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Genetic Studies on Eleven Populations of Jammu and Kashmir, India

H. Walter[1], M. K. Bhasin[2], Heidi Danker-Hopfe[1], Asha Khanna[2], Ute Hahm[1] and Iris Witt[1]
1. Department of Human Biology, University of Bremen, D-2800 Bremen 33, Germany
2. Department of Anthropology, University of Delhi, Delhi 110 007, India

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ABSTRACT Eleven population groups of Jammu and Kashmir (India) with a total of n = 1131 unrelated male and female individuals were typed for HP polymorphism and for GC and PI subtype polymorphisms. The genetic variability among these eleven population groups under study is considerable, which is analyzed in detail. One of the most striking observations is the distribution of PI allele frequencies, in which the three Tibeto-Chinese speaking population groups - Baltis, Bodhs, and Tibetans - show remarkable differences from all the other groups under study. Genetic distance analyses revealed a genetic distance pattern, which is in good accordance with the ethnic structure and ethnohistory of the populations of this region.

INTRODUCTION

In the last decades many genetic studies have been carried out on Indian population groups, which showed a considerable genetic variability among them. It is interesting, however, to notice from these studies that this variability is obviously linked up with the ethnic and linguistic structure of the Indian population. This could be demonstrated clearly by Bhasin, Walter and Danker-Hopfe (1992) as well as by Walter, Danker-Hopfe and Bhasin (1991), who compiled and analyzed all so far available genetic data from India in detail. Nevertheless these two comprehensive studies disclosed as well that our knowledge concerning the regional and ethnic distribution of genetic markers in India is far from being complete, and there are even now many regions and ethnic groups for which either no or only few genetic data have been reported.

One of the Indian regions for which up to now only very few genetic data are available is Jammu and Kashmir, which is inhabited by many populations of different geographic origin and different ethnic and linguistic characteristics. In order to contribute to our knowledge on the population genetics of this region we collected blood samples from eleven different population groups and analyzed them for various blood groups, red cell enzyme and serum protein polymorphisms. The results of the latter typings will be presented and discussed here in detail. A short previous report of this joint research project has been given already elsewhere (Walter et al., 1991).

AREA AND PEOPLE

The state of Jammu and Kashmir, situated in the transverse segment of the Himalayas known as the Punjab and Kashmir Himalaya, lies between 32°17' and 36°58' north latitude and 73°25' and 80°30' east longitude. Jammu and Kashmir is the most northern state of the Indian Union. The state is bounded in the north by Chinese and Russian Turkistan, in the east by Chinese Tibet, in the south by Himachal Pradesh and the Punjab, and in the west by the North-Western Frontier Province of Pakistan. One of the largest states of the Indian Union it covers an area of 222870 km^2 and includes besides the well-known Kashmir Valley the areas of Jammu, Ladakh, Baltistan, Gilgit,

Hunza and Nagar. Out of these Gilgit, Hunza and Nagar are at present under Pakistani occupation. Jammu and Kashmir is divided into three ecological zones : 1. The Outer Hills or Jammu Region, 2. The Middle Himalayas or Kashmir Region, and 3. the Inner Himalayas or Ladakh Region . Administratively there are 14 districts in the state : two in Ladakh Region (Kargil, Leh), six in the Kashmir Region (Anantnag, Pulwama, Srinagar, Budgam, Baramulla, Kupwara), and six in the Jammu Region (Doda, Udhampur, Kathua, Jammu, Rajouri, Punch). Figure 1 shows the location of Jammu and Kashmir in India and the places within this state where our population samples come from.

The following eleven population groups of Jammu and Kashmir could be considered in this study :

1. Baltis : The Baltis - a scheduled tribe - are a product of an admixture between Caucasoids and Mongoloids. Baltistan, the real home of this group, is synonymous with the Tehsil of Skardu, which is now a disputed area. The Tehsil of Kargil, where our Balti sample comes from, also contains a considerable Balti population, the bulk of which professes the Shia Muslim faith. The Baltis of the Ladakh region mostly belong to the Shia sect, and that is perhaps why only the Bodhs of the Leh use the term "Balti" specifically for Shia Muslims. They are a hardy, industrious peoples living on the meagre yield of the lands and transport labour. The language spoken by them is Balti, which belongs to the Tibeto-Chinese language family.

2. Bodhs : The Bodhs - a scheduled tribe - form the bulk of the population of the Tehsil of Leh. They speak Tibetan (popularly called Bodhi), which belongs to the Tibeto-Chinese language family. The devotion of the Bodhs to their religion, a tantric form of Buddhism, is profound and intense. They do not recognize any caste or racial distinction, but some differentiation is made on the basis of social and occupational considerations. The Bodhs are even now mainly nomadic pastoralists. Those who have settled practise agriculture in addition to pastoralism. Racially the Bodhs belong to the Mongoloids.

3. Brahmins : The Brahmins or Dogra-Brahmins as they are called to distinguish themselves from Mohyal and Kashmiri Pandits, claim the largest population of the Jammu district. They are traditionally a priestly caste, who rendered services to Rajputs in religious ceremonies and rituals. In recent times, under the stress of economic pressure the Dogra-Brahmins have, to a large extent, left their hereditary occupation and taken to cultivation and other remunerative professions. They speak Dogri (Indo- Aryan), a mixture of Sanskrit, Punjabi, Persian, and Urdu words, which belongs to the Indo-European language family. According to their physical appearance they can be regarded as Caucasoids.

4. Muslims : The Muslims of Kashmir, who are mostly converts, belong to the Caucasoid racial group. They speak Kashmiri, which is part of the Indo-European language family. The Muslim rule came to Kashmir in 1339 A.D., when Shah Mir usurped the throne from the Hindu Queen Kota Rani. With this started the conversion of Hindus into Islam, forced by the rulers. With the passage of time, the Muslim community became a major population of Kashmir. The Kashmiri Muslims profess Islamism of both Sunni and Shia sects. They can be divided into four divisions : Shaikhs, Saiyads, Mughals, and Pathans. The Shaikhs, who are by far the most numerous, are the descendants of Hindus, but have retained none of the caste rules of their forefathers. There is no marital taboo among Shaikhs. They are considered to be the pure Kashmiri Muslims, profess Sunni faith and form the major part of the population of the Srinagar district (85 - 88%) and the population of the whole state. The Saiyads can be divided into those who follow the profession of religion, and those who have taken to agriculture and other pursuits. These are indistinguishable from Kashmiri Muslims, but profess Shia sect. The

remaining two divisions, Mughals and Pathans, are not numerous.

5. Khatris : The modern Khatris are without doubt the ancient Kshatryas, though they have taken to trade. Traditionally, the Khatris monopolized the markets of Eastern and Southern India. They have the secular Kshatrya tradition of the independence of thought and freedom from Brahmanical control. Racially the Khatris belong to the Caucasoids, linguistically to the Indo-European language family (they speak Dogri).

6. Gujjars : The Gujjars - a scheduled tribe-, the hill people of Kashmir, are mostly herdsmen by occupation. They are met with in the most parts of Jammu and Kashmir. Their diffusion and spread in the state is not definitely known, however. The early history of this population is quite obscure. There are several theories about their geographic origin. According to some ethnologists before their arrival in India they were the inhabitants of Georgia (Gurjia), a territory situated between the Black Sea and the Caspian Sea. Under certain pull and push factors they left their ancient habitat, and through Central Asia, Iraq, Iran and Afghanistan crossed the Khyber Pass to enter into the Indian sub-continent. Here, making a southward-march, they reached Gujarat through the plains of Indus, wherefrom at the occurrence of draughts they entered the green pastures of the Sivaliks and Himalayas. In the opinion of some social anthropologists the Gujjars probably got their name from the Sanskrit word "Gurjara", the original name of Gujarat. They were Hindus at the time when they first were noticed in the Indian sub-continent and later on embraced Islam. The major concentration of the Gujjar tribe lies in the Jammu Region. Their language belongs to the Indo-European language family. They are Caucasoids.

7. Mahajans : Mahajan is a title bestowed on the Banias. As such it is almost synonymous with Shah (King), the popular term for a money lender. In the hills, the Pahari Mahajans form an occupational group of shopkeepers, which is tending to form a true caste. The Mahajans are of composite origin. Even the Brahmin shopkeepers are also referred to as Mahajans although the majority of them appears to be Banias, Bohras, or Kayasths, who have intermarried or expoused wives of the lower Rajput grades such as Rathis or Rawats. But the Mahajans are essentially traders or shopkeepers. They belong to the Caucasoid racial group and linguistically to the Indo-European language family.

8. Rajputs : The Rajputs claim their existence from the families of erstwhile Rajput rulers, who reigned over this country for many centuries. Their origin is traced from the Rajputs of the plains. Rajputs who belong to the Kshatriya *Varna* are a martial class and are mostly serving in the army or employed in agriculture. They profess Hinduism, Islamism and Sikhism. Anthropologically they can be regarded as Caucasoids. Their language belongs to the Indo-European language family.

9. Scheduled Castes : The Scheduled Castes are found in the Jammu Province only and are concentrated in the Jammu District. They constitute 28.3% of the total population of this district and form mostly the working class. A minority of them are in government service including army. A negligible percentage of them hold small lands. They are Caucasoids in their physical appearance and belong linguistically to the Indo-European language family.

10. Pandits : The Brahmins of Kashmir, more commonly known as Pandits, are considered to be the present descendants of the Indo-Aryan immigrants to India. Kashmir was not only inhabited by these Hindus (called Pandits), but was also ruled by Hindu Kings belonging to various dynasties up to the end of the 13th century. The Muslim rule came to Kashmir in 1339, when Shah Mir usurped the throne from the Hindu Queen Kota Rani. With this started the conversion of Hindus to Islam, which also led to the first mass exodus of Pandits from Kashmir to other parts of India. Today the Kashmiri Pandits - or Brahmins - are a very small group left but they still continue

to show a phenomenal instinct for survival, which is primarily due to the tradition of marrying within the community. The Kashmiri Pandits constitute about 10% of the total population of the Srinagar district, where our Pandit sample comes from. According to their physical appearance they can be regarded as Caucasoids. Their language (Kashmiri) belongs to the Indo-European language family.

11. Tibetans: The Tibetans, who are mostly concentrated in the Ladakh Region, are immigrants from Tibet. They are mostly agriculturists and herdsmen; the Yaks play an important role in their economy. Anthropologically the Tibetans belong to the Mongoloid racial group. Their language is Tibetan, which forms part of the Tibeto-Chinese language family.

MATERIAL AND METHODS

Blood samples of a total of n =1131 unrelated male and female individuals out of these eleven population groups were collected. The names of the population samples under study, sample sizes and sampling places are specified in the following synopsis:

1. Baltis	n = 113	Kargil
2. Bods	181	Leh
3. Brahmins	141	Jammu
4. Muslims	120	Srinagar
5. Khatris	22	Jammu
6. Gujjars	123	Jammu
7. Mahajans	36	Jammu
8. Rajputs	118	Jammu
9. Schedules Castes	143	Jammu
10. Pandits	32	Srinagar
11. Tibetans	102	Leh

Figure 1 shows the geographical location of these places.

HP typing and GC and PI subtypings were done as described by Spielmann and Kühnl (1982) and Prokop and Göhler (1986).

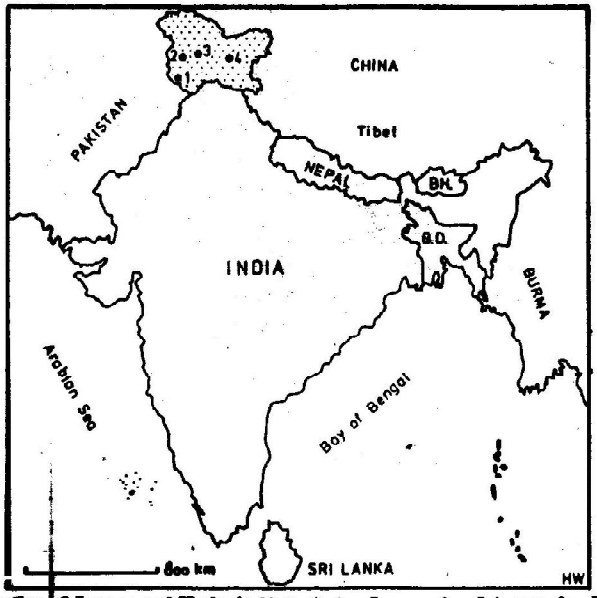


Fig. 1. Location of Jammu and Kashmir (dotted). 1 = Jammu, 2 = Srinagar, 3 = Kargil, 4 = Leh
BH. = Bhutan, B.D. = Bangla Desh

RESULTS AND DISCUSSION

Haptoglobin system

Table 1 shows the distribution of HP phenotype and allele frequencies in the eleven Jammu and Kashmir population samples under study. Genetic equilibrium can be assumed for most of them. The deviations from Hardy-Weinberg equilibrium found in Baltis, Muslims and Khatris may be due to sample size.

Figure 2 displays the variation of HP allele frequencies within the Jammu and Kashmir populations. This variation is considerable and ranges (*HP*1*) from 0.1700 (Tibetans) to 0.3472 (Mahajans). Kaur et al. (1977) found among 86 Muslims from the Ladakh Region

Table 1: HP phenotype and allele frequencies

Population	*Phenotype*	*Observed*	*Expected*	*Allele frequency*	$\chi^2_{(1)}$
Baltis	HP 1	3	6.94		
(n = 109)	2-1	49	41.12	*HP*1* = 0.2523	
	2	57	60.94	*HP*2* = 0.7477	3.998*
Bodhs	HP 1	10	8.84		
(n =181)	2-1	60	62.32	*HP*1* = 0.2210	
	2	111	109.84	*HP*2* = 0.7790	0.251
Brahmins	HP 1	6	6.60		
(n = 141)	2-1	49	47.80	*HP*1* = 0.2163	
	2	86	86.60	*HP*2* = 0.7837	0.088
Muslims	HP 1	3	7.96		
(n = 113)	2-1	54	44.07	*HP*1* = 0.2655	
	2	56	60.96	*HP*2* = 0.7345	5.736*
Khatris	HP 1	3	1.25		
(n = 20)	2-1	4	7.50	*HP*1* = 0.2500	
	2	13	11.25	*HP*2* = 0.7500	4.356*
Gujjars	HP 1	5	4.88		
(n = 123)	2-1	39	39.24	*HP*1* = 0.1992	
	2	79	78.88	*HP*2* = 0.8008	0.005
Mahajans	HP 1	4	4.34		
(n = 36)	2-1	17	16.32	*HP*1* = 0.3472	
	2	15	15.34	*HP*2* = 0.6528	0.063
Rajputs	HP 1	1	4.09		
(n =113)	2-1	41	34.82	*HP*1* = 0.1903	
	2	71	74.09	*HP*2* = 0.8097	3.561
Scheduled Castes	HP 1	9	9.57		
(n = 143)	2-1	56	54.85	*HP*1* = 0.2587	
	2	78	78.57	*HP*2* = 0.7413	0.063
Pandits	HP 1	2	2.68		
(n = 27)	2-1	13	11.65	*HP*1* = 0.3148	
	2	12	12.68	*HP*2* = 0.6852	0.364
Tibetans	HP 1	4	2.89		
(n = 100)	2-1	26	28.22	*HP*1* = 0.1700	
	2	70	68.89	*HP*2* = 0.8300	0.619

*** : p < 0.001, ** : 0.01 > p > 0.001, * : 0.05 > p > 0.01

Table 2 : Contd.....

Population	*Phenotype*		*Observed*	*Expected*	*Allele frequency*	$\chi^2_{(3)}$
Scheduled Castes	GC	1F	3	2.84		
(n = 134)		1F-1S	20	22.41		
		1S	44	44.25		
		2-1F	13	10.91	*GC*1F* = 0.1455	
		2-1S	46	43.10	*GC*1S* = 0.5746	
		2	8	10.49	*GC*2* = 0.2799	1.457
Pandits	GC	1F	2	0.78		
(n = 32)		1F-1S	6	5.00		
		1S	9	8.00		
		2-1F	-	3.44	*GC*1F* = 0.1563	
		2-1S	8	11.00	*GC*1S* = 0.4999	
		2	7	3.78	*GC*2* = 0.3438	9.222*
Tibetans	GC	1F	12	10.04		
(n = 102)		1F-1S	26	28.55		
		1S	19	20.30		
		2-1F	14	15.37	*GC*1F* = 0.3137	
		2-1S	27	21.86	*GC*1S* = 0.4461	
		2	4	5.89	*GC*2* = 0.2402	2.629

*** : $p < 0.001$, ** : $0.01 > p > 0.001$, * : $0.05 > p > 0.01$

*HP*1* = 0.268, and among 62 Buddhists from the same region *HP*1* = 0.274, which is within the range of our data. In comparison with other Indian populations especially from Central, East and South India the *HP*1* frequencies observed in the Jammu and Kashmir population are rather high. The possible reason for these regional differences in the distribution of *HP*1* allele frequencies in India have been discussed by us in detail elsewhere (Walter, Danker-Hopfe and Bhasin, 1991).

2. *GC system*

The distribution of GC subtype phenotype and allele frequencies in the eleven Jammu and Kashmir population samples is shown in table 2. With the exception of Brahmins, Mahajans and Pandits genetic equilibrium can be assumed for all the other samples. These deviations may be due to sample size. - GC variants could not be observed.

Kaur et al. (1980) studied the conventional GC polymorphism in 127 Ladakhis and found a *GC*2* frequency of 0.240, which is obviously lower than in the most of the population samples tested by us. It is, however, remarkable that this value is identical with that of our Tibetan sample (0.2402).

Figure 3 demonstrates the variation of GC allele frequencies among the Jammu and Kashmir populations. One can see that the Tibetans (11) are striking by a quite deviating position, which is in particular caused by their high *GC*1F* and low *GC*2* frequencies. Baltis (1) and Bodhs (2) as well as Khatris (5) and Mahajans (7) are also showing remarkable positions, by which they contrast not only form the Tibetans but also form the rest of the Jammu and Kashmir populations. All these four groups are characterized by *GC*1F* frequencies, which are oviously lower than the *GC*1F* frequency of the Tibetans but higher than those of Brahmins (3), Muslims (4), Gujjars (6), Rajputs (8), Scheduled Castes (9), and Pandits (10). *GC*1S* and *GC*2* frequencies are rather similar in Baltis and Bodhs, whereas Khatris and Mahajans differ clearly from these two

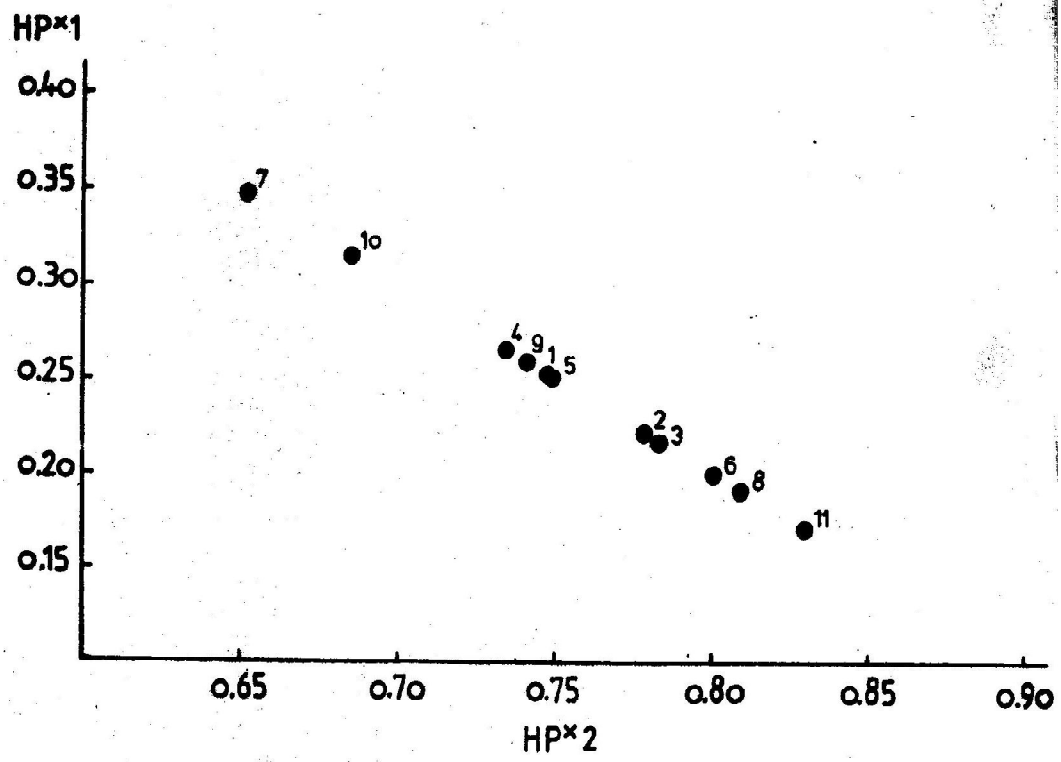


Fig. 2. Distribution of HP allele frequencies. 1 = Baltis, 2 = Bodhs, 3 = Brahmins, 4 = Muslims, 5 = Khatris, 6 = Gujjars, 7 = Mahajans, 8 = Rajputs, 9 = Scheduled Castes, 10 = Pandits, 11 = Tibetans

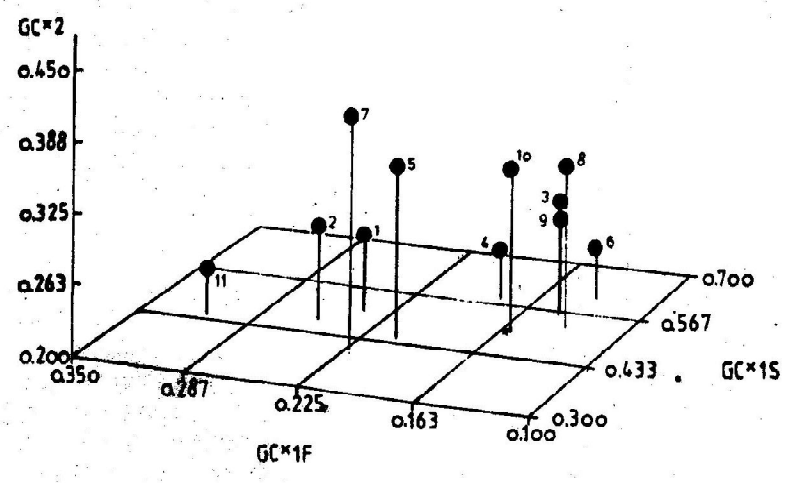


Fig. 3. Distribution of GC allele frequencies; see legend of Figure 2

groups as well as from each other. This intergroup variability in the distribution of GC allele frequencies corroborates the genetic heterogeneity within the total population of Jammu and Kashmir which emerged already from the variation of HP allele frequencies (see Table 1 and Fig. 2) we will refer to this later on.

3. PI system

Table 3 demonstrates the distribution of PI subtype phenotype and allele frequencies in the eleven populations under study. With the exception of the Gujjars genetic equilibrium can be assumed for all the other population samples. It is interesting to notice that in the Gujjars homozygous phenotypes are generally somewhat more frequent than expected whereas on the other hand the heterozygous ones are somewhat less frequent.

Rare PI phenotypes were found in some of the Jammu and Kashmir populations : each one case of PI M1-Z in Baltis and Bodhs, and one case of PI M4-1 in Brahmins. These frequencies do not differ from those found in other populations (Roychoudhury and Nei, 1988).

Figure 4 shows the variation of PI allele frequencies within the populations under study. This figure discloses two groups of populations : 1, 2, 11 (Baltis, Bodhs, Tibetans) which are characterized by very high *PI*M1* and low *PI*M2* and *PI*M3* frequencies, and 3-10 (Brahmins, Muslims, Khatris, Gujjars, Mahajans, Rajputs, Scheduled Castes, Pandits) in which *PI*M1* frequencies are much lower and *PI*M2* and *PI*M3* frequencies are much higher than in the groups 1, 2, and 11. The intragroup variability within the groups 3 - 10 is comparatively small. The PI allele distribution pattern observed in the Baltis, Bodhs and Tibetans corresponds on the whole with that which is known for Mongoloid populations (*see* Roychoudhury and Nei, 1988) and is understandable considering origin and racial affilation of these three Jammu and Kashmir populations.

4. Locus and allele specific heterogeneity

From the foregoing discusison it can be supposed that within the Jammu and Kashmir population samples tested by us a considerable genetic heterogeneity is existing. In order to examine this we analyzed the locus and allele specific heterogeneity according to Rao (1952). The results of this analysis are shown in table 4, which also contains the F_{ST} values. For the HP locus as well as for the GC and PI loci statistical significance is seen. Concerning the GC locus the interpopulation heterogeneity is mainly due to the highly significant variation of the *GC*1F* and *GC*1S* frequencies, whereas the heterogeneity in regard of the PI locus is mainly due to the *PI*M1*, *PI*M2* and *PI*M3* frequencies. All these allele specific heterogeneities are statistically significant at a high level ($p < 0.01$ and less). These results are corroborated by the F_{ST} values (*see* Table 4). It can be supposed that the genetic heterogeneity among the various Jammu and Kashmir populations is the result of group specific microevolutionary effects as *e.g.* genetic drift or founder effects, and could be preserved because of the endogamous mating systems of all these groups by which gene flow either did not happen or only to a very little extent. Thus one can regard the social and geographical isolation of these population groups from each other as a main factor for their genetic isolation and hence for the marked genetic heterogeneity among them.

5. Average heterozygosity

Table 5 shows the average heterozygosity values (AVH) for the eleven Jammu and Kashmir population samples based on the three loci HP, GC, and PI. It is to be seen that in the most populations the AVH values are obviously lower than 0.50 indicating a considerable degree of endogamy in them. Rather high AVH values are seen only in the Khatris (0.52), Mahajans (0.54), and Pandits (0.53), which

Table 3: PI phenotype and allele frequencies

Population	*Phenotype*	*Observed*	*Expected*	*Allele frequency*	χ^2
Baltis	PI M1	65	64.69		
(n = 113)	2-1	22	21.19		
	2	2	1.73		
	3-1	18	19.67		
	3-2	2	3.22		
	3	3	1.50		
	1-Z	1	0.76	*PI*M1* = 0.7567	
	2-Z	-	0.14	*PI*M2* = 0.1239	
	3-Z	-	0.11	*PI*M3* = 0.1150	
	Z	-	< 0.01	*PI*Z* = 0.0044	$2.511_{(6)}$
Bodhs	PI M1	112	111.40		
(n = 181)	2-1	45	46.29		
	2	6	4.81		
	3-1	14	14.12		
	3-2	2	2.93		
	3	1	0.45		
	1-Z	1	0.78	*PI*M1* = 0.7845	
	2-Z	-	0.16	*PI*M2* = 0.1630	
	3-Z	-	0.05	*PI*M3* = 0.0497	
	Z	-	< 0.01	*PI*Z* = 0.0028	$1.588_{(6)}$
Brahmins	PI M1	58	56.99		
(n = 139)	2-1	36	36.50		
	2	7	5.84		
	3-1	25	26.89		
	3-2	7	8.61		
	3	5	3.17		
	4-1	1	0.64	*PI*M1* = 0.6403	
	4-2	-	0.21	*PI*M2* = 0.2050	
	4-3	-	0.15	*PI*M3* = 0.1511	
	4	-	< 0.01	*PI*M4* = 0.0036	$2.301_{(6)}$
Muslims	PI M1	39	42.58		
(n = 107)	2-1	34	29.65		
	2	4	5.16		
	3-1	23	20.19	*PI*M1* = 0.6309	
	3-2	5	7.03	*PI*M2* = 0.2196	
	3	2	2.39	*PI*M3* = 0.1495	$2.243_{(3)}$
Khatris	PI M1	9	8.28		
(n = 22)	2-1	7	7.36		
	2	2	1.64		
	3-1	2	3.07	*PI*M1* = 0.6136	
	3-2	1	1.36	*PI*M2* = 0.2727	
	3	1	0.28	*PI*M3* = 0.1136	$2.434_{(3)}$
Gujjars	PI M1	48	44.38		
(n = 112)	2-1	32	29.58		
	2	5	4.93		
	3-1	13	22.66	*PI*M1* = 0.6295	
	3-2	5	7.55	*PI*M2* = 0.2098	
	3	9	2.89	*PI*M3* = 0.1607	$18.369_{(3)}$***

Table 3 : Contd....

Population	*Phenotype*	*Observed*	*Expected*	*Allele frequency*	χ^2
Mahajans	PI M1	14	14.01		
(n = 33)	2-1	9	8.47		
	2	2	1.28		
	3-1	6	6.51	*PI*M1* = 0.6515	
	3-2	-	1.97	*PI*M2* = 0.1970	
	3	2	0.76	*PI*M3* = 0.1515	$4.486_{(3)}$
Rajputs	PI M1	47	48.31		
(n = 118)	2-1	45	41.59		
	2	8	8.95		
	3-1	12	12.80	*PI*M1* = 0.6399	
	3-2	4	5.51	*PI*M2* = 0.2754	
	3	2	0.85	*PI*M3* = 0.0847	$2.446_{(3)}$
Scheduled Castes	PI M1	54	53.59		
(n = 138)	2-1	45	41.75		
	2	5	8.13		
	3-1	19	23.06	*PI*M1* = 0.6231	
	3-2	12	8.98	*PI*M2* = 0.2428	
	3	3	2.48	*PI*M3* = 0.1341	$3.299_{(3)}$
Pandits	PI M1	10	10.56		
(n = 29)	2-1	12	9.05		
	2	1	1.94		
	3-1	3	4.83	*PI*M1* = 0.6035	
	3-2	1	2.07	*PI*M2* = 0.2586	
	3	2	0.55	*PI*M3* = 0.1379	$6.491_{(3)}$
Tibetans					
(n = 102)	PI M1	66	65.12		
	2-1	25	26.37		
	2	4	2.67		
	3-1	6	6.39	*PI*M1* = 0.7990	
	3-2	—	1.29	*PI*M2* = 0.1618	
	3	1	0.16	*PI*M3* = 0.0392	$6.596_{(3)}$

*** : $p < 0.001$, ** : $0.01 > p > 0.001$, * : $0.05 > p > 0.01$

may be due to the small sample sizes of these groups (n = 22, 36 and 32, respectively).

6. Genetic distances

As a last step of our analyses we computed the standard genetic distances according to Nei (1972). The results of UPGMA clustering of these distances are shown in figure 5. Though it is problematic to base such a measurement on three loci only (HP, GC, PI) figure 5 reveals nevertheless some interesting findings which are without doubt discussible.

1. Baltis, Bodhs and Tibetans are found in one cluster, which demonstrates their genetic similarity as compared with the other Jammu and Kashmir groups under study. Considering the ethnology and history of these three groups mentioned above this cluster cannot surprise. It reflects the manifold common traits of them as *e.g.* racial origin (Mongoloid) and affiliation to the same language family (Tibeto- Chinese).

2. A second cluster is formed by the majority of the Jammu and Kashmir populations, which, however, is composed of two clear-cut sub-clusters. One of them comprises the Khatris

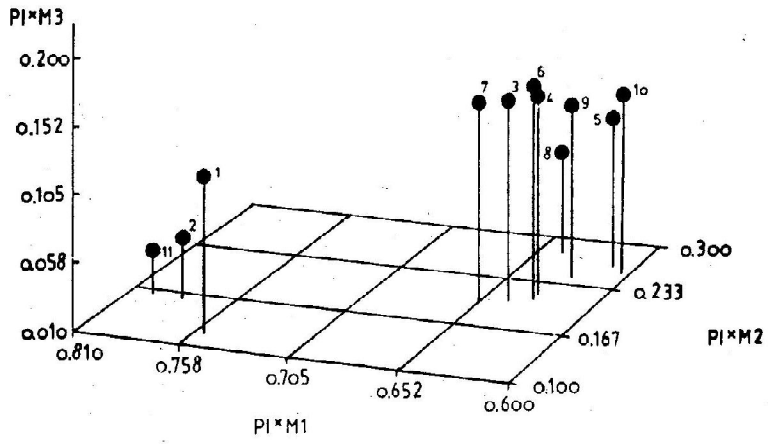


Fig. 4. Distribution of PI allele frequencies; see legend of Figure 2

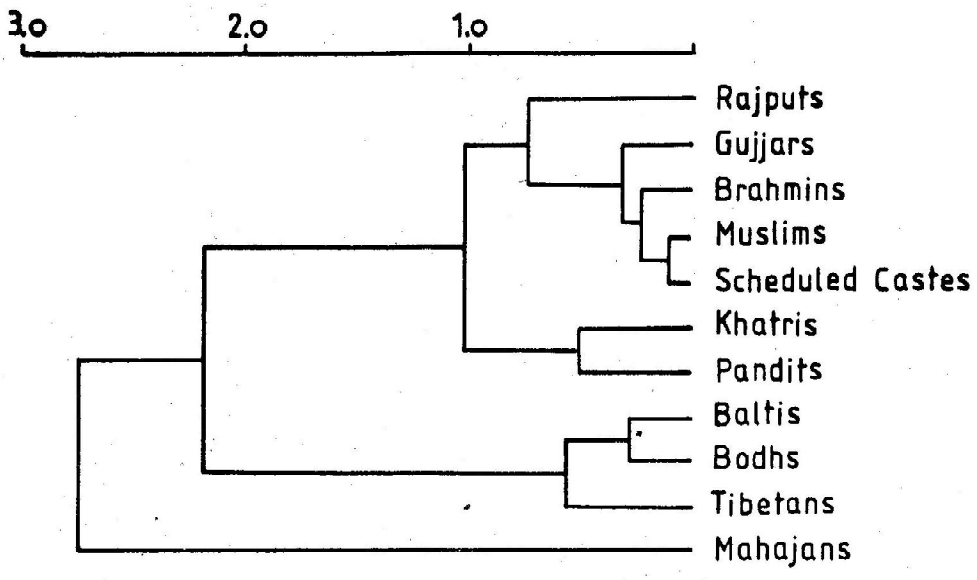


Fig. 5. Genetic distances (d x100) based on 3 loci (HP, GC and PI) between 11 populations of Jammu and Kashmir

Table 4: Locus and allele specific heterogeneity and F_{ST} values in 11 population samples from Jammu and Kashmir

Locus/Allele	χ^2	*df*	*p*	F_{ST}	χ^2	*df*	*p*
HP	19.27	10	*	.0040	19.73	10	*
GC	70.36	20	***	.0105			
*GC*1F*	50.64	10	***	.0185	50.98	10	***
*GC*1S*	34.67	10	***	.0113	32.33	10	***
*GC*2*	18.04	10	ns	.0035	21.31	10	*
PI	89.53	40	***	.0146			
*PI*M1*	53.30	10	***	.0197	55.76	10	***
*PI*M2*	27.74	10	**	.0080	28.24	10	**
*PI*M3*	42.64	10	***	.0147	61.51	10	***
*PI*M4*	6.88	10	ns	-.0005	5.88	10	ns
*PI*Z*	5.86	10	ns	.0000	6.88	10	ns

***: $p < 0.001$; **: $0.01 > p > 0.001$; *: $0.05 > p > 0.01$; ns: $p > 0.05$

and Pandits, the other one the Rajputs, Gujjars, Brahmins, Muslims and Scheduled Castes. It is interesting to notice that the Rajputs show a clear distance from the other groups of this subcluster. though Khatris and Pandits are of the same racial stock (Caucasoids)and speak the same language there are no indications for assuming any marked genetic contacts between them. Hence one can suppose that their presence in one subcluster might either be due to analogous genetic differentiation processes in the past or even by chance. Whilst the subclustering of this second cluster of the total Jammu and Kashmir population should not be overestimated it is, however, of considerable interest, that - with the exception of Mahajans - all Caucasoid and Indo-European language speaking populations are found in one cluster, which is quite different from that one comprising the Mongoloid and Tibeto-Chinese speaking populations.

3. The Mahajans do not belong to one of these two clusters but are striking by a quite deviating position in the dendrogram shown in figure 4. Considering the ethnology and history of the Mahajans mentioned above the obvious genetic distance of this group from all the other cannot surprise. They are of composite origin, which means that they have experienced gene flow from various sides. Their rather high AVH value (Table 5) is in good accordance with this.

Table 5: AVH values in 11 population samples from Jammu and Kashmir

Population	*AVH*	*SE*
Baltis	0.47	0.08
Bodhs	0.45	0.10
Brahmins	0.48	0.07
Muslims	0.50	0.06
Khatris	0.52	0.08
Gujjars	0.46	0.07
Mahajans	0.54	0.06
Rajputs	0.47	0.08
Scheduled Castes	0.50	0.06
Pandits	0.53	0.05
Tibetans	0.42	0.11

Summing up one can point out : 1. A marked genetic heterogeneity is seen among the population groups of Jammu and Kashmir which may be due to group specific differences in the microevolutionary processes within and between these groups. 2. In spite of this marked genetic heterogeneity within the total population of Jammu and Kashmir genetic distance analysis revealed two clear-cut population clusters. The first comprises with one exception all Indo-European languages speaking populations of Causcasoid origin, the second one the three Tibeto-Chinese speaking Mongoloid groups : Baltis, Bodhs and Tibetans. A quite deviating position from these two clusters is displayed by the Mahajans, a caste group of composite origin. In general one can notice that the genetic distance pattern observed on the eleven Jammu and Kashmir populations under study reflect clearly the ethnohistorical processes, which took place in this region.

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