exp.	2.7	24.5	54.8	82.0				±0.030	±0.030
MS	Obs.	4	16	47	67	2.37	1	0.124	0.179	0.821
	Exp.	2.2	19.7	45.1	67.0				±0.033	±0.033
CS	Obs.	6	35	107	148	1.95	1	0.162	0.159	0.841
	Exp.	3.7	39.6	104.7	148.0				±0.021	±0.021
HB	Obs.	13	58	75	146	0.14	1	0.711	0.288	0.712
	Exp.	12.1	59.8	74.1	146.0				±0.027	±0.027
MU	Obs.	2	7	16	25	0.85	1	0.357	0.220	0.780
	Exp.	1.2	8.6	15.2	25.0				±0.059	±0.059

All x^2 values are non-significant.

Table 19. Phenotype frequencies for PGM_1 locus among the Siddis and other populations of Karnataka.

	Population											
	PS		HS		MS		CS		HB		MU	
Phenotype	O	E	O	E	O	E	O	E	O	E	O	E
1	64	63.4	20	22.6	15	14.4	29	28.2	46	42.6	–	–
2	8	9.2	5	7.7	2	1.5	1	0.9	4	1.3	–	–
3	0	0.4	0	0.3	0	0.1	0	0.0	2	0.8		--
4	1	0.8	1	0.6	0	0.1	0	0.1	0	0.0	–	–
1–2	50	48.5	31	26.4	9	9.4	10	10.2	10	15.0	–	–
1–3	12	9.6	9	4.9	2	2.7	1	1.6	11	11.3	–	–
1 4	9	14.0	4	7.5	2	2.0	3	3.9	0	1.5	–	–
2–3	1	3.6	0	2.8	1	0.9	0	0.3	0	2.0	–	–
2–4	9	5.4	8	4.4	0	0.7	1	0.7	2	0.3	–	
3–4	2	1.1	0	0.8	1	0.2	1	0.1	0	0.2	–	–
Total	156	156.0	78	78.0	32	32.0	46	46.0	75	75.0	–	–
χ^2	8.31		14.33^{+}		4.69		8.21		24.22^{++}		--	–

Note: All χ^2 values are with 6 d.f. + $P < 0.05$; ++ $P < 0.01$

Table 20. Allele frequencies for PGM_1 locus among the Siddis and other populations of Karnataka.

	Allele frequencies			
Population	a_1	a_2	a_3	a_4
PS	0.638 ± 0.027	0.244 ± 0.024	0.048 ± 0.012	0.070 ± 0.015
HS	0.538 ± 0.040	0.314 ± 0.037	0.058 ± 0.019	0.090 ± 0.023
MS	0.672 ± 0.059	0.219 ± 0.052	0.062 ± 0.030	0.047 ± 0.026
CS	0.783 ± 0.043	0.141 ± 0.036	0.022 ± 0.015	0.054 ± 0.024
HB	0.754 ± 0.035	0.133 ± 0.028	0.100 ± 0.024	0.013 ± 0.009
MU	–	–	–	

Table 21. Phenotype and allele frequencies for AK locus among the Siddis and other populations of Karnataka.

Population		Phenotype frequencies 1	2 1	2	Total	χ^2	df	Prob.	Allele frequencies AK^1	AK^2
PS	Obs.	85	14	1	100	0.24	1	0.625	0.920	0.080
	Exp.	84.7	14.7	0.6	100.0				±0.019	±0.019
HS	Obs.	32	9	1	42	0.14	1	0.704	0.869	0.131
	Exp.	31.7	9.6	0.7	42.0				±0.037	±0.037
MS	Obs.	–	–	–	–	–	–	–		
	Exp.					–	–	–	–	–
CS	Obs.	53	5	0	58	0.12	1	0.732	0.957	0.043
	Exp.	53.1	4.8	0.1	58.0				±0.019	±0.019
HB	Obs.	45	26	2	73	0.60	1	0.438	0.795	0.205
	Exp.	46.1	23.8	3.1	73.0				±0.033	±0.033
MU	Obs.					–	–	–	–	–
	Exp.				–	–	–	–	–	–

All χ^1 values are non-significant.

Table 22. Phenotype and allele frequencies for ADA locus among the Siddis and other populations of Karnataka.

Population		Phenotype frequencies 1	2–1	2	Total	χ^2	df	Prob.	Allele frequencies ADA^1	ADA^2
PS	Obs.	31	9	1	41	0.12	1	0.124	0.866	0.134
	Exp.	30.8	9.5	0.7	41.0				±0.038	±0.038
HS	Obs.	15	5	1	21	0.43	1	0.513	0.833	0.167
	Exp.	14.6	5.8	0.6	21.0				±0.058	±0.058
MS	Obs.	–	–		–	–	–	–	–	–
	Exp.	–	–	–	–	–			–	–
CS	Obs.	16	4	0	20	0.25	1	0.619	0.900	0.100
	Exp.	16.2	3.6	0.2	20.0				±0.047	±0.047
HB	Obs.	–	–			–	–	–	–	–
	Exp.	–	–	–	–	–			–	–
MU	Obs.	–	–			–	–	–	–	–
	Exp.	–	–	–	–	–			–	–

All χ^2 values are insignificant.

Table 23. Phenotype and allele frequencies for EsD locus among the Siddis and other populations of Karnataka.

Population		Phenotype frequencies 1	2-1	2	Total	χ^2	df	Prob.	Allele frequencies EsD^1	EsD^2
PS	Obs.	171	68	6	245	0.06	1	0.804	0.837	0.163
	Exp.	171.5	67.0	6.5	245.0				±0.017	±0.017
HS	Obs.	36	9	0	45	0.55	1	0.456	0.900	0.100
	Exp.	36.5	8.1	0.4	45.0				±0.032	±0.032
MS	Obs.	38	21	2	61	0.19	1	0.659	0.795	0.205
	Exp.	38.6	19.9	2.5	61.0				±0.037	±0.037
CS	Obs.	98	37	4	139	0.05	1	0.823	0.838	0.162
	Exp.	97.7	37.7	3.6	139.0				±0.022	±0.022
HB	Obs.	20	27	1	48	5.36+	1	0.021	0.698	0.302
	Exp.	23.4	20.2	4.4	48.0				±0.047	±0.047
MU	Obs.	–	–	–	–	–	–	–	–	–
	Exp.	–	–	–	–				–	–

+Significant at 0.05 level; all other χ^2 values are non-significant.

Table 24. Phenotype and allele frequencies for LDH locus among the Siddis and other populations of Karnataka.

Population	Phenotype frequencies Normal	Cal-1	Total	Allele frequencies Normal	Cal-1
PS	247	9	256	0.982 ± 0.006	0.018 ± 0.006
HS	75	7	82	0.957 ± 0.016	0.043 ± 0.016
MS	44	2	46	0.978 ± 0.015	0.022 ± 0.015
CS	128	0	128	1.0	0.0
HB	48	0	48	1.0	0.0
MU	22	1	23	0.978 ± 0.022	0.022 ± 0.022

Table 25. Phenotype and allele frequencies for Hb locus among the Siddis and other populations of Karnataka.

Population		Phenotype frequency AA	AS	SS	Total	χ^2	df	Prob.	Allele frequencies Hb^A	Hb^S
PS	Obs.	258	2	0	260	0.04	1	0.950	0.996	0.004
	Exp.	258.0	2.0	0.0	260.0				±0.003	±0.003
HS	Obs.	81	2	0	83	0.01	1	0.912	0.988	0.012
	Exp.	81.0	2.0	0.0	83.0				±0.009	±0.009
MS	Obs.	48	0	0	48				1.0	1.0
	Exp.	48.0	0.0	0.0	48.0					
CS	Obs.	129	0	0	129				1.0	1.0
	Exp.	129	0.0	0.0	129.0					
HB	Obs.	49	0	0	49				1.0	1.0
	Exp.	49.0	0.0	0.0	49.0					
MU	Obs.	26	0	0	26				1.0	1.0
	Exp.	26.0	0.0	0.0	26.0					

Table 26. Allele/haplotype frequencies for 16 genetic systems among the Siddis compared with Havig Brahmins and Muslims of Karnataka and Ethiopeans of Africa.

Locus	Allele/ Haplotype	Pooled Siddis	Hindu Siddis	Muslim Siddis	Christ. Siddis	Havig Brahmins	Local Muslims	Ethio-peans	Ref. for Ethiopeans
ABO	A_1	0.114	0.064	0.144	0.114	0.143	0.253	0.111	2, 3, 4, 7
	A_2	0.024	0.084	0.017	0.009	0.013	0.051	0.067	
	B	0.182	0.135	0.153	0.214	0.055	0.183	0.130	
	O	0.680	0.717	0.686	0.662	0.789	0.513	0.692	
	n	237	40	72	125	140	27	1220	
MNSs	MS	0.077	0.021	0.079	0.095	0.067	0.237	0.218	3, 6, 7
	Ms	0.381	0.467	0.313	0.382	0.571	0.374	0.423	
	NS	0.089	0.117	0.117	0.067	0.135	0.208	0.039	
	Ns	0.453	0.395	0.491	0.456	0.227	0.181	0.320	
	n	202	40	51	111	47	27	904	
Rh	CDE	0.000	0.000	0.000	0.000	0.000	0.000	0.003	2, 3, 4, 6, 7
	CDe	0.324	0.337	0.451	0.261	0.638	0.593	0.180	
	cDE	0.000	0.000	0.068	0.153	0.064	0.111	0.053	
	cDe	0.494	0.517	0.342	0.442	0.073	0.087	0.507	
	CdE	0.000	0.000	0.000	0.000	0.000	0.000	0.016	
	cdE	0.084	0.140	0.000	0.000	0.000	0.000	0.000	
	cde	0.098	0.006	0.139	0.143	0.225	0.209	0.241	
	n	202	40	51	111	47	27	1340	
Duffy	Fy^a	0.153	0.225	0.148	0.130	0.674	0.570	0.120	3, 6, 7
	Fy^b+Fy	0.847	0.775	0.852	0.870	0.326	0.430	0.880	
	n	202	40	51	111	47	27	764	
Diego	Di^a	0.000	0.000	0.000	0.000	0.000	0.019	0.000	3
	Di^b	1.000	1.000	1.000	1.000	1.000	0.981	1.000	
	n	202	40	51	111	47	27	146	
Hp	Hp^1	0.354	0.254	0.370	0.403	0.133	0.156	0.394	1, 6
	Hp^2	0.646	0.746	0.630	0.597	0.867	0.844	0.606	
	n	222	63	46	113	135	16	625	

Table 26 contd. see next page.

Table 26. Contd.

Locus	Allele/ Haplotype	Pooled Siddis	Hindu Siddis	Muslim Siddis	Christ. Siddis	Having Brahmins	Local Muslims	Ethiopeans	Ref. for Ethiopeans
Tf	Tf^C	0.990	0.985	0.981	1.000		1.000	0.998	1, 5, 6
	Tf^D	0.010	0.015	0.019	0.000	–	0.000	0.002	
	n	103	34	26	43	–	13	704	
Gc	Gc^1	0.845	0.834	0.667	0.935	0.818	0.706	0.863	5
	Gc^2	0.155	0.166	0.333	0.065	0.182	0.294	0.137	
	n	152	39	36	77	44	17	80	
Gm	Gm^1	0.430	0.000	0.535	0.397	0.474	–	0.196	6, 10
	$Gm^{1,2}$	0.065	0.000	0.031	0.086	0.097	–	0.018	
	$Gm^{1,5}$	0.502	1.000	0.433	0.515	0.193	–	0.584	
	Gm^5	0.003	0.000	0.001	0.012	0.236	–	0.202	
	n	109	7	32	70	43	–	311	
Km	Km^1	0.171	0.244	0.190	0.155	0.035	–	0.307	10
	Km^{non-1}	0.829	0.756	0.810	0.845	0.965	–	0.693	
	n	109	7	32	70	43	–	140	
aP	p^a	0.170	0.183	0.179	0.159	0.288	0.220	0.069	6
	p^b	0.830	0.817	0.821	0.841	0.712	0.780	0.931	
	n	297	82	67	148	146	25	168	
PGM_1	PGM_1^1	0.686	0.575	0.724	0.805	0.854	–	0.697	6
	PGM_1^2	0.314	0.425	0.276	0.195	0.146	–	0.303	
	n	156	78	32	46	75	–	163	
AK	AK^1	0.920	0.869	–	0.957	0.795	–	0.987	6
	AK^2	0.080	0.131	–	0.043	0.205	–	0.013	
	n	100	42	–	58	73	–	303	
EsD	EsD^1	0.837	0.900	0.795	0.838	0.698	–	0.937	8
	EsD^2	0.163	0.100	0.205	0.162	0.302	–	0.063	
	n	245	45	61	139	48	–	64	
LDH	LDH^{normal}	0.982	0.957	0.978	1.000	1.000	0.978	1.000	9
	LDH^{Cal-1}	0.018	0.043	0.022	0.000	0.000	0.022	0.000	
	n	256	82	46	128	48	23	100	
Hb	Hb^A	0.996	0.988	1.000	1.000	1.000	1.000	1.000	3
	Hb^S	0.004	0.012	0.000	0.000	0.000	0.000	0.000	
	n	260	83	48	129	49	26	434	

Ref. for Ethiopeans (for details see references):

[1]Barnicot et al. (1962)
[2]But-Miriam (1962)
[3]Bowen-Simpkins et al. (1974)
[4]Fourquet (1969)
[5]Goedde et al (1974)
[6]Harrison et al. (1969)
[7]Ikin et al. (1962)
[8]Ojikutu et al. (1977)
[9]Saha et al (1978)
[10]Steinberg (1973)

Chi-square values are insignificant in all the population groups regarding A_1A_2BO bloodgroups and Tf, Gc, aP, AK and ADA systems. Significant Chi-square values are most likely due to sample size. Henceforth the pooled Siddis will be referred to as PS, Hindu Siddis as HS, Muslim Siddis as MS, Havig Brahmins as HB and local Muslims as MU.

ABO system: The results of the ABO grouping are shown in Table 1. The O phenotype is very frequent in all the groups, it shows the maximum in the HB (62.14 %), and ranges in the Siddis from 43.05 % in MS to 50.00 % in HS. The B phenotype is very low in HB (9.29 %) and in the PS it is about 29 %. The A_1 phenotype ranges from 10 % (HS) to 26.38 % (MS); A_2 in general is low in all the groups (3.80 % in PS). The O allele shows a considerable frequency in all the groups, being highest with 0.789 in HB. The range of this allele in the Siddis is from 0.662 (CS) to 0.717 (HS), while A_1 and B alleles move almost hand in hand in all the groups (Table 2).

The distribution of ABO gene frequencies in the Indian populations shows lot of heterogeneity and no clear cut pattern emerges, though in a considerable number of populations a higher incidence of B is noticed (Majumdar 1980). There is very little information available about the populations of Karnataka including the Havig Brahmins and Muslims, and it is difficult to compare the gene frequency of the Siddis with other local populations. In African populations including Ethiopians (Table 26), the O allele is relatively more frequent (about 0.69), which is also true in the case of pooled Siddis (0.680), though in the HB it is still slightly higher (0.789). The ABO loci do not show much variation amongst these groups. The local Muslims studied are not considered here for any comparison because of the small sample size.

MNSs system: All the nine MNSs phenotypes have been noticed here (Table 3), caused by four alleles namely MS, Ms, NS and Ns (Table 4). The MNss phenotype is relatively frequent in all the Siddi groups (35.29 % in MS to 45.00 % in HS) in comparison to HB (29.79 %) and MU (18.52 %). Next is NSS, which is found about 21 % in PS, but very low in HB (4.25 %) and MU (3.70 %). The MSS phenotype is absent in HS and MS; similarly MNSS in HS and MSs in MU is also not found. Apparently, there is a marked difference between the Siddi groups and the other two local groups in respect to MNSs allele frequencies (Table 4). Allele Ns depicts a maximum incidence among the Siddi groups (0.395 in HS to 0.491 in MS), which is more than double the incidence found among HB (0.227) and MU (0.181). The MS allele is abnormally very high in the MU, which is possibly due to small sample size. The MS allele in Ethiopians ranges between 0.1900 to 0.2168. The pooled Siddis show a very low frequency of MS (0.077) in comparison to Ethiopians (Ikin & Mourant 1962). But in respect to Ns allele the PS (about 0.45) are closer to the Ethiopians (about 0.36) rather than HB (about 0.22); Table 26.

Rh system: Six phenotypes (CCD.ee, CcD.Ee, CcD.ee, ccD.Ee, ccD.ee and ccddee) have been detected in the population groups (Table 5), of which CcD.ee is most common in all the groups ranging from 27.03 % (CS) to 42.50 % (HS). Next type is ccD.ee which is very high in the PS (34.16 %) and very low in the HB (6.38 %) and MU (3.70 %). On the contrary, CCD.ee is found quite high in HB (42.55 %) and in MU (29.63 %) in comparison to PS (11.38 %). The CcD.Ee type also demarcates the Siddi groups (PS = 6.44 %)

from the HB (12.77 %) and MU (14.81 %). ccddee is low in all the groups (PS = 1.98), being absent in HS. Four haplotypes — CDe, cDe and cde and cdE — are present in these population groups (Table 6). The CDe haplotype is 0.638 in HB and 0.593 in MU but, much lower in the Siddi groups (from 0.261 in CS to 0.451 in MU). The cDe haplotype is much higher in the Siddis, ranging from 0.342 in MS to 0.517 HS, and obviously infrequent in the HB (0.073) and MU (0.087). cdE is found only in the HS (0.140). In most of the Indian populations, the CDe (R1) haplotype predominates and cDe (Ro) occurs in much lower frequencies. The Rh system of the Siddis compares very well with the African populations and it is observed that particularly cDe (Ro) gene is very high (nearly 0.80) in most of the populations of Africa including Ethiopians. cDe is 0.508 in the Afar community of Ethiopia (Fourquet 1969), which is very close to the Siddi groups (PS = 0.494). On the other hand, CDe is less common in African populations; in Afar it is about 0.235. In the pooled Ethiopians it comes to 0.32 (Table 26), which is also closer to the Siddis (PS – 0.3240).

Duffy system: Duffy phenotypes and corresponding allele frequencies are shown in the Table 7. All the Siddi populations are found to have a very high frequency of Fy(a–) (range 60.00 % in HS to 75.68 % in CS), but Fy(a+) is present in very high frequency in HB (89.36 %) and in MU (81.48).

Corresponding the Fy^a allele is quite low in the Siddis (range 0.130 in CS to 0.225 in HS) and very high in HB (0.674) and MU (0.570). There is not much difference amongst the three Siddi groups in respect to the Fy^a allele.

In India most of the populations show a higher incidence of Fy^a than Fy^b. The Fy^a allele is found to be very low in the Ethiopian Amharas (0.146) and other African populations (about 0.02; Iken & Mourant 1962). It is interesting to note that the pooled Siddi data (0.153) are very similar to that of Ethiopian populations referred above.

Diego system: Table 8 gives the distribution of Diego phenotypes as well as the allele frequencies. Except one case of Di(a+) in the Muslims all the others are found to be Di (a–).

Hp system: Three common phenotypes, Hp 1-1, Hp 2-1 and Hp 2-2, are found in all the groups. The local Muslim sample size is quite small and not considered for any discussion. The Hp 1-1 phenotype shows some variation amongst the Siddis. It is highest in CS (17.70 %) and lowest in MS (4.35 %), and further low in HB (2.22 %) (Table 9). Hp2-2 phenotype is maximum in HB (75.56 %) and minimum in MS (30.43 %). MS shows highest frequency of Hp 2-1 (65.22 %). Corresponding allele frequency, particularly of Hp^1, is much higher in the Siddis (PS = 0.354) than the HB (0.133). Indian populations are characterized by the presence of low Hp^1 frequencies (Mukherjee & Das 1984) which is reflected in the HB. In African populations Hp^1 gene is found about 30 % to 39 % (Mourant et al. 1976), which is higher than in the Indians. Among the Siddis Hp^1 frequency (PS = 0.354) is very near to that of the Ethiopians (about 0.39, Table 26).

Cp system: Only Cp-B type is detected here (Table 10). In most of the world populations Cp appears as monomorphic for B type, except sporadic occurrence of CpA type, which is also true for other Indian populations.

Tf system: Four subtypes of Tf could be detected in the Siddi groups (C1, C2-1, C2 and C1-D). Havig Brahmin sample could not be tested and local Muslim sample size is too small (Table 11). C2-1 type accounts for about 50 % in the Siddi groups (PS = 47.57 %) and next is C2 (PS = 36.89 %); correspondingly, Tf^{C2} allele is predominant (Table 12) in the Siddis (PS = 0.607) than Tf^{C1}. Two cases of D variant (C1-D) are also found which has sporadic distribution in other Indian populations (Mukherjee et al. 1986). In African populations Tf^{D} gene is also very uncommon (Mourant et al. 1976). There is hardly any information about the Tf sub-typing in the African populations in general and in the Ethiopians in particular.

Gc system: Subtyping of Gc loci shows six phenotypes as 1F, 1F-1S, 1S, 2-1F, 2-1S and 2 (Table 13). The Muslim sample size is small and excluded for the discussion. Pooled Siddis have almost equal frequency of both 1F (34.87 %) and 1F-1S (35.35 %) type, while 1S is very low (3.29 %). Apparently MS has less 1F (16.67 %) than the rest of the two Siddi groups (CS = 45.45 % and HS = 30.77 %) which indicates some variations amongst them. Gc^{1F} allele shows maximum frequency in PS (0.602) and minimum in HB (0.170); Gc^{1S} allele occurs in higher frequency in HB (0.648) than PS (0.243); Table 14. In respect to Gc system the HB differentiates well from the Siddi groups. There is very little information available about Gc subtyping among the Indian populations and therefore there is not much opportunity to compare the present results. Gc^{2} allele is very low in the Ethiopians, about 10 % (Table 26), which is closer to the Siddis (PS = 0.155).

Gm and Km system: For Gm and Km typing the three Siddi groups as well as the Havig Brahmins could be tested, of which the HS sample is very small (Table 15). It appears that out of five Gm phenotypes (Gm^{1}; $Gm^{1,2}$; $Gm^{1,3}$; $Gm^{1,2,3}$; Gm^{3}) in the Siddi groups only four of them are present, of which $Gm^{1,3}$ is very frequent in both MS (62.00 %) and CS (62.86 %). $Gm^{1,2}$ is very low in all the Siddis (in CS it is 1.43 %). Phenotype and haplotype frequencies (Table 16) show that all the three Siddi groups are quite different from the Havig Brahmins. — Regarding the Km(1) distribution (Table 17) it is seen that Km(-1) predominates in the Siddis (PS = 68.81 %), but especially in the Havig Brahmins (HB = 93.02 %). Thus the Km^{1} frequencies are much lower in HB (0.035) as compared to all the Siddi groups (PS = 0.171). With high $Gm^{1,3}$ and Km^{1} frequencies the Siddis are quite close to Ethiopians (Table 26).

aP system: Three common phenotypes (A, AB, B) are observed (Table 18) and B is predominant in all the Siddi groups (range 67.07 % in HS to 72.30 % in CS) as well as in HB (51 %). The A type on the contrary occurs in rather low frequencies among the Siddis (PS = 4.38 %). p^{b} allele frequency is maximum in all the Siddi groups (0.830 in PS), but relatively less in HB (0.712). In Indian populations p^{a} allele is found about 0.20—0.40 (Mukherjee et al. 1986), while in African populations it is very low (Table 26) and particularly in the Ethiopian Amharas it is about 0.07 (Harrison et al. 1969). The present pooled Siddi frequency for p^{a} allele shows about 0.17 which is quite low like the African distribution.

PGM_1 system: PGM_1 sub-typing gives 10 phenotypes as follows: 1, 2, 3, 4, 1-2, 1-3, 1-4, 2-3, 2-4 and 3-4. These are heterogeneously distributed in the present population groups (Table 19). The Local Muslim group could not be tested for PGM. Phenotype

1 is dominant in all the groups followed by 1-2, which is quite less frequent in HB (13.33 %). Two cases of type 3 are present only in HB, and type 4, 1-2 and 2-3 are found to be absent in HB. Correspondingly, four alleles for PGM_1 have been detected in the groups (a1, a2, a3 and a4) (Table 20) of which a1 allele is found maximum in all the groups (PS = 0.638 and HB = 0.754) though it is relatively higher in HB. Allele a4 is about 0.07 in all the Siddi groups and in HB it is lowest (0.013). a3 allele is about 0.10 in HB, but it is also less than 0.05 in PS. PGM_1^2 allele varies widely in Indian population (0.22—0.45; Mukherjee et al. 1986). In the African populations also, PGM_1^2 allele shows about 0.15—0.24 incidence (Mourant et al. 1976) and in Ethiopian Amharas it is about 0.30 (Harrison et al. 1969), which is closer to the Siddis (PS = about 0.25) but quite different from HB (0.13).

AK system: Muslim Siddis and Local Muslims could not be tested for AK types and the results of the rest are given in Table 21. Homozygous AK 1 is very high in all the groups (61.64 % in HB to 91.38 % in CS) and AK 2 is absent in CS. AK^2 allele is negligible in all the groups here, which is the general feature for most of the world populations, including India, except Mongoloid populations (0.02—0.05) (Mourant et al. 1976). In the Amharas of Ethiopia, AK^2 is 0.013 (Harrison et al. 1969), which is closer to the pooled Siddis (0.080).

ADA system: Only 21 and 20 samples from HS and CS, respectively, could be tested for the ADA marker. Phenotype ADA 1 is found to be 75.61 % in PS, and 2.44 % of ADA 2 is present in the same population showing corresponding low ADA^2 allele frequencies (0.134 in PS; Table 22). Not much data about ADA system is available in different populations of the world including India.

EsD system: Local Muslim samples could not be tested for EsD system. Phenotype EsD 1 is found over 62 % in all the Siddi groups (being maximum in HS: 80 %) than the HB (41.67 %), while EsD 2 occurs in low frequency in all the groups (Table 23). EsD^2 allele occurs in low frequency in all the groups except in HB (0.302) (Table 23). In Indian populations EsD^2 allele generally varies from 0.266 to 0.625 (Mukherjee et al. 1986). In African Negroes, (Cameroone) EsD^2 is nearly 0.05 (Mourant et al. 1976) and in the Ethiopians it is about 0.06 (Table 26). In the Siddis, this allele tends to occur in low frequency (0.163 in PS) like the African populations.

LDH system: Table 24 gives the distribution of both LDH phenotypes as well as its allele frequencies. Cal-1 variant of LDH is found in the Siddis (PS = 3.52 %), being maximum in HS (8.54 %), but absent in CS as well as in HB. LDH variants are seldom encountered in world populations (Mourant et al. 1976), but in India a A sub-unit variant kown as LDH Cal-1 is found almost uniformly distributed in most of the population groups, ranging from 1—5 % (Mukherjee & Reddy 1984), but in other world populations this allele (LDH^{Cal-1}) has not yet been detected, though very few populations from Africa have been screened for LDH variants. However, it is interesting to notice here that Cal-1 allele is present among 0.02 of the Siddis.

Haemoglobin variants: The most widely studied marker in most of the populations all over the world including India, is Hb. The distribution of Hb types with the corresponding allele frequencies is given in Table 25. Only 2 cases of sickle cell trait are detected

here in the HS (0.77 % in PS). In an earlier study in South Gujarat, NEGI (1968) found about 6 % sickle cell trait carriers amongst the Siddis (by morphological test of RBC for sickling phenomenon). It is well known that a high frequency of sickle cell gene occurs in African populations. Strikingly among the Siddis, it occurs in rather low frequency.

Discussion

It was mentioned earlier, that the Siddis now found in the North Kanara district of Karnataka and other places in India, were in fact brought from largely the East African countries. It is, however, not very clear whether only males or some females also were brought from Africa. On the other hand there is some firm evidence that the Siddis did marry some Indian females. In view of this, we therefore expect that the Siddis will not only show biological affinities with the African population but also with some Indian populations living in Karnataka. The extent of similarities or differences between the Siddis and African population would certainly depend upon the amount of admixture that occurred between the Siddis and the Indian populations. Unfortunately the extent of Indian admixture among the Siddis, in quantitative terms, is not known.

In order to evaluate qualitatively the affinities between the Siddis, Ethiopians and Havig Brahmins (of the North Kanara district) data of a number of genetic markers among these populations is presented in Table 26.

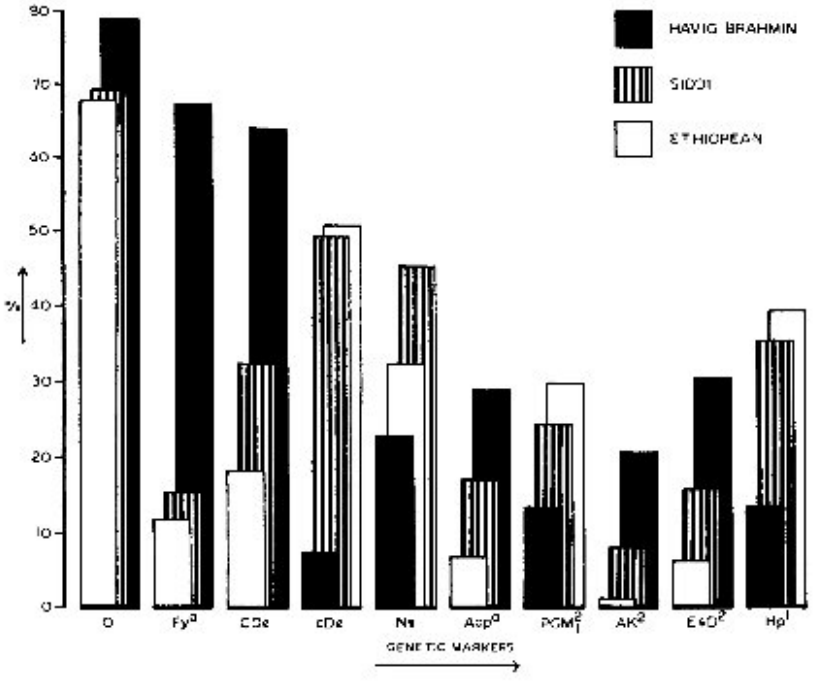

Fig. 4. Distribution of genetic markers in Havig Brahmins, Siddis and Ethiopians.

An inspection of Table 26 and Fig. 4 shows that, in general, the Siddis for an overwhelming number of loci depict closer affinities with the Ethiopeans rather than with the Havig Brahmins. In respect of the so-called «African genes» like cDe (R_o) and Hp^1 the Siddis show almost identical frequencies as the Ethiopians. The same is seen concerning the Fy^a allele, which is rather infrequent in all African populations, and which shows low frequencies in Ethiopians as well as in Siddis. Further marked similarities between Siddis and Ethiopians are seen with respect of 0, CDe, Ns, p^a, PGM_1^1, AK^2, and EsD^2 (Fig. 4).

At last, in order to find out the genetic position of the Siddis in comparison with Ethiopians and Havig Brahmins genetic distance measurement according to Cavalli-Sforza & Bodmer (1971) was conducted, using 13 loci: ABO, MNSs, Rhesus, Duffy, Hp, Tf, Gc, Gm, Km, aP, AK, PGM_1, and Hb. The result is shown in Fig. 5. The genetic

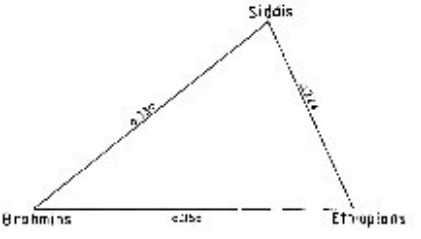

Fig. 5. Genetic distances, based on 13 polymorphic loci, between Siddis, Havig Brahmins and Ethiopians.

distances between Havig Brahmins and Ethiopians (0.356) and Havig Brahmins and Siddis (0.330) are rather great, whereas the distance between Siddis and Ethiopians is obviously smaller (0.224). One can assume that this is due to the genetic isolation of the Siddis, by which their originally African genetic pattern could be preserved largely. However, some gene flow from Indian side cannot be ruled out completely considering the figures given in Table 26 and Fig. 4. Thus the frequencies of CDe, Gm^1, p^a, AK^2 or EsD^2, in which the Siddis show some intermediate position between Ethiopians and Havig Brahmins, suggest such a gene flow. That this in fact happened follows from known marriages between Siddi males with Indian females. Unfortunately the extent of Indian admixture among the Siddis, in quantitative terms, is not yet known. The detailed analysis of this, considering also dermatoglyphics, anthropometric and anthroposcopic characters, remains for further research.

Summing up one can say that this comparative analysis of the distribution of a number of genetic markers between the Siddis, the Ethiopians and the Havig Brahmins confirms the historical evidence about the African ancestry of the Siddis of Karnataka, India. Though their genetic pattern seems to be influenced to a certain degree by gene flow from Indian side the Siddis could preserve their «African» gene pattern on the whole.

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