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Genetic Markers: Colour Blindness and Taste Sensitivity Among People of India*

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INTRODUCTION

Population genetics deals on the one hand with exact genetic description of human populations, but which on the other hand tries to find out the reasons for genetic differences among them. To study these genetic differentiation processes in man, which are obviously still ongoing, reliable population data are necessary. The existence of genetic variation in man is caused by many factors alongwith selection, migration and gene flow, genetic drift and founder effects are the most important ones. By means of many examples Vogel and Motulsky (1986) have shown the importance of these factors for the understanding of genetic variation in man. In the present study an attempt has been made to study the two genetic markers - colour blindness and taste sensitivity among the people of India and the factors responsible to operate in favour of these traits.

In the present study an attempt has been made to analyse the above mentioned biological traits into I. Regional Groups, II. Ethnic Groups, III. Traditional Occupational Groups and IV. Linguistic Groups.

I. REGIONAL GROUPS

These can be divided into the following groups:

1. Natural Regions of India
2. Climatological Factors and Climatic Regions of India
3. Political Division of India

Each region has its own characteristics and a brief description of each one will give an idea of what it constitutes of.

1. Natural Regions of India

The natural regions have broad uniformity in their characteristics, such as relief, geomorphological history, drainage, climate, soil, natural vegetation and wild life. Broadly speaking, Indian subcontinent may be divided in the following natural regions:

1. The Himalayan Mountain Complex
2. The Indus-Ganga-Brahmaputra Plain
3. The Penisular Plateau and
4. The Islands

2. Climatological Factors and Climatic Regions of India

Various climatological factors (Rainfall, Humidity, Temperature) and Altitude have been considered to study correlations with different biological traits. The values for the climatological factors are after "Climatological Tables of Observations in 1931-1960" Meterological Department, Government of India, New Delhi.

A climatic region generally possesses a broad uniformity in climatic conditions produced by combined effects of climatic regions after Koppen's method, based on the monthly values of temperature and precipitation.

(1) Tropical Savannah Type, (2) Monsoon Type with Short Dry Season, (3) Monsoon Type with Dry Season in High Sun Period, (4) Semiarid and Steppe Climate, (5) Hot Desert Type, (6) Monsoon Type with Dry Winters, (7) Cold humid Winters Type with Shorter Summer, and (8) Polar Type.

3. Political Division of India

India is a Union of States. Comprising 25 states and 7 Uninn Teritories, according to the Census 1981, there are 3949 towns and 5,57,138 inhabited and 48,086 uninhabited villages in the country. The country had 412 districts in 1981.

India-Political and Ethnic Zones: The weighted mean values of various biological traits have been classifed into 25 States and 7 Union Territories (U.T.) which have been categorised as follows (after Bhasin, 1988):

I. North India, II West India, III. East India, IV. Central India, V. South India and VI. Islands. Himalayan Region may be divided into three divisions, *i.e.* A) Western Himalaya, B) Central Himalaya and C) Eastern Himalaya as follows:

I. North India

(A) Western Himalaya (S. No. 1,2)

(1) Jammu and Kashmir, (2) Himachal Pradesh, (3) Punjab, (4) Chandigarh (U.T.), (5) Haryana, (6) Delhi (U.T.), (7) Uttar Pradesh

(B) Central Himalaya (S.No. 7 Eight Districts of Uttar Pradesh)

[(i) Almora, (ii) Chamoli, (iii) Dehra Dun, (iv) Garhwal (Pauri), (v) Naini Tal, (vi) Pithoragarh, (vii) Uttarkashi.] and 8. Rajasthan

II. West India

(1) Gujarat, (2) Maharashtra, (3) Goa*, (4) Daman and Diu (U.T.) and (5) Dadra and Nagar Haveli (U.T.)

**For details see* : Bhasin, M.K., Walter, H. and Danker-Hopfe, Heidi: *People of India: An Investigation of Biological Variability in Ecological, Ethno-Economic and Linguistic Groups*. Kamal-Raj Enterprises, Delhi (1994).

III. East india

(C) Eastern Himalaya : (S.No. 1 to 8 and Darjeeling District of West Bengal)

(1) Arunachal Pradesh, (2) Assam, (3) Nagaland, (4) Manipur, (5) Mizoram, (6) Tripura, (7) Meghalaya, (8) Sikkim, (9) West Bengal, (10) Bihar, and (11) Orissa.

IV. Central India

(1) Madhya Pradesh

V. South India

(1) Karnataka, (2) Andhra Pradesh, (3) Tamil Nadu, (4) Kerala and (5) Pondicherry (U.T.).

VI Islands

(1) Lakshadweep (U.T.) and (2) Andaman and Nicobar Islands (U.T.)

II. ETHNIC GROUPS

An aggregation of biological and socio-cultural characteristics constitutes an ethnic group. Within the category of Ethnic Group, we include Castes, Scheduled Castes, Scheduled Tribes and Communities (The names of Scheduled Castes and Scheduled Tribes after Manual of Election Law 1982 Government of India, New Delhi), Biological Anthropological studies of such ethnic groups as well as "Communities" have been reported in India. By Community we generally refer to a group of people who may have occupational, linguistic, religious or regional characteristics (Bhasin, 1988).

III. TRADITIONAL OCCUPATIONAL GROUPS

In the traditional society, there were occupational guilds. The *chaturvarna* system with its division into *Brahman* (priestly caste). *Kshatriya* (warrior caste). *Vaishya* (land owners and traders) and *Sudra* (labouring caste) was based on occupational differentiation. The occupations are graded-mannual labour is looked down upon, and those dealing with swine-herding, scavenging, butchery, removal of night soil are regarded as polluting (Bhasin, 1988). The caste based division of occupation is - 1. Priesthood, 2. Warfare, 3. Trade and Commerce, 4. Agriculture, 5. Animal Husbandry, 6. Artisan and 7. Menial workers.

IV. LINGUISTIC GROUPS

Although the Schedule VIII recognized fifteen languages in India, there are innumerable dialects which change after few scores of kilometers. Linguistic deversity is an important factor in the formation of regional groups and it also reflects the regional differentiation. The four fold regional division can be seen for the major languages *i.e.*, (i) the Dravidian region of the South; (ii) the Indo-Aryan regions of the north and north-west; (iii) the Mon Khmer and the Tibeto-Burman region of the north-east and the Himalayan region; and (iv) the Austric region of the Aravalli-Vindhya-Chota Nagpur complex. These languages are again divided into sub-families and groups as follows:

*The frequency distributions for the State of Goa and Union Territory of Daman and Diu have been lised under Goa, Daman and Diu

Language Classification - Indian Languages

The family, branch, group and languages of India are as follows:

I. Austro-Asatic Family

Mon-Khmer Group (Mon-Khmer Branch)
Munda Group (Munda Branch)

II. Tibeto-Chinese Family

Siamese-Chinese Sub-Family
Tai Group
Tibeto-Burman Sub Family
Tibeto-Himalayan Branch :
Bhotia Group (Tibetan Group)
Himalayan Group (Pronominalized/Non-Pronominalized Himalayan Group)
North-East Frontier Group (North Assam Branch):
Assam-Burmese Branch:
Bodo Group (Bara or Bodo Group)
Naga Group
Kachin Group
Kuki-Chin Group
Burma Group

III. Dravidian Family

South Dravidian Group
Central Dravidian Group
North Dravidian Group

IV. Indo-European Family Aryan Sub-Family

Dardic (or Pisacha) Branch:
Kafr Group
Khowar Group
Dard Group
Indo-Aryan Branch:
Outer Sub-Branch:
North-western Group
Southern Group
Eastern Group
Bihari (Bhojpuri, Maithilli & Magahi Sub-Group)
Mediate Sub-Branch/Inner Sub-Branch:
Mediate Group/Central Group/Pahari Group
Mediate Group/Central Group
Pahari Group
Eastern Pahari
Central Pahari
Western Pahari

MEAN WEIGHTED VALUES

To discern the pattern of regional group, ethnic groups, traditional occupational groups and linguistic groups using the frequency data, the mean weighted values of the biological traits have been calculated and estimates for the various groups are presented.

COLOUR BLINDNESS

A normal man can distinguish an array of colours by mixing in various proportions the three primary colours *i.e.* red, green and blue. At times, an individual's power of perceiving one of these three primary colours is either subnormal or completely lost, and occasionally an individual may lose colour vision defect is inherited as X-linked trait with the normal colour vision dominating over colour vision defect (chromosome location Xq28). Clement's (1930) work is one of the earliest account available for the population differences in colour blindness. Subsequently, the gene for colour blindness has been studied extensively and exhaustively throughout the world.

Most of the surveys have been done only with pseudoisochromatic plates, mainly those of Ishihara. This screening method is generally accepted as quite satisfactory for the detection of colour vision defects in the red-green region of spectrum. It is less reliable, however, with regards to the classification of the defects into the protan and the deutan series and certainly much less reliable for subclassifications, in each of the series, into the "anomaly", "extreme anomaly" and "anopia" categories. It has been repeatedly stressed by experts in the field of colour-vision (*e.g.* Franceschetti, 1928; Wright, 1947; Waardenburg et al., 1963) that an accurate diagnosis can be attained only by the use of an anomaloscope.

The frequency of colour blindness is around 0.08 among Europeans. In African populations, the frequencies are about 0.01 to 0.06 with average around 0.04. Among Southwest Asian populations the frequencies of colour blindness are 0.02 to 0.07 with an average of 0.05. In the East Asian and southeast Asian regions the frequencies are 0.03 to 0.06. Among south American Indians and Eskimos the average frequency is about 0.01 (Mourant et al., 1967; Roychoudhury and Nei, 1988).

From the distribution of colour blindness in the different population groups of the world, Post (1962, 1971) and Pickford (1963) cite it to be the best trait for investigating relaxed selection. This argument is based on the low rates of colour blindness prevailing in primitive communities, especially in hunters and food gatherers as compared with higher rates among civilized communities. Neel and Post (1968) proposed positive selection of mutant colour blindness genes in traditional cultures. The above hypothesis and subsequent supporting discussions of it (*e.g.* Salzano, 1964; Dutta, 1966) dealt with colour vision defects in general terms, disregarding subclassification according to the severity of the defects and assumed selection presence for all alleles.

Adam (1969, 1985, 1986) critically reviewed the available data on the incidence of colour blindness in various ethnic groups and concluded that the present evidence mostly does not support the Post-Pickford hypothesis of relaxed natural selection. To test this hypothesis Kapoor et al. (1983) categorised the various studies available on the populations of India and pooled the data on colour blindness in three categories and namely hunters, food gatherers and nomads, semisettled primitive agriculturists, settled agriculturist and urbanised communities and observed lower incidence of colour blindness among hunters, food-gatherers and nomads with simple or primitive culture and similar findings have been reported by Malhotra et al. (1974) and Malhotra (1978a) from the studies on nomads among whom negligible frequencies of colour blindness have been observed. Kapoor et al. (1983) concluded that the differences in these categories for the incidence of colour blindness indicate selection relaxation in settled communities. Selection pressure increases and tends to eliminate colour blind individuals from primitive populations, whereas the habitats of modern populations provide a protected environment for the colour blind gene.

The validity of Post's hypothesis was tested also by Deka (1977) and Deka et al. (1997) who observed low frequencies of colour blindness among scheduled tribes (varies from complete absence to 0.013), followed by scheduled castes (0.0156 to 0.020), whereas among caste groups the frequency is quite high (0.573 to 0.0689). Naidu et al. (1978) categorized the studies from Andhra Pradesh into "Advanced Non-Tribals" and "Primitive Tribals" and observed low frequency among latter and also supported the relaxation of selection hypothesis, whereas Mukherjee et al. (1979) from their study on some populations from Delhi, Maharashtra and West Bengal for the incidence of colour blindness suggested a need for further investigations of Post-Pickford hypothesis.

Table 1: Colour blindness (in per cent)

Particulars	*Subject studied*	*No. of studies*	*Frequency*		
			Mean	*Min*	*Max*
1. NATURAL REGION					
Himalayan Mountain Complex	11435	78	0.030	0.000	0.118
Indus-Ganga-Brahmaputra Plains	13528	83	0.040	0.000	0.121
Peninsular Plateau	38881	250	0.036	0.000	0.231
Islands	126	3	0.024	0.000	0.057
2. CLIMATIC REGION					
Monsoon Type with Short Dry Season	277	5	0.043	0.000	0.080
Monsoon Type with Dry Season	2923	19	0.040	0.000	0.073
Tropical Savannah Type	31626	207	0.033	0.000	0.231
Semi Arid Steppe Type	3841	21	0.052	0.000	0.143
Hot Desert Type	-	0	-	-	-
Monsoon Type with Dry Winters	24483	154	0.036	0.000	0.121
Cold Humid Winters with Short Summers	672	6	0.040	0.000	0.104
Polar Type	148	2	0.027	0.000	0.032
3. POLITICAL DIVISION OF INDIA					
I. NORTH INDIA					
A. Western Himalaya (S.No. 1,2)					
1. Jammu and Kashmir	504	3	0.072	0.065	0.077
2. Himachal Pradesh	3727	32	0.027	0.000	0.118
3. Punjab	1733	11	0.043	0.000	0.078
4. Chandigarh UT	1654	4	0.035	0.000	0.050
5. Haryana	-	0	-	-	-
6. Delhi UT	2430	15	0.037	0.000	0.067
B. Central Himalaya (S.No. 7, Eight Districts of Uttar Pradesh)					
7. Uttar Pradesh	4533	34	0.043	0.000	0.121
8. Rajasthan	237	3	0.017	0.000	0.031
II. WEST INDIA					
9. Gujarat	2223	18	0.037	0.000	0.090
10. Maharashtra	13210	74	0.031	0.000	0.100
11. Goa, Daman and Diu UT	64	1	0.031	0.031	0.031
12. Dadra and Nagar Haveli UT	277	3	0.033	0.024	0.043
III. EAST INDIA					
C. Eastern Himalaya (S.No. 13 to 20 and Darjeeling District of West Bengal)					
13. Arunachal Pradesh	799	7	0.043	0.000	0.104
14. Assam	2259	17	0.033	0.000	0.055
15. Nagaland	185	2	0.000	0.000	0.000
16. Manipur	-	0	-	-	-
17. Mizoram	224	1	0.018	0.018	0.018
18. Tripura	195	1	0.015	0.015	0.015
19. Meghalaya	495	1	0.038	0.038	0.038
20. Sikkim	3628	15	0.026	0.000	0.037
21. West Bengal	2937	19	0.041	0.000	0.080
22. Bihar	-	0	-	-	-
23. Orissa	2917	19	0.033	0.000	0.075
IV. CENTRAL INDIA					
24. Madhya Pradesh	1310	10	0.033	0.000	0.125
V. SOUTH INDIA					
25. Karnataka	3371	18	0.048	0.018	0.143
26. Andhra Pradesh	11545	83	0.035	0.000	0.231
27. Tamil Nadu	3018	18	0.047	0.000	0.128
28. Kerala	-	0	-	-	-
29. Pondicherry UT	369	2	0.049	0.046	0.050
VI. ISLANDS					
30. Lakshadweep UT	-	0	-	-	-
31. Andaman Islands and	35	1	0.000	0.000	0.000
Nicobar Islands UT	91	2	0.033	0.018	0.057

Table 1: Contd.....

Particulars	*Subject studied*	*No. of studies*	*Frequency*		
			Mean	*Min*	*Max*
3A. ZONES OF INDIA					
I. North India	14818	102	0.038	0.000	0.121
II. West India	15774	96	0.032	0.000	0.100
III. East India	13639	82	0.033	0.000	0.104
IV. Central India	1310	10	0.033	0.000	0.125
V. South India	18303	121	0.040	0.000	0.231
VI. Islands	126	3	0.024	0.000	0.057
INDIA (TOTAL)	63970	414	0.036	0.000	0.231
3B. REGIONS OF HIMALAYA					
A. Western Himalaya	4231	35	0.032	0.000	0.118
B. Central Himalaya	1947	16	0.036	0.000	0.085
C. Eastern Himalaya	8011	45	0.029	0.000	0.104
HIMALAYA (TOTAL)	14189	96	0.031	0.000	0.118
NON-HIMALAYA REGIONS	49781	318	0.037	0.000	0.231
4. ETHNIC GROUP					
A. ZONES OF INDIA					
I. NORTH INDIA					
Caste	7323	50	0.041	0.000	0.093
Scheduled Caste	1349	15	0.030	0.000	0.118
Scheduled Tribe	877	5	0.018	0.000	0.032
Community	5269	32	0.039	0.000	0.121
II. WEST INDIA					
Caste	4732	35	0.044	0.000	0.100
Scheduled Caste	6028	19	0.028	0.000	0.051
Scheduled Tribe	2901	23	0.023	0.000	0.090
Community	2113	19	0.031	0.000	0.078
III. EAST INDIA					
Caste	2386	21	0.040	0.000	0.069
Scheduled Caste	2776	17	0.038	0.000	0.075
Scheduled Tribe	5844	34	0.026	0.000	0.104
Community	2633	10	0.036	0.026	0.056
IV. CENTRAL INDIA					
Caste	243	1	0.029	0.029	0.029
Scheduled Caste	-	0	-	-	-
Scheduled Tribe	856	7	0.031	0.000	0.059
Community	211	2	0.042	0.039	0.125
V. SOUTH INDIA					
Caste	3475	27	0.049	0.000	0.231
Scheduled Caste	2571	18	0.035	0.013	0.089
Scheduled Tribe	5400	39	0.030	0.000	0.128
Community	6857	37	0.045	0.000	0.154
VI. ISLANDS					
Caste	-	0	-	-	-
Scheduled Caste	-	0	-	-	-
Scheduled Tribe	126	3	0.024	0.000	0.057
Community	-	0	-	-	-
INDIA					
Caste	18159	134	0.043	0.000	0.231
Scheduled Caste	12724	69	0.032	0.000	0.118
Scheduled Tribe	16004	111	0.026	0.000	0.128
Community	17083	100	0.040	0.000	0.154
B. REGIONS OF HIMALAYA					
A. Western Himalaya					
Caste	2800	23	0.039	0.001	0.077
Scheduled Caste	412	6	0.032	0.000	0.118
Scheduled Tribe	779	4	0.017	0.000	0.032
Community	240	2	0.004	0.000	0.025

Table 1: Contd.....

Particulars	*Subject studied*	*No. of studies*	*Frequency*		
			Mean	*Min*	*Max*
B. Central Himalaya					
Caste	1688	13	0.034	0.000	0.085
Scheduled Caste	128	2	0.015	0.000	0.017
Scheduled Tribe	-	0	-	-	-
Community	131	1	0.084	0.084	0.084
C. Eastern Himalaya					
Caste	1369	7	0.037	0.029	0.045
Scheduled Caste	1046	7	0.035	0.000	0.055
Scheduled Tribe	4017	24	0.025	0.000	0.104
Community	1579	7	0.031	0.026	0.037
5. TRADITIONAL OCCUPATION					
Priesthood	9762	68	0.045	0.000	0.100
Warfare	3560	26	0.038	0.000	0.231
Trade and Commerce	2191	19	0.036	0.000	0.078
Agriculture	9503	43	0.032	0.000	0.093
Animal Husbandry	1429	9	0.022	0.000	0.046
Artisans	473	6	0.055	0.020	0.118
Menial Workers	4864	32	0.035	0.000	0.089
No Information	32188	211	0.034	0.000	0.154
6. LANGUAGE GROUP					
I. AUSTRO-ASIATIC FAMILY					
Mon Khmer Group	943	4	0.035	0.000	0.038
Munda Group	2074	10	0.024	0.009	0.080
II. TIBETO-CHINESE FAMILY					
(i) Siamese-Chinese Sub-Family					
Tai Group	-	0	-	-	-
(ii) Tibeto-Burman Sub-Family					
Bhotia Group	676	3	0.027	0.013	0.035
Himalayan Group	2616	13	0.026	0.000	0.118
North East Frontier Group	559	5	0.045	0.000	0.104
Bodo Group	325	3	0.009	0.000	0.015
Naga Group	462	5	0.019	0.000	0.055
Kachin Group	-	0	-	-	-
Kuki Chin Group	298	2	0.014	0.000	0.018
III. DRAVIDIAN FAMILY					
South Dravidian Group	14845	96	0.043	0.000	0.231
Central Dravidian Group	4292	29	0.029	0.000	0.068
North Dravidian Group	-	0	-	-	-
IV. INDO-EUROPEAN FAMILY					
Dard Group	504	3	0.072	0.065	0.077
North Western Group	-	0	-	-	-
Southern Group	12013	71	0.035	0.000	0.100
Eastern Group	949	9	0.037	0.000	0.075
Bihari	3772	27	0.043	0.000	0.069
Central Group	14309	93	0.037	0.000	0.125
Pahari Group	4089	31	0.028	0.000	0.057
Unspecified	-	0	-	-	-
Other Languages	399	6	0.028	0.000	0.057
No Information	845	4	0.001	0.000	0.003
6A. LANGUAGE FAMILY					
I. Austro Asiatic Family	3017	14	0.027	0.000	0.080
II. Tibeto Chinese Family	4936	31	0.026	0.000	0.118
III. Dravidian Family	19137	125	0.040	0.000	0.231
IV. Indo European Family	35636	234	0.036	0.000	0.125
Other Languages	399	6	0.028	0.000	0.057
No Information	845	4	0.001	0.000	0.003

The frequency of colour blind males among Indian populations is 0.036 (varies from complete absence to 0.231 among Kshatriyas of Andhra Pradesh). The average frequencies in West, East and Central zones are similar (0.032, 0.033 and 0.033, respectively) as compared to South and North zones from where high frequencies are observed (0.040 and 0.038, respectively). The frequency is lowest among scheduled tribes (0.026, varies from complete absence to 0.128 among Todas of Tamil Nadu studied by Clements, 1930) as compared to other ethnic groups - scheduled caste (0.035), community (0.045) and caste (0.049) and almost similar pattern is also observed from different zones of India. The frequencies are low from Islands (0.024) followed by Himalayan mountain complex (0.030) as compared to other natural regions. The maximum number of studies are available from tropical savannah type and monsoon type with dry winters climatic regions from where the frequencies are similar to that observed among total populations of India (0.033. 0.036 and 0.036, respectively) (Table 1).

From North India, in the Western Himalayan region the frequency of colour blindness is highest in Jammu and Kashmir among urban populations - Pandits and Dogras (0.072), whereas from Himachal Pradesh, the frequency is low (0.027); most of the population groups reported from this state are either agriculturists or pastoralists or both (for example Gaddis, Bodhs, Swangalas, Kanets, Kolis among others). Among Artisan of Dharamsala, frequency is quite high (0.118) which perhaps is due to sample size (17 subjects tested). From the other areas - Punjab, Chandigarh, Delhi and from plains of Uttar Pradesh, the frequencies are high and almost uniform among the castes and communities reported. On the other hand, among Gujjars (nomads), Raigars and Pawar of Rajasthan the frequencies are quite low (average 0.017).

In West India from all the States and Union Territories the frequency of colour blindness is almost uniform (0.03. varies from complete absence to 0.10 among Vadnagara Nagar Brahmans). The frequencies are low among scheduled tribes (0.023) followed by scheduled castes (0.028) as compared to communities (0.031) and castes (0.044).

Among the populations with Mongoloid affinities from the states of Nagaland, Mizoram, Tripura and Sikkim of Eastern Himalayan region the frequencies are low (0.00, 0.018, 0.015, 0.026, respectively) from where most of the populations studied are either agriculturists or pastoralists or both as compared to Arunachal Pradesh (0.043), where quite high frequencies are observed among Apatani (0.104), Tangsa (0.055), Miji (0.056), Gallong (0.043), Assam (among castes and communities) and Meghalaya (Khasis), whereas among Nepalies (Bhasin, 1967) and Tibetans (Tiwari, 1969) the frequencies of colour defects are high (0.042 and 0.050, respectively). From West Bengal, high frequencies are reported among Santal tribals (varies from 0.049 to 0.079) and scheduled castes (Duley-0.059, Tentulia Bagdi-0.059), and from Orissa, the frequency is low (0.033, varies from complete absence to 0.075 among Sudra-scheduled caste). In general the frequency is low among scheduled tribe (0.026) as compared to rest of the groups, among whom differences are small.

From Central India, the frequency is low among scheduled tribe (0.031), but a little higher as compared to scheduled tribes of other regions.

From South India, the frequency of colour blinds is high (0.040, varies from nil to 0.231) and the frequency is uniform in all the States and Union Territory. Among scheduled tribes of this zone the frequency is low (0.030) as compared to other groups.

Among Onges of Andaman Islands, the colour blindness is absent, whereas among Shompens of Nicobar Islands the frequency is quite high (0.057).

In general, the frequency of colour blindness is high in South and North India zones (0.040 and 0.038, respectively) as compared to rest of the zones in which the frequencies are low and similar, and lowest being from Islands (0.028). Among the ethnic groups, the lowest frequencies are observed among scheduled tribes, followed by scheduled castes as compared to communities and castes.

The frequency of colour defect correlations

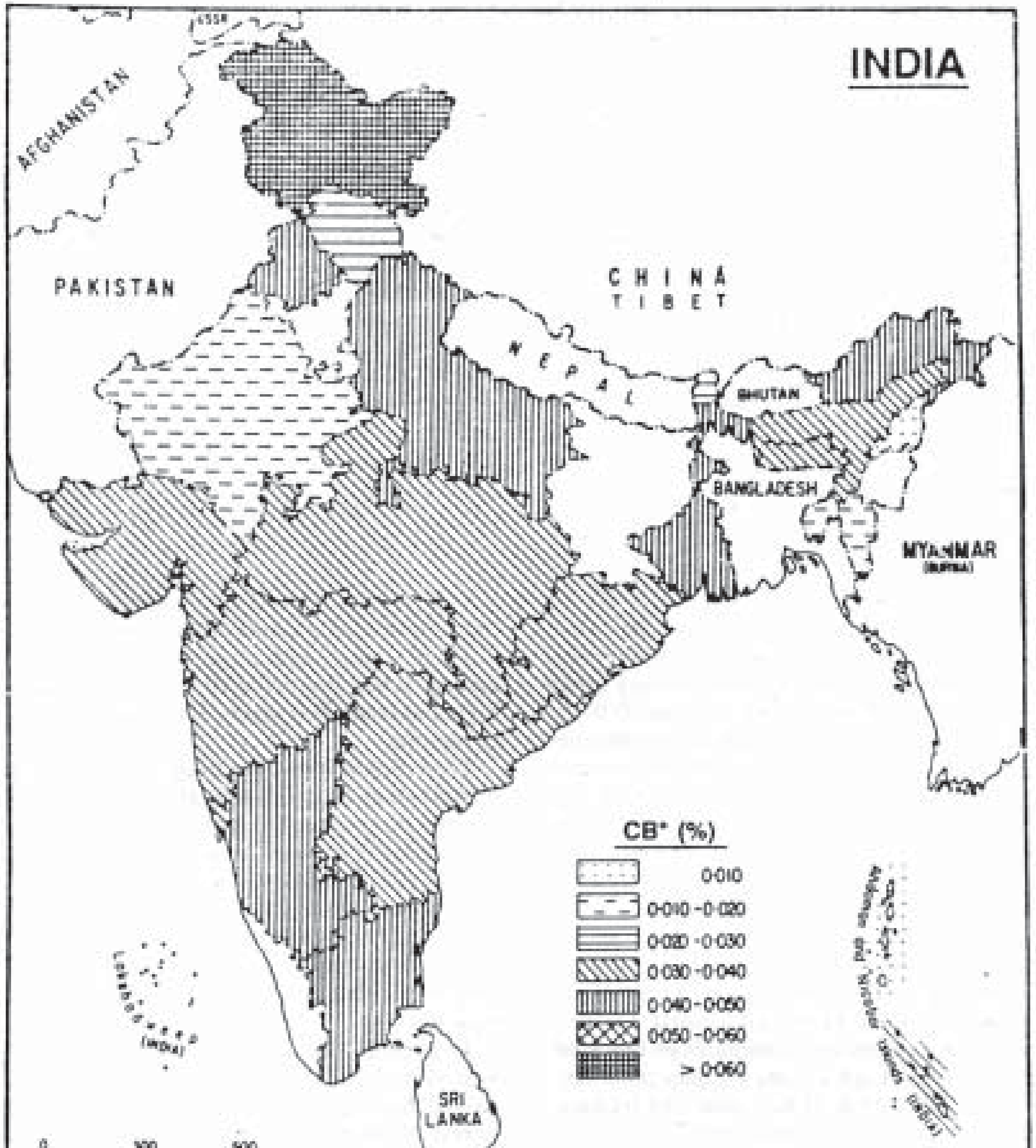

Fig. 1. CB⁺ (Colour Blindness) frequency in percentage in different regions of India

with various climatic factors and altitude by different ethnic groups though showing significant differences are not high (for details see Bhasin et al., 1994).

The frequency of colour blindness is low among the populations from animal husbandry (0.022), agriculture (0.032) and menial workers (0.035) of lower occupational groups as compared to higher occupational groups like priesthood (0.045) and warfare (0.038). So the comparatively low frequency among lower occupational groups may be due to relaxation of selection operating in them.

The frequency of colour blinds is low among the speakers of Munda group (0.024) of Austro-Asiatic; Bhotia group (0.027) Himalayan group (0.026), Bodo group (0.009), Naga group (0.019) and Kuki Chin group (0.014) of Tibeto-Chinese; Pahari group (0.028) of Indo-European, Central Dravidian group (0.029) of Dravidian languages mostly belonging to scheduled tribe and scheduled caste groups. In general, the frequencies are low among Austro-Asiatic and Tibeto-Chinese languages speakers as compared to Indo-European (0.036) and Dravidian (0.040) language speakers.

Since colour blindness may result in a severe impediment in different environment conditions, the role of one of the vital elements of evolutionary forces *viz.*, selection cannot be ruled out. From the results of colour blindness studies in the different populations groups of the world, Post (1962) observed the frequency of colour blindess in descending order of magnitude among food gatherers and hunters, settled agriculturists and civilized communities. On the basis of these results, he thought that colour vision defects would be more damaging to primitive populations, since they have to depend upon game for their subsistence, and in which therefore the full vision power for differentiating colours is of vital importance. According to him, the comparatively high frequencies of colour blindness in agricultural societies are due to the relaxation of selection operating in them. This assumption has been supported by Pickford (1963), Cruz-Coke (1970), Kalmus (1972) and many others. Dutta (1966) compiling the data of Indian populations, found 0.024 of colour vision defects among tribals as against 0.044 in economically advanced Hindus, which confirm Post's (1962) hypothesis of relaxation of selection.

It has been observed that overall frequency of colour vision defects has been observed low among scheduled tribe groups (traditionally food-gatherers and hunters and later occupied in shifting cultivation and as agricultural labourers) from all the zones and India followed by scheduled caste groups (about 90 per cent of scheduled castes are agricultural labourers) which is followed by caste groups. The same pattern has been observed in lower occupational groups, like the animal husbandry group as compared to the higher ones *e.g.*, priesthood, warfare and trade and commerce groups. This observation perfectly fits into the hypothesis porposed by Post (1962) and Pickford (1963).

The model of Post (1962) and Pickford (1963) explains satisfactorily the status of colour blindness in tribal population groups. As long back as 1963, Pickford put forward an explanation regarding the high incidence of colour vision deficiency among Brahmans and other caste groups of India stating that the higher castes are further removed from hunting and food gathering than the lower castes.

Although Adam et al. (1967) and Adam (1969, 1985, 1986) critically viewed Post's hypothesis arguing that the role of mild and severe defects must bé reasoned out before discussing the role of the selective pressures yet the possibility of relaxation of selection was not ruled out. However, Post (1971) strongly justified his previous assertion. Interestingly, some of the tribal populations of India (for frequencies distribution see Bhasin, Walter and Danker-Hopfe, 1992) reveal high frequencies of colour vision defects. Although the high percentage of inbreeding and settled agricultural economy etc. are the reasons given to explain the prevalent high frequency of colour blindness in these populations, the validity of the theory of relaxation of selection will have to be substantiated by further studies and more quantitative data.

The frequency of colour defects is 0.036 in populations groups of India (males only) which varies from complete absence to 0.231.

It is present in low frequency in scheduled tribe as compared to other ethnic groups. In different zones, it is high in North (0.038) and South (0.040) India than in other zones. In the Himalayan region a low frequency is observed from Eastern (0.029) as compared to Western (0.032) and Central (0.036) regions. In occupational groups, it is low among agricultre group and high in priesthood, warfare and trade and commerce groups. A similar pattern is observed from different language families *i.e.* low freqency in Austro-Asiatic and Tibeto Chinese family as compared to Dravidian and Indo-European family. The validity of the hypothesis of relaxation of selection among different ethnic groups explain to some extent the status of colour blindness in tribal population groups *i.e.* low frequency among them as compared to other ethnic groups particularly caste groups, but still it has to be sustantiated with further data.

TASTE SENSITIVITY

The importance of the ability to taste phenylthiocarbamide (P.T.C.) was realized long back in 1932 by Fox, when he failed to make any taste out of it, while his colleague found it to be bitter. Thereafter, Synder (1932) showed that the inheritance of the ability to taste P.T.C. was dependent on a single autosomal dominant gene. The simple model is, however, complicated by other factors like sex (Blakeslee and Salmon, 1931; Falconer, 1947; Mohr, 1951a; Pons, 1955), age (Harris and Kalmus, 1949a; 1951a; Kalmus, 1958; Glanville et al., 1964); the presence or absence of the saliva of the subject (Cohen and Ogden, 1949) and also the strength of the test solution (Harris and Kalmus, 1949b). These factors invariably modify the phenotypic expression and their genetic relationships to tasting and non-tasting alleles are not yet determined. It has been suggested that there are modifying genes at other loci (Stern, 1960; Blumberg, 1961) or otherwise, the penetrance of the two alleles may vary (Boyd, 1950; Kalmus, 1958). Incomplete dominance and penetrance of the taster was suggested by Das (1958) and he estimated the degree of penetrance of taster gene to be 80 per cent, but it may be less (Das, 1966b). He further added that as it is most likely that the variation in the expression of the taster allele including its complete suppression could be due to extrageneic factors, the degree of penetrance might be different in different peoples, places, ages etc.

There are various methods to distinguish tasters from non-tasters (Fox, 1932; Parr, 1934; Blakeslee and Salmon, 1935; Boyd and Boyd, 1937; Hartman, 1939; Harris and Kalmus, 1949a) but the sorting technique with serial dilutions of Harris and Kalmus (1949a) is widely used with minor modifications because of its superiority in discerning the threshold of the individual with near perfection.

Today, it has been established beyond doubt that the ability to taste P.T.C. exhibits a strong dimorphism in human populations. The above factors which modify the actual response itself, additional researches have brought to light a number of relationships to this polymorphism, the most prominent being the ties of the thyroid, as well as its activity as a goitrogen (Harris and Kalmus 1949b). A number of studies have shown an excess of non-tasters among individual having adenomatous gioter (Harris et al., 1949; Kitchin et al., 1959; Azevedo et al., 1965) and in addition to this, it was found that athyreotic cretins were significantly more likely to be non-tasters than normal controls (Shepard and Gartler, 1960; Frazer, 1961). Non-tasters have also more susceptibility to dental caries (Chung et al., 1964) and diabetes mellitus (Terry and Segall, 1947; Terry, 1950).

Some more reports are also available regarding the association of non-tasters with diseases (Saldanha, 1956; Beiguelman, 1964a,b; Brachtel and Walter, 1974; Mourao and Salzano, 1978); such associations remain merely reports, and detailed work would be needed to advance further comments in this direction. Similarly, no specific relationships exists regarding the association of the ability to taste P.T.C. with the change of age, sex and social habits, *viz.*, smoking, dietary habits and betel chewing (Blakeslee and Salmon, 1935; Hartman, 1939; Falconer, 1947; Akesson, 1959; Sharma, 1959; Seth, 1962). For critical review on this subject see Jörgensen (1969).

The frequency of taster allele *T* is about 0.50 among European populations. Among Southwest Asian populations it varies from 0.43 to 0.75. Among Mongoloid populations of East Asia and Southeast Asia the frequency of allele *T* is very high (about 0.70 ranges from 0.55 to 0.95). The frequency among Tibetans varies from 0.62 to 0.67. Among Africans also the frequency is high albeit less than Mongoloids (Mourant et al., 1976a; Roychoudhury and Nei, 1988).

The frequency of allele *T* among Indian populations is 0.457 (varies from 0.108 among Munda of Ranchi - Bihar to 0.912 in scheduled caste of Andhra Pradesh) which is little low as compared to Europeans but similar to that of southwest Asian populations. The frequency is highest from the Island's zone as compared to rest of the zones of India - North (0.488), South (0.483), Central (0.389) and West (0.369) India. Among the population groups from Himalayan region mostly with Mongoloid affinities, the frequency is highest (0.533) as compared to Non-Himalayan regions (0.426). The frequency of allele *T* is low in scheduled tribes (0.451) as compared to other groups with minor differences. It appears that populations with Mongoloid affinities posses high frequency of taster allele (*T*) and quite high frequencies are observed among the Mongoloids of Asia as compared to Indian tribal groups among whom high frequencies of the non-taster allele (*t*) are found. The frequency of allele *T* is high from Islands natural region (0.547) and also from the Himalayan mountain complex region (0.545), from where the frequency starts decreasing towards peninsular plateau. From the different climatic regions, the frequencies are high in polar, cold, humid and all monsoon type regions and is lowest in tropical savannah type region (0.377) (Table 2).

From East India, the frequency of allele *T* is quite low from the state of Bihar (0.298, varies from 0.108 to 0.490) and Orissa (0.324, ranges from 0.268 to 0.571) from where the frequencies are low among scheduled tribes as compared to rest of the ethnic groups, whereas from the state of Nagaland, Tripura, Meghalaya, Sikkim and Darjeeling district of West Bengal among the populations with Mongoloid affinities the frequencies are quite high (0.702, 0.597, 0.580, 0.694 and about 0.60, respectively).

Similar high frequencies are observed from Western Himalayan region among populations with Mongoloid affinities from the states of Jammu and Kashmir (Ladakhis - 0.762), Himachal Pradesh (Gurkhas - 0.615, Lahaulies - 0.643, Spitians - 0.654, Kinnaura - 0.606, Shipi - 0.662, Bodhs - 0.656, Savangalas - 0.626) and Uttar Pradesh - Central Himalayan region (different groups of Bhotias about 0.60, Gurungs - 0.656 among others). The frequency of allele *T* is also quite high among Newars; Sherpas and Tamangs combined; and Sherpas (0.523, 0.533 and 0.719, respectively) of Nepal and Tibetans (varies from 0.616 to 0.672).

The frequency of allele *T* is low among scheduled tribes from Central India and it is almost similar among all the tribals except Dhurwa in which it is quite low (0.180). The frequency of allele *T* is highest among the populations groups with Mongoloid affinities from the Himalayan region followed by South Indians.

From West India the frequency of allele *T* is observed lowest (0.369, varies from 0.249 to 0.536) as compared to other zones and the frequencies are almost similar in both the states of Gujarat (0.388) and Maharashta (0.371). Among the scheduled castes and scheduled tribes of West India (0.302 and 0.331, respectively) the frequencies are lowest as compared to rest of the groups.

Among the Nicobarese with Mongoloid affinities the frequency of *T* allele is high (0.595) and from Anadaman Islands, among Onges the frequency is 0.436 as compared to Bhantus, who had migrated from Uttar Pradesh (0.335).

In general, the frequency of taster allele *T* is high among the population groups with Mongoloid affinities from the Himalayan region but lower than the Monogoloid populations from Far East and Southeast Asia and lowest among the scheduled tribes. The frequency of allele *T* is low in West India and from there the farequency starts increasing in all the directions (Table 2).

The allele frequency *T* correlations with

Table 2: Taste sensitivity allele frequencies

Particulars	*Subject studied*	*No. of studies*	*Frequency*		
			Mean	*Min*	*Max*
1. NATURAL REGION					
Himalayan Mountain Complex	6550	46	0.545	0.285	0.762
Indus-Ganga-Brahmaputra Plains	20610	86	0.469	0.248	0.664
Peninsular Plateau	23737	136	0.419	0.108	0.912
Islands	878	8	0.547	0.335	0.678
2. CLIMATIC REGION					
Monsoon Type with Short Dry Season	1397	13	0.519	0.268	0.678
Monsoon Type with Dry Season	3627	18	0.518	0.184	0.729
Tropical Savannah Type	16525	93	0.377	0.108	0.912
Semi Arid Steppe Type	1442	7	0.448	0.257	0.577
Hot Desert Type	-	0	-	-	-
Monsoon Type with Dry Winters	28021	141	0.489	0.248	0.755
Cold Humid Winters with Short Summers	271	1	0.631	0.631	0.631
Polar Type	492	3	0.659	0.643	0.762
3. POLITICAL DIVISION OF INDIA					
I. NORTH INDIA					
A. Western Himalaya (S.No. 1,2)					
1. Jammu and Kashmir	243	3	0.460	0.370	0.762
2. Himachal Pradesh	2395	18	0.508	0.285	0.654
3. Punjab	1608	10	0.410	0.248	0.586
4. Chandigarh UT	2288	7	0.519	0.426	0.655
5. Haryana	-	0	-	-	-
6. Delhi UT	1462	9	0.421	0.288	0.532
B. Central Himalaya (S.No. 7. Eight Districts of Uttar Pradesh)					
7. Uttar Pradesh	4530	37	0.513	0.307	0.702
8. Rajasthan	-	0	-	-	-
II. WEST INDIA					
9. Gujarat	3533	19	0.368	0.249	0.473
10. Maharashtra	2974	14	0.371	0.268	0.536
11. Goa, Daman and Diu UT	-	0	-	-	-
12. Dadra and Nagar Haveli UT	-	0	-	-	-
III. EAST INDIA					
C. Eastern Himalaya (S.No. 13 to 20 and Darjeeling District of West Bengal)					
13. Arunachal Pradesh	-	0	-	-	-
14. Assam	7324	23	0.515	0.348	0.664
15. Nagaland	273	3	0.702	0.635	0.755
16. Manipur	-	0	-	-	-
17. Mizoram	-	0	-	-	-
18. Tripura	401	1	0.597	0.597	0.597
19. Meghalaya	1624	13	0.580	0.502	0.676
20. Sikkim	261	2	0.694	0.638	0.733
21. West Bengal	6024	17	0.433	0.272	0.528
22. Bihar	1894	13	0.298	0.108	0.496
23. Orissa	3354	14	0.324	0.268	0.571
IV. CENTRAL INDIA					
24. Madhya Pradesh	867	9	0.389	0.180	0.483
V. SOUTH INDIA					
25. Karnataka	-	0	-	-	-
26. Andhra Pradesh	4346	28	0.447	0.184	0.912
27. Tamil Nadu	3274	15	0.550	0.342	0.729
28. Kerala	1211	9	0.496	0.257	0.638
29. Pondicherry UT	1011	4	0.406	0.363	0.422
VI. ISLANDS					
30. Lakshadweep UT	-	0	-	-	-
31. Andaman Islands and	188	2	0.370	0.335	0.436
Nicobar Islands UT	690	6	0.595	0.402	0.678

Table 2: Contd.....

Particulars	Subject studied	No. of studies	Frequency		
			Mean	Min	Max
3A. ZONES OF INDIA					
I. North India	12526	84	0.488	0.248	0.762
II. West India	6507	33	0.369	0.249	0.536
III. East India	21155	86	0.453	0.108	0.755
IV. Central India	867	9	0.389	0.180	0.483
V. South India	9842	56	0.483	0.184	0.912
VI. Islands	878	8	0.547	0.335	0.678
INDIA (TOTAL)	51775	276	0.457	0.108	0.912
3B. REGIONS OF HIMALAYA					
A. Western Himalaya	2638	21	0.504	0.285	0.762
B. Central Himalaya	2361	17	0.540	0.368	0.702
C. Eastern Himalaya	10228	43	0.538	0.348	0.755
HIMALAYA (TOTAL)	15227	81	0.533	0.285	0.762
NON-HIMALAYA REGIONS	36548	195	0.426	0.108	0.912
4. ETHNIC GROUP					
A. ZONES OF INDIA					
I. NORTH INDIA					
Caste	5974	44	0.489	0.285	0.702
Scheduled Caste	336	3	0.478	0.458	0.489
Scheduled Tribe	1489	9	0.601	0.486	0.762
Community	4727	28	0.452	0.248	0.656
II. WEST INDIA					
Caste	1665	8	0.410	0.318	0.485
Scheduled Caste	828	3	0.302	0.268	0.344
Scheduled Tribe	1476	9	0.331	0.249	0.473
Community	2538	13	0.387	0.282	0.536
III. EAST INDIA					
Caste	4803	16	0.439	0.296	0.571
Scheduled Caste	3452	12	0.486	0.313	0.664
Scheduled Tribe	8530	44	0.446	0.108	0.755
Community	4370	14	0.454	0.272	0.578
IV. CENTRAL INDIA					
Caste	-	0	-	-	-
Scheduled Caste	71	1	0.483	0.483	0.483
Scheduled Tribe	717	7	0.377	0.180	0.474
Community	79	1	0.405	0.405	0.405
V. SOUTH INDIA					
Caste	1636	8	0.504	0.257	0.729
Scheduled Caste	1537	10	0.662	0.555	0.912
Scheduled Tribe	4665	29	0.443	0.198	0.718
Community	2004	9	0.422	0.184	0.597
VI. ISLANDS					
Caste	-	0	-	-	-
Scheduled Caste	-	0	-	-	-
Scheduled Tribe	878	8	0.547	0.335	0.678
Community	-	0	-	-	-
INDIA					
Caste	14078	76	0.464	0.257	0.729
Scheduled Caste	6224	29	0.505	0.268	0.912
Scheduled Tribe	17755	106	0.451	0.108	0.762
Community	13718	65	0.436	0.184	0.656
B. REGIONS OF HIMALAYA					
A. Western Himalaya					
Caste	1535	13	0.456	0.285	0.606
Scheduled Caste	17	1	0.458	0.458	0.458
Scheduled Tribe	492	3	0.659	0.643	0.762
Community	594	4	0.499	0.348	0.621

Table 2: Contd.....

Particulars	*Subject studied*	*No. of studies*	*Frequency*		
			Mean	*Min*	*Max*
B. Central Himalaya					
Caste	-	0	-	-	-
Scheduled Caste	1642	12	0.512	0.368	0.702
Scheduled Tribe	660	4	0.600	0.575	0.615
Community	59	1	0.656	0.656	0.656
C. Eastern Himalaya					
Caste	1070	3	0.439	0.375	0.484
Scheduled Caste	1947	4	0.544	0.402	0.664
Scheduled Tribe	4638	27	0.589	0.394	0.755
Community	2573	9	0.484	0.348	0.578
5. TRADITIONAL OCCUPATION					
Preisthood	8415	37	0.453	0.285	0.729
Warfare	2265	15	0.499	0.325	0.702
Trade and Commerce	1972	13	0.459	0.257	0.587
Agriculture	4255	22	0.481	0.184	0.671
Animal Husbandry	538	4	0.295	0.248	0.348
Artisans	501	5	0.581	0.458	0.876
Menial Workers	3673	16	0.474	0.268	0.912
No Information	30156	164	0.450	0.108	0.762
6. LANGUAGE GROUP					
I. AUSTRO-ASIATIC FAMILY					
Mon Khmer Group	1958	14	0.579	0.394	0.678
Munda Group	3888	13	0.272	0.108	0.366
II. TIBETO-CHINESE FAMILY					
(i) Siamese-Chinese Sub-Family					
Tai Group	-	0	-	-	-
(ii) Tibeto-Burman Sub-Family					
Bhotia Group	492	3	0.659	0.643	0.762
Himalayan Group	699	6	0.599	0.458	0.733
North East Frontier Group	923	6	0.536	0.452	0.618
Bodo Group	1924	8	0.576	0.477	0.662
Naga Group	544	4	0.667	0.631	0.755
Kachin Group	-	0	-	-	-
Kuki Chin Group	-	0	-	-	-
III. DRAVIDIAN FAMILY					
South Dravidian Group	7390	40	0.489	0.184	0.876
Central Dravidian Group	2571	17	0.425	0.180	0.686
North Dravidian Group	395	5	0.407	0.275	0.496
IV. INDO-EUROPEAN FAMILY					
Dard Group	-	0	-	-	-
North Western Group	-	0	-	-	-
Southern Group	3184	16	0.365	0.268	0.500
Eastern Group	1391	12	0.492	0.390	0.912
Bihari	10383	28	0.462	0.272	0.664
Central Group	13255	82	0.447	0.248	0.702
Pahari Group	1810	14	0.476	0.285	0.621
Unspecified	638	4	0.552	0.486	0.614
Other Languages	330	4	0.378	0.329	0.436
No Information	-	0	-	-	-
6A. LANGUAGE FAMILY					
I. Austro Asiatic Family	5846	27	0.375	0.108	0.678
II. Tibeto Chinese Family	4582	27	0.591	0.452	0.762
III. Dravidian Family	10356	62	0.470	0.180	0.876
IV. Indo European Family	30661	156	0.449	0.248	0.912
Other Languages	330	4	0.378	0.329	0.436
No Information	-	0	-	-	-

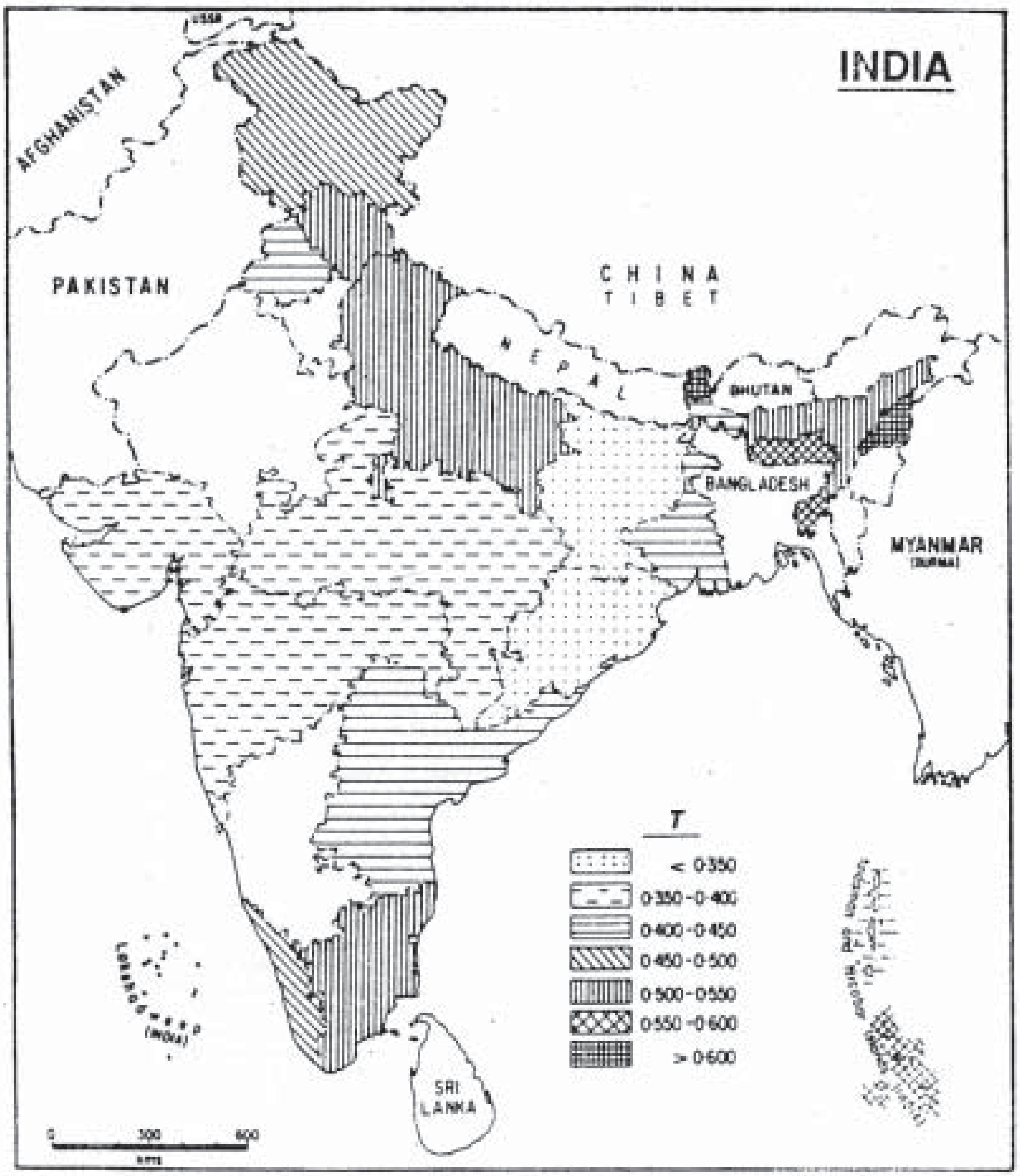

Fig.2. Allele T of taste sensitivity in different regions of India

various climatic factors and altitude by different ethnic groups though showing significant differences are not high (for details see Bhasin et al., 1994).

Among the different occupational groups, the frequency of allele *T* is almost similar among higher - priesthood (0.453), trade and commerce (0.459) and others - agriculture (0.481) and menial workers (0.474) groups, which indicates gene flow among them, as also observed for other genetic markers (for details see Bhasin et al., 1994) (Table 2).

Among the populations of Himalayan region with Mongoloid affinities, the frequency of allele *T* is high in Mon Khmer group (0.579) of Austro-Asiatic; in Bhotia group (0.659), Himalayan group (0.599, Bodo group (0.57), Naga group (0.667) of Tibeto-Chinese languages as compared to the speakers of Dravidian followed by Indo-Europeans and Munda group of Austro-Asiatic languages among whom the frequencies are low (0.470, 0.499 and 0.272, respectively) (Table 2).

Among population groups of India, the frequency of taster allele *T* is 0.457 (varies between 0.108 and 0.912). From the different zones, it is present in high frequency among population groups of Islands followed by North and South India and is low in West and Central India, as well as among scheduled tribe groups in general. In Himalayan region, it frequency is high (0.533) as compared to Non-Himalayan region (0.426). From Eastern Himalayan region, the frequency of allele *T* is low (0.538) among populations with Mongoloid affinities as compared to the Mongoloid populations of East Asia and Southeast Asia (0.70) which may be due to high incidence of goiter in the former region. Among the speakers of various languages, the frequency is high is Austro-Asiatic (Mon Khmer) and Tibeto-Chinese speakers with Mongoloid affinities from Himalayan region and Nicobar Islands than in the speakers of Dravidian and Indo-European languages.

KEY WORDS Colour Blindness. Taste Sensitivity. Castes. Tribes. India. Selection.

ABSTRACT The discipline of Biological Antrhropology (or Human Biology) incorporates study of biology and environmental factors, as well as the forces of micro-evolution leading to macroevolution, which ultimately influences the biological structure of human populations. In the present paper an attempt has been made to study the distribution of colour blindness and tasting ability among the people of India, which are analysed in relation to ecological, socio-economic and linguistic factors.

REFERENCES

Adam, A. : Further query on colour blindness and natural selection. *Soc. Biol.*, **16**: 197-202 (1969).

Adam, A. : Colourblindness in man: A call for re-examination of the selection-relaxation theory. pp. 181-194. In: *Genetic Microdifferentiation in Human and Other Animal Populations.* Y.R. Ahuja and J.M. Neel (Eds.). Proc. Int. Sym., Hyderabad (1983). Indian Anthropological Society, Delhi (1985).

Adam, A. : Polymorphisms of red-green vision among populations of the tropics. pp. 245-252. In : *Genetic Variation and its Maintenance with Particular Reference to Tropical Populations.* D.F. Roberts and G.F. De Stefano (Eds.). Cambridge University Press, Cambridge (1986).

Adam, A., Doron, D. and Modan, R. : Frequencies of protan and deutan alleles in some Israeli communities and a note on the selection - relaxation hypothesis. *Am. J. Phys. Anthrop.*, **26**: 297-305 (1967).

Akesson, H.O. : Taste sensitivity to phenyl-thio-urea in tuberculosis and diabetes mellitus. *Ann. Hum. Genet.*, **23**: 262 (1959).

Azevedo, E.H., Krieger, M.P.M. and Morton, N.E. : P.T.C. taste sensitivity and endemic goiter in Brazil. *Am. J. Hum. Genet.*, **17**: 87-90 (1965).

Beiguelman, B. : Taste sensitivity to phenyl-thiocarbamide among patients affected with both tuberculosis and leoprosy. *Acta Genet. Med. Gemell.*, **13**: 190 (1964).

Bhasin, M.K. : The frequency of colour blindness in the Newars of Nepal valley. *Acta Genet. Stat. Med.*, **17**: 454 (1967).

Bhasin M.K. : *Biology of the Peoples of Indian Region (Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka). A Classified and Comprehensive Bibliography.* Kamla-Raj Enterprises, Delhi (1988).

Bhasin M.K., Walter, H. and Danker-Hoffe, H. : *The Distribution of Genetical, Morphological and Behavioural Traits Among The Peoples of Indian Region.* Kamla-Raj Enterprises, Delhi (1992).

Bhasin, M.K., Walter, H. and Danker-Hoffe, H. : People of India: *An Investigation of Biological Variability in Ecological, Ethno-economic and Linguistic Groups.* Kamla-Raj Enterprises, Delhi (1994).

Blakeslee, A.F. and Salmon, M.R. : Odour and taste blindness. *Eugenical News*, **16**: 105-108 (1931).

Blakeslee, A.F. and Salmon, T.N. : Genetics of sensory thresholds, Individuals taste reactions for different substances. *Proc. Natl. Acad. Sci., U.S.A.*, **21**: 84 (1935).

Blumberg, B.S. : Inherited susceptibility to disease. *Arch. Environ. Health*, **3**: 612-636, (1961).

Boyd, W.C. : *Genetics and Races of Man.* Blackwell, Oxford (1950).

Boyd, W.C. and Boyd, L.G. : Sexual and racial variations in ability to taste phenylthicarbamide, with some data on inbreeding in Syria. *Am. J. Phys. Anthrop.*, **28**: 319-330 (1941a).

Brachtel, R. and Walter, H. : PTC-Schmeckfahigkeit and Psoriasis vulgaris. *Anthrop. Anz.*, **34**: 231 (1974).

Chung, C.S., Witkop, C.J. and Henry, J.L. : A genetic study of dental caries with special reference to PTC taste sensitivity. *Am. J. Hum. Genet.*, **16**: 231-245 (1964).

Clements, F. : Racial differences in colour blindness. *Am. J. Phys. Anthrop.*, **14**: 417 (1930).

Cohen, J. and Ogden, D.P. : Taste blindness to PTC as a function of saliva. *Sciencer*, **110**: 532-533 (1949).

Cruz-Coke, P. : *Colour Blindness: An Evolutionary Approach*. C.C. Thomas, Springfield (1970).

Das, S.R. : Inheritance of the PTC taste character in man: An analysis of 126 Rarhi Brahmin families of West Bengal. *Ann. Hum. Genet.*, **22**: 200-212 (1958).

Das, S.R. : Application of phenylthio-carbamide taste character in the study of racial variation (data on world taste gene distribution). *J. Ind. Anthrop. Soc.*, **1**: 63 (1966a).

Das, S.R. : Genetics of PTC taste character in man incomplete dominance and penetrance of taste gene. pp. 250-258. In: *Human Adaptability to Environments and Physical Fitness*. M.S. Malhotra (Ed.). Defence Inst. Physiol. and Allied Sciences, Madras (1966b).

Deka, U. : Genetic variation in the population of Koraput District. Paper presented in the *Seminar on Human Variations in India*. Anthropological Survey of India, Calcutta (1977).

Deka, U., Sahu, P.N. and Pattojoshi, P. : Variations in defective colour vision in some population of Orissa. Paper presented in the *Seminar on Human Variations in India*. Anthropological Survey of India, Calcutta (1977).

Dutta, P.C. : A review of the inherited defective colour vision variability and selection relaxation among Indians. *Acta Genet. Stat. Med.*, **16**: 327-339 (1966).

Falconer, D.S. : Sensory thresholds for solutions of phenythiocarbamide. *Ann. Eugen.*, **13**: 211-222 (1947).

Fox A. : The relationship between clinical constitution and taste. *Proc. Natl. Acad. Sci. Washington*, **18**: 115-120 (1932).

Franceschetti, A. : Die Bedutung der Eintstellungsbreite am Anomaloskop für die Diagnose der enzelnen Typen der Farbensinnstörungen, nebst Bemerkingen über ihren veverbungsmodus. *Schw. Med. Wchns.*, **52**: 1273-1279 (1928).

Frazer, G.R. : Cretinism and taste sensitivity to phenylthiocarbamide. *Lancet*, **i**: 964-965 (1961).

Glanville, E.V., Kaplan, A.R. and Fischer, R. : Age, sex and taste sensitivity. *J. Gerontol.*, **19**: 474-478 (1964).

Harris, H. and Kalmus, H. : The measurement of taste sensitivity to PTC. *Ann. Eugen.*, **15**: 24-31 (1949a).

Harris, H. and Kalmus, H. : Genetical differences in taste sensitivity to phenylthiourea and to anti-thyroid substances. *Nature Lond.*, **163**: 878 (1949b).

Harris, H., Kalmus, H. and Trotter, W.R. : Taste sensitivity to phenyl-thiourea in goiter and diabetes. *Lancet*, **ii**: 1038-1039 (1949).

Hartmann, G. : Application of individual taste difference towards PTC in genetic investigations. *Ann. Eugen.*, **10**: 532 (1939).

Jörgensen, G. : Schemocken und Riechen, S. 108. In: *Handbuch der Humangenetik*. Bd. 1/2. P.E. Becker (Hrsgb.). Thieme, Stuttagrt (1969).

Kalmus, H. : Improvement in the classification of the tasters genotypes. *Ann. Hum. Genet.*, **22**: 222-230 (1958).

Kalmus, H. : Pure (unique) green and a neutral zone in the spectrum of colour defectives. *Ann. Hum. Genet.*, **35**: 375 (1972).

Kapoor, A.K., Satwanti and Kashatriya, G.K. : Incidence of colourblindness in different Indian populations: Further example of selection relaxation hypothesis. *Acta Anthropogenet.*, **7**: 41-52 (1983).

Kitchin, F.D., Howel-Evans, W., Clarke, C.A., McConnell, R.B. and Sheppard, P.M. : PTC taste response and thyroid disease. *Birt. Med. J.*, **i**: 1069-1074 (1959).

Malhotra, K.C. : Inbreeding among 22 semi-nomadic Dhangar Castes of Maharashtra: A preliminary report. *ISI Tech. Report. No. Anthrop /4/76* (1976).

Malhotra, K.C., Mutalik, G.S., Bhanu, B.V., Kate, S.L. and Fulmali, P.M. : Incidence of colour blindness among four endogamous nomadic groups. An example of natural selection. *Heredity*, **32**: 145 (1974).

Mohr, J. : Taste sensitivity of phenylthiourea in Denmark. *Ann. Eugen.*, **16**: 282-286 (1951a).

Mourant, A.E., Kopec, A.C. and Domaniewska, Sobczak, K.: *The Distribution of the Human Blood Groups and Other Polymorphisms*. Oxford University Press, London, 2nd Edition (1976).

Mourão, L.A.C.B. and Salzano, F.M. : New data on the association between PTC tasting and tuberculosis. *Rev. Brasil Biol.*, **38**: 475 (1978).

Naidu, J.M., Babu, V.K. and Veerraju, P. : The incidence of colourblindness among tribal population of Andhra Pradesh. *Ann. Hum. Biol.*, **5**: 159-163 (1978).

Neel, J.V. and Post, R.H. : Transitory "positive" selection for colourblindness? *Eugen. Quart.*, **10**: 33-35 (1963).

Parr, L.W. : Taste blindness and race. *J. Hered.*, **25**: 187-190 (1934).

Pickford, R.W. : Natural selection and color blindness. *Eugen. Rev.*, **55**: 97-101 (1963).

Pons, J. : Taste sensitivity to phenylthiourea in Spaniards. *Hum. Biol.*, **27**: 153-160 (1955).

Post, R.H. : Population differences in red and green colour vision deficiency: A review and a query on selection relaxation. *Eugen. Quart.*, **9**: 131-146 (1962).

Post, R.H. : Possible cases of relaxed selection in civilized populations. *Humangenetik*, **13**: 253-284 (1971).

Post, R.H. : Population differences in red and green colour vision deficiency: A review, and query on selection relaxation. pp. 387-401. In: *Man in Evolutionary Perspective*, C.L. Brace and J. Meetress (Eds.). New York (1973).

Roychoudhury, A.K. and Nei, $M_{.}$: *Human Polymorphic Genes. World Distribution*. Oxford University Press, Oxford (1988).

Saldanha, P.H. : Apparent pleiotropic effect of gene determining taste threshold for PTC. *Lancet*, **ii**: 74 (1956).

Salzano, M.S. : Colorblind among Indians from Santa catavina Brazil. *Acta Genet. Stat. Med.*, **14**: 212-219 (1964).

Seth, P.K. : PTC taste threshold distributions among the

betel chewers, non-vegetarians and smokers. *East. Anthrop.*, **15**: 36-49 (1962).
Sharma, J.C. : Blood and PTC taste studies in Punjabis and the effect of age and certain eating habits on taste threshold. *Anthropologist*, **6**: 40 (1969).
Shepard, T.H. and Gartler, S.M. : Increased incidence of non-tasters of phenylthidocarbamide among congenital athryreotic cretins. *Science*, **131**: 929 (1960).
Stern, C. : *Principles of Human Genetics*. W. H. Freeman, San Francisco (1960).
Terry, M.C. : Taste blindness and diabetes in the coloured population of Jamaica. *J. Hered.*, **41**: 305-307 (1950).
Terry, M.C. and Segall, G. : The association of diabetes taste blindness. *J. Hered.*, **38**: 135-137 (1947).
Tiwari, S.C. : The incidence of colour-blindness among the Tibetans. *J. Genet. Hum.*, **17**: 95-98 (1969).
Vogel, F. and Motulsky, A.G. : *Human Genetics, Problems and Approaches*. Springer Verlag, Berlin, Heidelberg, New York, Tokyo, 2nd Edition (1986).
Waardenburg, P.J., Franceschetti, A. and Klein, D. : *Genetics and Ophthalmology*, Volume II, Blackwell, Oxford (1963).
Wright, W.D. : *Researches on Normal and Defective Colourvision*. Mosby Co., St. Louis (1947).

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