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Genetics of Castes and Tribes of India: A Review of Population Differences in Red and Green Colour Vision Deficiency in India

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KEYWORDS Colour vision defect; X-linked trait; population differences; relaxed natural selection

ABSTRACT The discipline of Biological Anthropology (or Human Biology) incorporates study of biology and environmental factors, as well as the forces of micro-evolution leading to macro-evolution, which ultimately influences the structure of human populations. In the present paper and attempt has been made to study the distribution differences in Red and Green Colour Vision Deficiency in India, which are analysed in relation to ecological, socio-economic and linguistic factors. The frequency of colour defects is 0.036 in population groups of India (males only) which varies from complete absence to 0.231. The validity of the hypothesis of relaxation of selection among different ethnic groups explains 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 substantiated with further data.

INTRODUCTION

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 sense completely. It has been established that 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. 1976; 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 sub-sequent 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

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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 Malhotra et al. (1974) and Malhotra (1978) from the studies on nomads observed negligible frequencies of colour blindness among them.

Deka (1977) and Deka et al. (1977) 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 (0.0573 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. The differences in various ethnic groups for the incidence of colour blindness show selection relaxation in settled communities. Selection pressure increases and it eliminates colour blind individuals from primitive populations and among modern populations the living conditions provide a protected environ-ment for the colour blind gene. However, 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.

IDENTIFY AND DISTINGUISH THE PEOPLE

For the biogenetical study of the people of India, researchers have generally used the following criteria to identify and distinguish the people: 1. Regional Groups, 2. Ethnic Groups, 3. Linguistic Groups, and 4. Religious Groups.

It should, however, be kept in mind that these are the convenient units of study, although there are significant levels of overlapping between them. For example, an occupational group pursuing traditional job inhabits a region, shares religion with other categories, belongs to one or the other language group and has an aggregation of ethnic properties. But in the human population genetic studies, out of these criteria one is chosen (Bhasin 1988).

In the present study an attempt has been made to analyse the above mentioned biogenetical traits into 1. Regional Groups, 2. Ethnic Groups, 3. Traditional Occupational Groups and 4. Linguistic Groups (For details see Bhasin et al. 1994; Bhasin and Walter 2001; Bhasin, 2006 on page 50- this issue).

Mean Weighted Values: To discern the pattern of regional groups, ethnic groups, traditional occupational groups and linguistic groups using the frequency data, the mean weighted values of the this trait has been calculated and estimates for the various groups are presented.

RED AND GREEN COLOUR VISION DEFICIENCY IN INDIA

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 (Bhasin et al. 1994; Bhasin and Walter 2001) (Table 1).

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) (Bhasin et al. 1994; Bhasin and Walter 2001).

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

Table 1: Colour blindness (in per cent)

Particulars	*Subjcects studied*	*No. of studies*	*Frequency CB⁺*		
			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	0.121
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. Chandigrah 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. Andman Islands and Nicobar Islands UT	35 91	1 2	**0.000** **0.033**	0.000 0.018	0.000 0.057
3A. ZONES OF INDIA					
I. North India	14814	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-HIMALAYAN REGIONS	49781	318	**0.037**	0.000	0.231
4. ETHNIC GROUP					
A. ZONES OF INDIA					
1. 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

Table 1: Contd.....

Particulars	Subjcects studied	No. of studies	Frequency CB+ Mean	Min	Max
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**	0.042	0.039
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
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	0.068
III. DRAVIDIAN FAMILY					
South Dravidian Group	14845	96	**0.043**	0.000	0.018
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

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 (0.032, 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 (Bhasin et al. 1994; Bhasin and Walter 2001).

From Central India, the frequency is low among scheduled tribes (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 (Fig. 1).

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

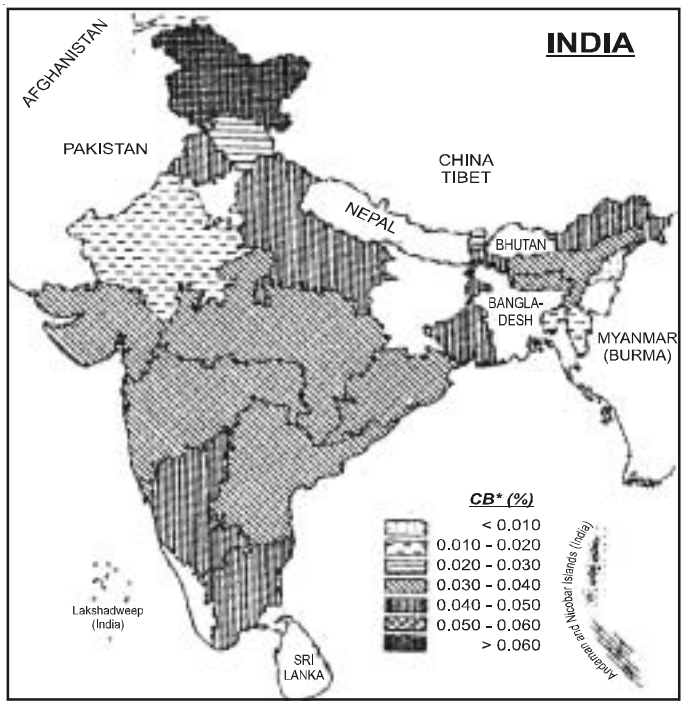

Fig. 1. CB⁺ (Colour Blindness) frequency in percentage in different regions of India

Table 2: Correlations with climatic factors and ethnic group

Ethnic groups	*Colour blindness*
	CB⁺
Mean Annual Temperature	
Caste	-0.155
Scheduled Caste	0.056
Scheduled Tribe	0.086
Community	0.043
Total	-0.019
Mean Annual Rainfall	
Caste	0.130
Scheduled Caste	0.012
Scheduled Tribe	-0.011
Community	0.006
Total	0.080
Mean Annual Humidity	
Caste	-0.176[1]
Scheduled Caste	-0.158
Scheduled Tribe	0.286[2]
Community	-0.087
Total	0.026
Mean Altitude	
Caste	0.187[1]
Scheduled Caste	0.214
Scheduled Tribe	-0.116
Community	0.027
Total	0.036

1. Significant at $P < 0.05$ 2. Significant at $P < 0.01$

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 with various climatic factors and altitude by different ethnic groups though showing significant differences are not high (Table 2).

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 (Bhasin et al. 1994; Bhasin and Walter 2001).

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 (Bhasin et al. 1994; Bhasin and Walter 2001).

RELAXED SELECTION IN POPULATIONS

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 blindness 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 occupation 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 be 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 et al. 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 population groups of India (males only) which varies from complete absence to 0.231. It is present in low frequency in scheduled tribes 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 agriculture groups and high in priesthood, warfare and trade and commerce groups. A similar pattern is observed from different language families *i.e.* low frequency 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 explains 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 substantiated with further data (Bhasin et al. 1994; Bhasin and Walter 2001).

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