IJHG-246

 Int J Hum Genet, 6(1): 81-88 (2006)

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

**M.K. Bhasin**

*Department of Anthropology, University of Delhi, Delhi 110 007, India*

**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

*Postal address:* Dr. M.K. Bhasin, B-2 (GF), South City II, Gurgaon 122 002, Haryana, India

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<br>91 | 1<br>2 | **0.000**<br>**0.033** | 0.000<br>0.018 | 0.000<br>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).

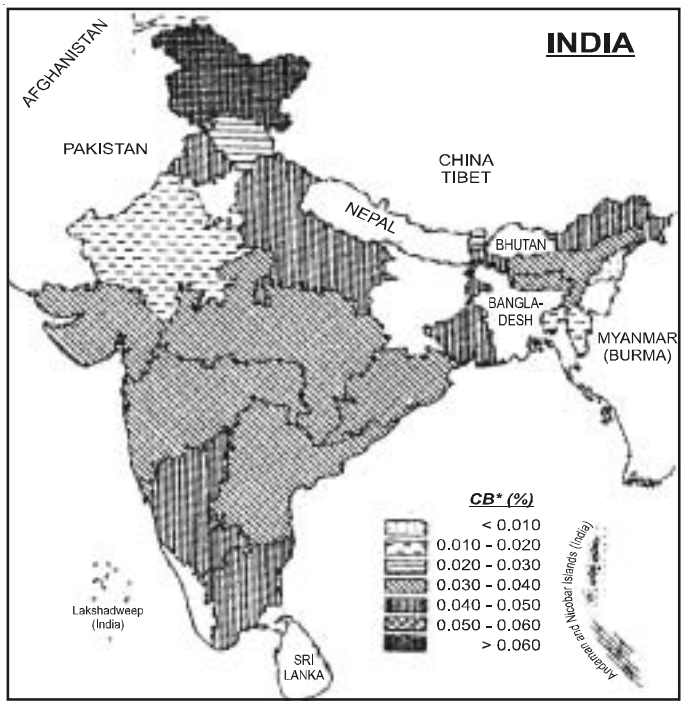


**Fig. 1. CB⁺ (Colour Blindness) frequency in percentage in different regions of India**

**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).

## REFERENCES


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

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

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

Adam A, Doron D, Modan R 1967. 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.

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

Bhasin MK, Walter H, Danker-Hopfe H 1992. *The Ditribution of Genetical,* Morphological and Behavioural Traits Among the People of Indian Region (Bangladesh, *Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka).* Delhi: Kamla-Raj Enterprises.

Bhasin MK, Walter H, Danker-Hopfe H 1994. *People of India. An Investigation of Biological Variability in Ecological, Ethno-Economic and Linguistic Group.* Delhi: Kamla-Raj Enterprises.

Bhasin MK, Walter H 2001. *Genetics of Castes and Tribes of India.* Delhi: Kamla-Raj Enterprises.

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

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

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

Deka U, Sahu PN, Pattojoshi P 1977. Variation in defective colour vision in some populations of Orissa. *Paper presented in the Seminar on Human Variation in India.* Calcutta: Anthropological Survey of India.

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

Franceschetti A 1928. Die Bedentung der Einstellungsbreite am Anomaloskop für die Diagnose der einzelnen Typen der Farbensinnstörungen, nebst Bemerkingen über ihren Vererbungsmodus. *Schw Med Wchns,* **52:** 1273-1279.

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

Malhotra KC 1978. Natural selection and colour blindness: Fresh data on Indian castes. *Genet Res*, **31:** 203.

Malhotra KC, Mutalik GS, Bhanu BV, Kate SL, Fulmali PM 1974. Incidence of colour blindness among four endogamous nomadic groups. An example of natural selection. *Heredity*, **32:** 145.

Mourant AE, Kopec AC, Domaniewska-Sobczak K 1976. *The Distribution of the Human Blood Groups and Other Polymorphisms*. 2nd Edn., London: Oxford University Press.

Mukherjee BN, Malhotra KC,, Kate SL 1979. Incidence of red green colour blindness in some populations of Delhi, Maharashtra and West Bengal: An examination of the selection relaxation hypothesis. *J Biosoc Sci*, **11:** 11-15.

Naidu JM, Babu VK, Veerraju P 1978. The incidence of colour blindness among tribal population of Andhra Praadesh. *Ann Hum Biol*, **5:** 159-163.

Neel JV, Post RH 1963. Transitory "positive" selection for colour blindness? *Eugen Quart*, **10:** 33-35.

Pickford RW 1963. Natural selection and color blindness. *Eugen Rev*, **55:** 97-101.

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

Post RH 1971. Possible cases of relaxed selection in civilized populations. *Humangenetik*, **13:** 253-284.

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

Roychoudhury AK, Nei M 1988. *Human Polymorphic Genes. World Distribution*. Oxford: Oxford University Press.

Salzano MS 1964. Colorblind among Indians from Santa Catavina Brazil. *Acta Genet Stat Med*, **14:** 212-219.

Waardenburg PJ, Franceschetti A, Klein D 1963. *Genetics and Ophthalmology*, Volume II. Oxford: Blackwell.

Wright WD 1947. *Researches on Normal and Defective Colourvision*. St. Louis: Mosby Co.