

Genetics of Castes and Tribes of India: Dermatoglyphics

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ABSTRACT Human population studies using dermatoglyphic traits began with early population descriptions and currently utilise multivariate procedures for detecting evolutionary processes. Dermatoglyphic variables are complex genetic traits (polygenic); therefore these may be more useful than simple genetic traits in tracing widely separated or distantly related populations. The polygenic nature of dermatoglyphic variables would make them less subject to random genetic drift, and in addition they would be free of assortative mating effect. Dermatoglyphic traits would possess advantages in being less subject to environmental influences, but would also be less affected by gene flow. Therefore dermatoglyphic traits would be most suitable for classifying older and more basic relationships between populations. In the present paper an attempt has been made to study the distribution of dermatoglyphic traits frequencies among the people of India, which are analysed in relation to ecological, socio-economic and linguistic factors.

INTRODUCTION

The term “dermatoglyphics” (dermo = skin and graphe = carve) was coined by Cummins and Midlo (1926), who went on to write what became the text book in this field (Cummins and Midlo 1943, republished in 1961). This book served as the most comprehensive grounds to dermatoglyphic analysis. To standardize dermatoglyphic terminology, an international symposium was organized which resulted in publication of “Memorandum on Dermatoglyphics” (Penrose 1968). In 1965, Penrose proposed a typological method to study the complex of configurations present on whole surface of the palms or soles which was much more difficult to use in comparisons, particularly because of the great variability of the pattern details and the difficulties in reducing them into statistically acceptable units. Further comments and details on this method have appeared in a monograph (Loesch 1983). Flexion creases although they differ in origin from the epidermal ridges and do not belong strictly to the dermatoglyphic system are usually included in routine dermatoglyphic analyses because their alterations may be of diagnostic value in a variety of medical disorders. Numerous attempts have been made to classify the creases (Wendt 1958; Leiber 1960; Loeffler 1969; Alter 1970).

The studies on the mode of inheritance of the dermal patterns yielded contradictory conclu-

sions. At present, there is a wide agreement that the heredity of most dermatoglyphic factors conforms to polygenic system, with individual genes contributing a small additive effect. The correlations between individual chromosome aberrations and dermatoglyphic features may lead to establishing the loci of genes that influence dermatoglyphics (Holt 1968; Schaumann and Alter 1976; Loesch 1983).

Dermatoglyphic traits are probably not influenced by ecological and climatic pressures (Hiernaux and Froment 1976), but a very large number of studies describing association between the dermatoglyphic traits and various congenital malformations and diseases have been reported (for review see Schaumann and Alter 1976; Loesch 1983).

Human population studies using dermatoglyphic traits began with early population descriptions and currently utilise multivariate procedures for detecting evolutionary processes. Birdsell (1952) stated that complex genetic traits (polygenic) would be more useful than simple genetic traits in tracing widely separated or distantly related populations. Rife (1954) observed that the polygenic nature of dermatoglyphic variables would make them less subject to random genetic drift, and in addition they would be free of assortative mating effect. Newman (1960) made a similar review and reported that anthropometric variables were highly susceptible to extensive postnatal alteration by the environment, while blood group alleles might reflect too much recent evolutionary activity from gene flow and suggested that dermatoglyphic traits would possess

advantages in being less subject to environmental influences, but would also be less affected by gene flow. Therefore dermatoglyphic traits would be most suitable for classifying older and more basic relationships between populations. Rothhammer et al. (1977) applied this idea and observed that polygenic (dermatoglyphic) traits evolve at a slow rate as compared with monogenic systems, and are thus less susceptible to evolutionary forces, particularly genetic drift.

For details of various topics in dermatoglyphic techniques, classification, methods of analysis, association with congenital malformations and diseases a number of monographs are available (Cummins and Midlo 1961; Holt 1968; Schaumann and Alter 1976; Loesch 1983).

Schlaginhaufen (1906) was the first to study dermatoglyphics of the Indian population. Collins (1913) and Biswas (1936) did additional studies on the finger and palm prints of Indians. These were followed by a number of other studies as reviewed by Singh and Bhasin (1980).

The studies on Genetics of Castes and Tribes have been reported on Serum Protein Polymorphisms KM and GM systems (Bhasin and Walter 2002); Glucose -6- Phosphatase Dehydrogenase Deficiency and Halmoglobin Variants (Bhasin, 2006a); Red and Green Colour Vision Deficiency (Bhasin 2006b); Taste Sensitivity, 2006c) and Samatometry (2006e)

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 (For details see Bhasin 1988; Bhasin et al. 1994; Bhasin and Walter 2001; Bhasin 2006d).

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.

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 the Indian sub-continent may be divided in the following natural regions:

1. The Himalayan Mountain Complex
2. The Indus-Ganga-Brahmaputra Plain
3. The Peninsular 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" Meteorological Department, Government of India, New Delhi.

A climatic region generally possesses a broad uniformity in climatic conditions produced by combined effects of climatic factors. India can be divided into the following climatic regions after Köppen'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 Union Territories, according to the Census 1991, there are 4689 towns and 587,226 inhabited and 47,095 uninhabited villages in the country. The country had 466 districts in 1991.

India Political and Ethnic Zones: The weighted mean values of various biological traits have been classified 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) Tehri Garhwal, and (viii) 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.)

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 grade manual 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 recognizes fifteen languages in India, there are innumerable dialects which change after few scores of kilometers. Linguistic diversity 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:

Language Classification—Indian Languages

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

I. AUSTRIC-ASIATIC 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*
- Dradic (or Pisacha) Branch*
- Kafir Group
- Khowar Group
- Dard Group
- Indo-Aryan Branch:*
- Outer Sub-Branch*
- North-Western Group
- Southern Group
- Eastern Group
- Bihari Group (Bhojpuri, Maithili & 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 groups, 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.

1. FINGER DERMATOGLYPHICS

1.1. Finger Patterns

The frequencies of different patterns on the fingers among European population are 36 per cent for whorls, 60 per cent for loops and 4 per

cent for arches as compared to Africans, in which the frequency of whorls is the lowest (27 per cent) and that of loops the highest (64 per cent); the frequency of arches is also high (9 per cent). Among Mongoloid populations from East Asia, the frequency of whorls is high (about 46 per cent, varies from 40 per cent among Japanese to 52 per cent in Chinese) than among Southeast Asians (about 36 per cent). Among Tibetans and Bhutanese the frequencies are quite high (about 55 per cent). The frequency of arches is quite low among Mongoloid populations (varies from 1 to 4 per cent). From Central Asia, the frequency of whorls is little lower than 50 per cent. The highest frequency of whorls is observed among Australian aborigines (78 per cent) and Eskimo (72 per cent) after Fleischhacker (1951) and Plato (1983).

The distribution of the frequencies of different finger patterns (in percentage) may be generalized among major population groups as follows:

Whorls: Mongoloids (47) > American Indians (43) > Europeans (36) > Africans (27)

Loops: Africans (64) > Europeans (60) > American Indians (52) > Mongoloids (51)

Arches: Africans (9) > American Indians (5) > Europeans (4) > Mongoloids (2)

In general, among Indian populations, the frequency of whorls is low (43.62 per cent, varies from 22.50 to 66.70) as compared to loops (53.30 per cent, ranges from 33.00 to 75.30), whereas the frequency of arches is 3.08 per cent (from complete absence to 8.10 per cent). For radial loops, the range is large (absence to 12.10 per cent) with average frequency of 2.41 per cent. The highest frequency of whorls is observed from Islands natural region (50.40 per cent) from where three studies are available among Nicobarese (who have Mongoloid affinities) among whom the frequency is quite high (51.85, varies from 41.30 to 53.90 per cent) as compared to Onges of Andaman with quite low frequency (35.70 per cent). In the Himalayan mountain complex region from where most of the populations are having Mongoloid affinities the frequency of whorls is high (46.54 per cent) and it starts decreasing gradually towards south. The frequency of arches is low in the Himalayan mountain complex and starts increasing towards south (Table 1). The frequency of various patterns in the Himalayan region is similar to that observed among populations with Mongoloid affinities from East

Asia, Southeast Asia, whereas from the Non-Himalayan region it is similar to that of European populations (Figs. 1 - 4.). From the climatic regions of monsoon type with dry winters and tropical savannah type regions, from where the maximum number of studies is reported the differences are not significant as compared to other regions (Bhasin et al. 1994; Bhasin and Walter 2001).

The percentage frequency of whorls is quite high from the states of Jammu and Kashmir (49.36) and Himachal Pradesh (43.78) of Western Himalayan region and Uttar Pradesh (43.28, Central Himalayan region) among the populations with Mongoloid affinities (Ladakhis - 56.00; Lahulis - 53.30; Bodhs - 58.35; Gurungs - 55.90; Tharus - 51.13; Bhotias - 50.73 among others) and similar higher frequencies are observed from the states of Arunachal Pradesh (Wanchoo - 50.1); Assam (Rabha - 54.31; Kachari - 54.66; Lalung - 51.04; Abor - 57.31 among others); Nagaland (53.43); Manipur (47.77; Mathei - 51.95, Tangkul - 53.45, Paite - 51.39); Meghalaya (45.38); Sikkim (50.35; Lepchas - 64.90; Bhutias - 56.00; Sherpas - 61.70; Tamangs - 61.40) of Eastern Himalayan region (For details see Bhasin et al. 1992). The frequency of arches is low among them (Fig. 1). From Islands, among Nicobarese with Mongoloid affinities the frequency of whorls is quite high (51.85) whereas among Onges (Negrito), the frequency is quite low (35.70). Among other population groups from Himachal Pradesh, Uttar Pradesh, Punjab, Delhi, Rajasthan (North India), Gujarat, Maharashtra (West India) the frequency of whorls is low (about 40) and arches high (around 4) as compared to populations with Mongoloid affinities. From South India, quite high frequencies of whorls (50.16) and low for arches (1.80) are reported from Kerala (most of the studies are on tribes) as compared to Karnataka (whorls = 34.85; arches = 3.44, most of the studies are among castes and communities). The frequency of whorls is quite high among scheduled tribes (45.68) as compared to other ethnic groups (caste - 42.86; community - 41.94; scheduled caste - 39.82) and that of arches low (3.51). Almost similar pattern of distribution is observed from all the zones of India, and highest frequency is observed among scheduled tribes of Central India (48.95) followed by East India (46.52) and South India (46.80) and arches are in low frequency. The differences are observed when the different ethnic groups from various zones are compared to each other but in the same

zone, the castes, scheduled castes and communities showing less difference amongst themselves. The frequency of radial loop is low among scheduled tribes as compared to other ethnic groups and similar results are observed in the Himalayan region as compared to the non-Himalayan region.

In general, the frequency of whorl patterns gradually starts decreasing from north (Himalayan mountain complex region) to south (Indus-Ganga-Brahmaputra plains and Peninsular region) and that of loops and arches from south to north region (Table 1, Figs. 1-4).

The correlations percentage frequencies of whorls, loops (ulnar, radial and total) and arches with various climatic factors and altitude by different ethnic groups though showing significant differences are not high (Table 6). Hiernaux and Froment (1976) were unable to find any correlation between climate and finger patterns and concluded that climate or climatic selection may be ruled out as an influence in dermatoglyphic variability.

The frequencies of finger patterns are almost similar among trade and commerce, animal husbandry and menial worker occupational groups—whorls (42 per cent), loops (55 per cent) and arches (about 3 per cent). These groups are falling closer to priesthood, agriculture and artisans occupational groups—whorls (39 per cent), loops (57 per cent) and arches (4 per cent) which shows admixture among these groups as also observed for other biological traits (Bhasin et al. 1994; Bhasin and Walter 2001).

Among the speakers of Mon Khmer group of Austro-Asiatic languages the frequency of whorls is 40.12 per cent (varies from 35.40 to 55.90 per cent) which is high as compared to the Mongoloid populations of Southeast Asia. Whereas among the speakers of Tibeto-Chinese languages the frequency of whorls is high (Bhotia group - 52.54 per cent; Himalayan group - 50.59 per cent; Naga group - 51.97 per cent) and similar high frequencies are observed among Chinese and Tibetans. The frequency of whorls is also high among the Munda group of Austro-Asiatic speakers (46.27 per cent), and among speakers of North Dravidian group (52.68 per cent) mostly belonging to scheduled tribes. It has been observed that the frequencies are high for whorls and low for arches among the population groups with Mongoloid affinities and among the

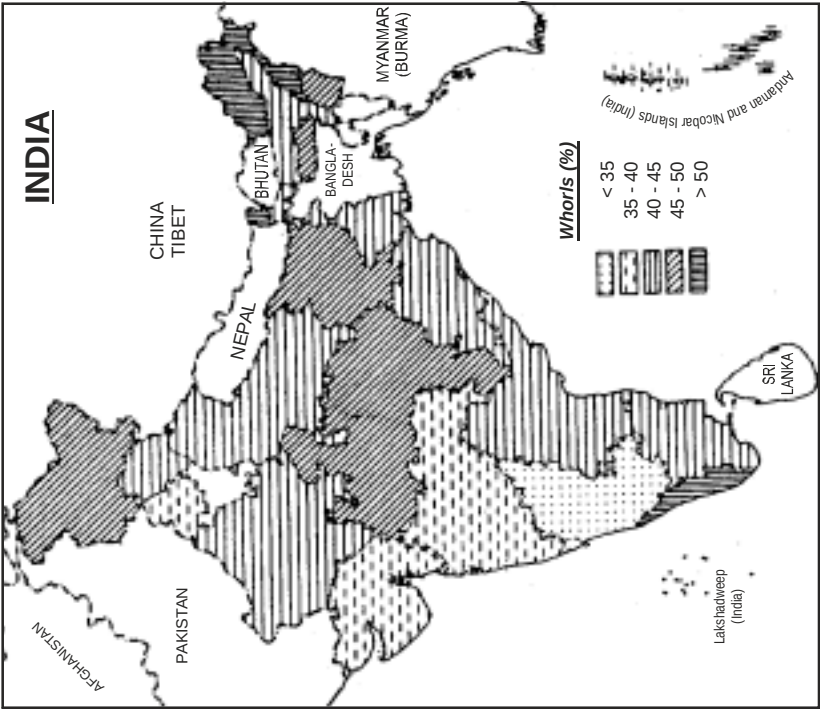


Fig. 1. Frequencies in percentage of whorls of finger patterns in different regions of India

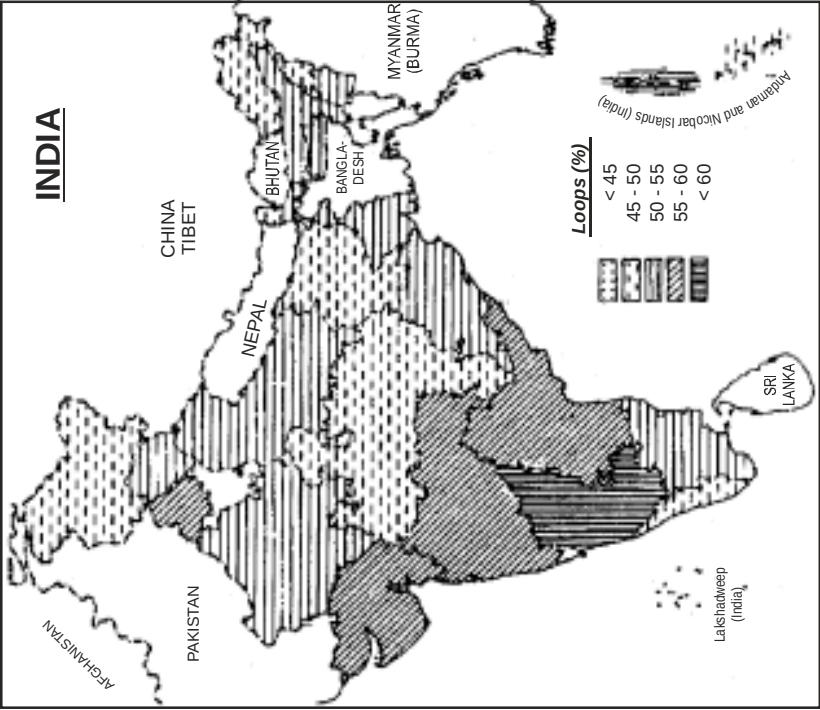


Fig. 2. Frequencies in percentage of loops of finger patterns in different regions of India

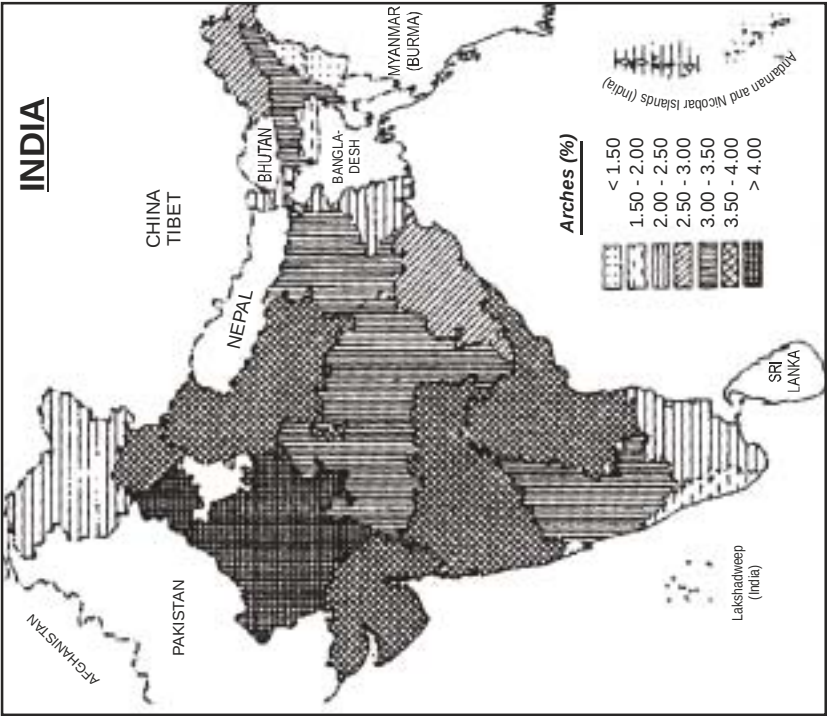


Fig. 4. Frequencies in percentage of arches of finger patterns in different regions of India

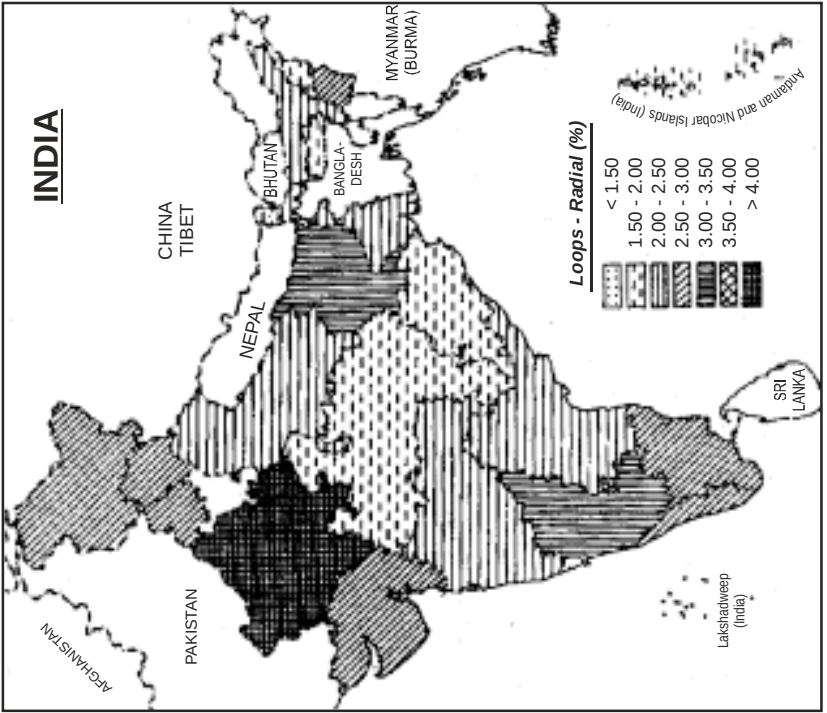


Fig. 3. Frequencies in percentage of loops radial of finger patterns in different regions of India

Table 1: Contd.....

Particulars	Subjects studied	No. of studies	Whorls		Subjects No. of Studied	Loops Ulnar		Loops Radial		Loops Total		Arches	
			Mean	Min	Max	Mean	Min	Max	Min	Max	Mean	Min	Max
IV. CENTRAL INDIA													
24. Madhya Pradesh	551	11	46.98	36.30	55.00	424	8	44.88	37.00	51.80	1.94	1.00	3.30
V. SOUTH INDIA													
25. Karnataka	638	6	34.85	29.00	39.80	308	3	60.77	58.40	63.30	3.44	2.80	4.50
26. Andhra Pradesh	5674	47	40.34	29.40	52.40	1562	17	51.98	45.40	57.00	2.07	1.00	3.40
27. Tamil Nadu	2065	17	42.92	34.50	60.70	1458	13	49.57	35.60	57.90	2.87	1.10	4.90
28. Kerala	1065	8	50.16	31.20	59.40	925	7	45.61	37.40	63.00	2.97	1.00	4.30
29. Pondicherry UT	-	0	-	-	-	-	0	-	-	-	-	-	-
VI. ISLANDS													
30. Lakshadweep UT	-	0	-	-	-	-	0	-	-	-	-	-	-
31. Andaman Islands and Nicobar Islands UT	24 243	1 3	35.70 51.85	35.70 41.30	35.70 53.90	24 243	1 3	60.50 45.06	60.50 43.80	60.50 50.70	1.70 1.60	1.70 1.50	62.20 46.67
3A. ZONES OF INDIA													
I. North India	9130	99	42.93	28.10	61.00	5894	69	49.89	35.00	59.30	2.72	0.20	12.10
II. West India	1726	15	39.00	33.80	51.20	1549	12	54.65	45.20	60.50	2.58	1.60	6.00
III. East India	16026	162	45.44	22.50	66.70	15146	153	50.27	32.20	71.90	2.23	0.00	8.00
IV. Central India	551	11	46.98	36.30	55.00	424	8	44.88	37.00	51.80	1.94	1.00	3.30
V. South India	9442	78	41.64	29.00	60.70	4253	40	50.41	35.60	63.30	2.63	1.00	4.90
VI. Islands	267	4	50.40	35.70	53.90	267	4	46.45	43.80	60.50	1.61	1.50	2.30
INDIA (TOTAL)	37142	369	43.62	22.50	66.70	27533	286	50.33	32.20	71.90	2.41	0.00	12.10
3B. REGIONS OF HIMALAYA													
A. Western Himalaya	3050	39	44.18	35.20	61.00	2621	34	49.26	35.00	57.80	2.56	0.20	12.10
B. Central Himalaya	1973	18	45.43	39.40	55.90	880	9	48.17	44.20	51.40	2.69	1.30	3.80
C. Eastern Himalaya	9037	90	45.87	33.20	66.20	8765	86	49.73	32.20	60.70	2.12	0.00	4.90
HIMALAYA (TOTAL)	14060	147	45.44	33.20	66.20	12266	129	49.52	32.20	60.70	2.25	0.00	12.10
NON-HIMALAYAN REGIONS	23082	222	42.50	22.50	66.70	15267	157	50.99	33.30	71.90	2.53	0.00	9.40
4. ETHNIC GROUP													
A. ZONES OF INDIA													
I. NORTH INDIA													
Caste	4023	42	42.86	34.20	51.90	2495	30	50.16	42.20	56.90	3.02	0.20	9.40
Scheduled Caste	820	11	39.82	35.10	61.00	547	8	51.52	35.00	57.80	2.67	1.00	3.30
Scheduled Tribe	1893	18	45.68	36.20	56.00	1663	16	48.81	38.90	54.20	2.22	1.30	4.10
Community	2394	28	41.94	28.10	55.90	1189	15	50.07	40.20	59.30	2.84	0.90	12.10
II. WEST INDIA													
Caste	410	2	40.92	40.70	42.70	410	2	53.60	53.60	53.60	2.38	2.20	2.40
Scheduled Caste	115	1	33.80	33.80	33.80	115	1	60.50	60.50	60.50	1.80	1.80	1.80
Scheduled Tribe	815	9	39.98	35.10	51.20	638	6	53.99	45.20	59.00	2.32	1.60	3.10
Community	386	3	36.44	34.50	37.40	386	3	55.12	52.10	56.20	3.47	2.50	6.00
III. EAST INDIA													
Caste	2778	26	41.16	34.10	56.20	2778	26	53.59	39.20	59.40	2.25	1.00	4.00
Scheduled Caste	3369	26	42.94	33.20	54.00	3369	26	52.04	42.40	60.70	2.29	1.40	3.20
Scheduled Tribe	7975	90	48.52	22.50	66.70	7195	83	47.89	32.20	71.90	2.17	0.00	8.00
Community	1904	20	43.21	35.60	61.40	1804	18	51.33	35.10	57.00	2.33	0.50	4.90

Table 1: Contd.....

Particulars	Subjects No. of studied studies	Whorls		Subjects No. of Studied Studies	Loops Ulnar		Loops Radial		Loops Total		Arches								
		Mean	Min		Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max					
IV. CENTRAL INDIA																			
Caste	-	0	-	-	0	-	-	-	-	-	-	-	-						
Scheduled Caste	42	1	36.30	36.30	36.30	-	-	-	-	60.20	60.20	60.20	3.50	3.50	3.50				
Scheduled Tribe	456	9	48.95	40.70	55.00	424	44.88	37.00	51.80	1.94	1.00	3.30	47.50	38.00	56.50	3.55	0.00	7.00	
Community	53	1	38.50	38.50	38.50	-	0	-	-	-	-	-	59.00	59.00	59.00	2.50	2.50	2.50	
V. SOUTH INDIA																			
Caste	3193	24	36.24	29.00	46.70	708	57.41	51.60	63.30	2.78	2.10	4.50	59.89	50.80	67.80	3.87	1.20	6.50	
Scheduled Caste	762	7	39.55	34.30	47.00	-	0	-	-	-	-	-	56.34	51.00	60.80	4.10	2.00	5.50	
Scheduled Tribe	4376	37	46.80	31.20	60.70	3118	29	48.42	35.60	63.00	2.56	1.00	4.90	50.51	37.80	67.30	2.69	0.00	6.50
Community	1111	10	38.31	29.40	48.40	427	4	53.34	47.90	56.10	2.91	1.80	3.90	58.83	50.70	65.20	2.86	0.90	5.40
VI. ISLANDS																			
Caste	-	0	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	
Scheduled Caste	-	0	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	
Scheduled Tribe	267	4	50.40	35.70	53.90	267	4	46.45	43.80	60.50	1.61	1.50	2.30	48.06	45.80	62.20	1.54	0.00	6.00
Community	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
INDIA																			
Caste	10404	94	40.30	29.00	56.20	6391	65	52.67	39.20	63.30	2.62	0.20	9.40	56.13	40.60	67.80	3.57	1.10	7.20
Scheduled Caste	5108	46	41.67	33.20	61.00	4031	35	52.21	35.00	60.70	2.33	1.00	3.30	55.03	38.00	62.90	3.30	0.70	8.10
Scheduled Tribe	15782	167	47.30	22.50	66.70	13305	146	48.30	32.20	71.90	2.26	0.00	8.00	50.19	33.00	75.30	2.51	0.00	7.40
Community	5848	62	41.27	28.10	61.40	3806	40	51.55	35.10	59.30	2.67	0.50	12.10	55.15	35.60	66.90	3.58	0.90	7.60
B. REGIONS OF HIMALAYA																			
A. Western Himalaya																			
Caste	1827	23	43.00	36.80	51.90	1461	20	50.73	42.20	56.90	2.44	0.20	5.40	53.54	46.10	59.90	3.46	1.10	6.30
Scheduled Caste	135	4	45.66	35.20	61.00	135	4	48.93	35.00	57.80	2.07	1.00	3.00	51.00	38.00	58.80	3.34	1.00	6.00
Scheduled Tribe	762	6	46.53	38.90	56.00	762	6	47.30	38.90	52.90	2.15	1.30	3.30	49.44	42.20	54.80	4.03	1.80	7.20
Community	326	6	44.74	40.00	46.90	263	4	46.98	40.30	50.50	4.61	1.30	12.10	52.01	50.70	56.00	3.25	1.40	4.80
B. Central Himalaya																			
Caste	1194	9	44.13	39.40	50.30	397	4	48.17	44.50	51.20	3.27	2.60	3.80	52.07	46.80	55.20	3.81	1.70	5.60
Scheduled Caste	-	0	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Scheduled Tribe	713	7	47.42	38.90	51.30	483	5	48.17	44.20	51.40	2.22	1.30	3.40	50.01	46.90	53.60	2.57	1.40	5.40
Community	66	2	47.57	40.00	55.90	-	0	-	-	-	-	-	-	50.47	41.40	55.00	1.97	1.60	2.70
C. Eastern Himalaya																			
Caste	588	6	41.81	35.90	56.20	588	6	52.24	39.20	57.00	2.01	1.00	4.00	54.25	40.60	61.00	3.94	1.60	4.60
Scheduled Caste	1615	12	41.90	33.20	50.60	1615	12	52.78	45.20	60.70	2.29	1.40	3.20	55.07	47.60	62.90	3.03	1.50	5.50
Scheduled Tribe	5270	55	48.12	34.40	66.20	5098	53	48.23	32.20	60.00	2.04	0.00	4.60	50.16	33.00	63.30	1.72	0.00	6.70
Community	1564	17	43.94	35.60	61.40	1464	15	50.59	35.10	57.00	2.25	0.50	4.90	52.57	35.60	60.30	3.50	0.90	7.20
5. TRADITIONAL OCCUPATION																			
Priesthood	4230	37	39.18	29.00	48.70	2772	26	53.90	46.90	63.30	2.62	1.00	7.60	56.99	46.80	67.80	3.83	1.20	7.20
Warfare	2129	29	43.91	36.80	56.20	1345	14	50.62	39.20	56.90	2.38	0.20	5.40	52.72	40.60	57.70	3.37	1.10	7.20
Trade and Commerce	1253	14	41.66	33.90	48.80	1153	13	52.21	43.30	56.80	2.57	1.20	4.40	55.31	47.70	61.40	3.04	1.10	5.90
Agriculture	3090	24	38.60	29.20	61.00	1375	13	54.31	35.00	60.70	2.24	1.00	4.10	57.42	38.00	63.20	3.98	1.00	7.60
Animal Husbandry	963	11	41.26	36.30	47.20	345	5	50.41	42.70	54.50	3.63	2.20	8.00	55.04	50.70	59.60	3.69	1.80	7.00
Artisans	210	3	37.70	34.30	41.60	174	2	53.54	53.40	55.00	2.55	2.00	2.60	56.89	56.00	60.80	5.41	1.40	5.90
Mental Workers	3628	32	42.00	33.80	54.00	2873	25	51.93	42.40	60.50	2.38	1.40	3.20	54.80	44.80	62.30	3.20	0.70	8.10
No Information	21639	228	45.72	22.50	66.70	17496	188	49.02	32.20	71.90	2.36	0.00	12.10	51.59	33.00	75.30	2.72	0.00	7.40

Table 1: Contd.....

Particulars	Subjects No. of studied studies		Whorls		Subjects No. of Studied Studies		Loops Ulnar		Loops Radial		Loops Total		Arches			
			Mean	Min	Max			Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
6. LANGUAGE GROUP																
I. AUSTR0-ASIATIC FAMILY																
Mon Khmer Group	577	7	40.12	35.40	55.90	577	7	54.88	42.20	58.40	2.27	0.60	3.10	57.15	42.80	60.60
Munda Group	1631	22	46.27	29.40	66.70	1437	20	49.21	33.30	65.30	2.38	0.00	8.00	51.27	33.30	66.20
II. TIBETO-CHINESE FAMILY																
(i) Siamese-Chinese Sub-Family																
Tai Group	56	1	36.00	36.00	36.00	56	1	58.40	58.40	58.40	2.70	2.70	2.70	61.10	61.10	61.10
(ii) Tibeto-Burman Sub-Family																
Bhotia Group	545	7	52.54	48.40	57.10	545	7	43.44	38.90	48.30	1.78	1.30	3.30	45.22	41.90	49.90
Himalayan Group	740	14	50.59	36.10	66.20	526	11	44.44	32.20	57.00	2.16	0.50	3.40	47.18	33.00	60.30
North East Frontier Group	888	12	46.06	37.60	57.30	888	12	49.82	36.10	57.60	2.20	1.10	4.60	52.02	40.20	60.20
Bodo Group	1462	14	48.66	38.30	55.20	1462	14	47.51	40.70	55.30	1.54	0.60	2.80	49.05	43.50	57.20
Naga Group	988	9	51.97	44.30	55.10	928	8	45.08	41.40	52.10	2.09	0.00	3.50	47.10	42.80	55.60
Kachin Group	-	0	-	-	-	-	0	-	-	-	-	-	-	-	-	-
Kuki Chin Group	1400	12	47.30	34.40	53.50	1400	12	48.84	43.00	60.00	2.46	0.50	3.70	51.30	45.20	63.30
III. DRAVIDIAN FAMILY																
South Dravidian Group	7931	65	40.93	29.00	60.70	3312	30	50.46	35.60	63.30	2.79	1.00	4.90	55.91	37.80	67.80
Central Dravidian Group	1788	19	43.85	22.50	55.00	1218	16	52.20	37.00	71.90	2.04	1.00	3.40	52.59	38.00	75.30
North Dravidian Group	1230	11	52.68	36.60	60.60	816	8	44.33	36.90	52.20	2.71	0.80	5.10	44.66	36.60	57.30
IV. INDO-EUROPEAN FAMILY																
Dard Group	45	1	50.70	50.70	50.70	45	1	46.00	46.00	46.00	2.00	2.00	2.00	48.00	48.00	48.00
Southern Group	556	5	38.15	33.80	42.70	556	5	55.88	52.10	60.50	2.42	1.80	3.10	58.30	55.20	62.30
Eastern Group	20	1	54.50	54.50	54.50	20	1	43.00	43.00	43.00	2.50	2.50	2.50	45.50	45.50	45.50
Bihari	7180	59	42.10	33.20	56.20	7080	57	52.60	39.20	60.70	2.30	1.00	4.90	54.81	40.60	62.90
Central Group	6590	65	41.81	28.10	55.60	3878	39	50.41	40.20	59.30	2.92	0.90	9.40	54.04	42.20	66.90
Pahari Group	2426	33	43.37	35.20	61.00	2027	29	50.35	35.00	57.80	2.62	0.20	12.10	53.27	38.00	61.00
Unspecified	599	5	44.22	38.20	51.30	449	4	52.31	48.90	54.20	1.92	1.70	2.90	52.39	46.90	55.90
Other Languages	313	4	48.30	35.70	53.30	313	4	47.91	44.30	60.50	1.75	1.30	3.10	49.66	45.80	62.20
No Information	177	3	37.44	35.10	39.80	-	0	-	-	-	-	-	-	57.01	53.50	60.00
6A. LANGUAGE FAMILY																
I. Austro Asiatic Family	2208	29	44.66	29.40	66.70	2014	27	50.83	33.30	65.30	2.35	0.00	8.00	52.81	33.30	66.20
II. Tibeto Chinese Family	6079	69	48.97	34.40	66.20	5805	65	47.23	32.20	60.00	2.04	0.00	4.60	49.23	33.00	63.30
III. Dravidian Family	10949	95	42.73	22.50	60.70	5346	54	49.92	35.60	71.90	2.61	0.80	5.10	54.10	36.60	75.30
IV. Indo European Family	17416	169	42.15	28.10	61.00	14055	136	51.76	35.00	60.70	2.51	0.20	12.10	54.31	38.00	66.90
Other Languages	313	4	48.30	35.70	53.30	313	4	47.91	44.30	66.50	1.75	1.30	3.10	49.66	45.80	62.20
No Information	177	3	37.44	35.10	39.80	-	0	-	-	-	-	-	-	57.01	53.50	60.00

scheduled tribes who are speaking mainly Tibeto-Chinese, Munda and Dravidian languages. Among the speakers of Indo-European languages, the frequency of whorls is low and that of arches high, as also observed among European population. The whorl: loop (W:L) ratio appears to be approximately as follow:

Austro-Asiatic Family: Mon Khmer group 40:60

Tibeto-Chinese Family 50:50

Austro-Asiatic Family: Munda group 48:52

Dravidian Family 44:56

Indo-European Family 43:57

In Indian populations the frequency of loops is higher (53 per cent) than whorls (44 per cent), whereas the frequency of arches is 3 per cent. In different zones, high frequency of whorls is observed from Islands (50 per cent) as compared to rest of the zones—Central (47 per cent), East (45 per cent), North (43 per cent), South (42 per cent) and West (39 per cent) India, and frequency of arches varies between 2 and 4 per cent in these zones. From Himalayan region, the frequency of whorls is high from Eastern (46 per cent) and a little lower (45 per cent) from Western Himalayas. The frequency of whorls is highest among scheduled tribes from various zones of India and different regions of Himalaya. In the language groups, highest frequency of whorls is found in Tibeto-Chinese language family (49 per cent) and lowest in Indo-European language family (42 per cent). No correlation with climatic factors and altitude is observed with different ethnic groups. The frequency of whorls is high in Himalayan region and it gradually starts decreasing towards south of India while and frequency of arches is low in East India and from there it starts increasing in all directions.

1.2. Total Finger Ridge Count (TFRC)

Genetics of finger patterns, using ridge counting method, have been extensively investigated. A series of genetical studies has established that the size of the patterns on finger balls is strongly determined by heredity, and that the patterns are controlled by almost additive polygenes that are not subject to extensive environmental influence (Holt 1968 and several earlier works). The additivity model for TFRC has been severely criticized by Weninger (1964, 1965, 1976). Other models of polygenic inheritance for digital patterns and TFRC have been proposed

by Armstrong (1978), de Wilde (1967), Fröhlich (1976), and Penrose (1969) among others. Schwidetzky and Jantz (1977) examined population trends in sexual dimorphism and showed males exceeding females in mean TFRC value. Recent works have reported that the value of dermatoglyphic traits is less subject to random genetic drift, whereas among others Thoma (1974) proposed that drift is the most probable evolutionary mechanism operating on dermal ridge systems.

The mean value of total finger ridge count (TFRC) is highest among Mongoloid populations (Bhutanese 155.35, Tibetans 156.23) as compared to American Whites (134.74) and American Blacks (130.53) reported by Jantz (1974), while it is quite low among African Blacks (123.50, studied by Jantz, 1974). From Nepal among the Newar populations with Mongoloid affinities the value is low which varies from 123.42 to 131.53, reported by Bhasin (1969).

Among the Indian populations, the mean value of TFRC is 141.26 (varies from 107.60 in Jats of Delhi to 183.60 among Car Nicobarese). The value is low among scheduled tribes (140.59) as compared to other ethnic groups—community (140.83); caste (140.91); scheduled caste (142.60), but the differences among these groups are insignificant. Highest value is observed from Islands natural region (167.97) followed by Indus-Ganga-Brahmaputra plains (145.20), Peninsular plateau (139.74) and Himalayan mountain complex (136.81). From the tropical savannah type and monsoon type with dry winters climatic region from where the maximum studies are reported the values are almost similar (142.99 and 142.03, respectively). The mean value of TFRC is low from the Himalayan region (136.08) as compared to Non-Himalayan region (142.24). Among the populations with Mongoloid affinities from the Himalayan region, the value is low as compared to Tibetans and Bhutanese. And among scheduled tribes also the mean value is lower than other ethnic groups (Bhasin et al. 1994; Bhasin and Walter 2001).

The TFRC mean value is quite high from Jammu and Kashmir (157.30 among Muslims, only one study available) as compared to Himachal Pradesh (132.64), where mean value is quite high among the caste groups from Kulu, Dharamsala, and low from Chamba and Kangra districts of Western Himalayan region (134.30). From Central Himalayan region (Uttar Pradesh), the mean value

is high (140.55) as found among populations from Jaunsar-Bawar (about 141.5) and Kumaon (Rajputs and Sah) as compared to other areas. Among the populations of Eastern Himalayan region the mean value of TFRC is low (136.19) as observed from the states of Assam (132.15), Meghalaya (139.25) and Sikkim (139.98). The value is low among populations with Mongoloid admixture as compared to that of Mongoloid origin who show high values but a little lower than that observed among Bhutanese and Tibetans (Bhutias- 146.90; Sherpas - 151.00). It is quite interesting to observe that among the Mongoloid populations the value of TFRC is quite high followed by Caucasoid populations, but the value is low among the populations with Mongoloid admixture in the Himalayan region.

From West India, the mean value of TFRC is almost similar among the populations from Gujarat (141.04) and Maharashtra (141.85) and lowest value is observed among scheduled tribes as compared to other ethnic groups. Among the populations from West Bengal, Bihar and Orissa the value of TFRC is quite high (150.15, 154.88 and 150.06, respectively). From West Bengal, most of the studies are conducted in different castes among whom quite high frequency is reported (Brahman, Kayastha, Vaidya and Namsudra), whereas among tribals of Bihar (Oraon and Munda) and Orissa (Naukadora, Ollar Gabada) the mean value is even higher. Similarly, from Central India among the tribals the value of TFRC is quite high (151.91).

The value of TFRC is lowest in South India

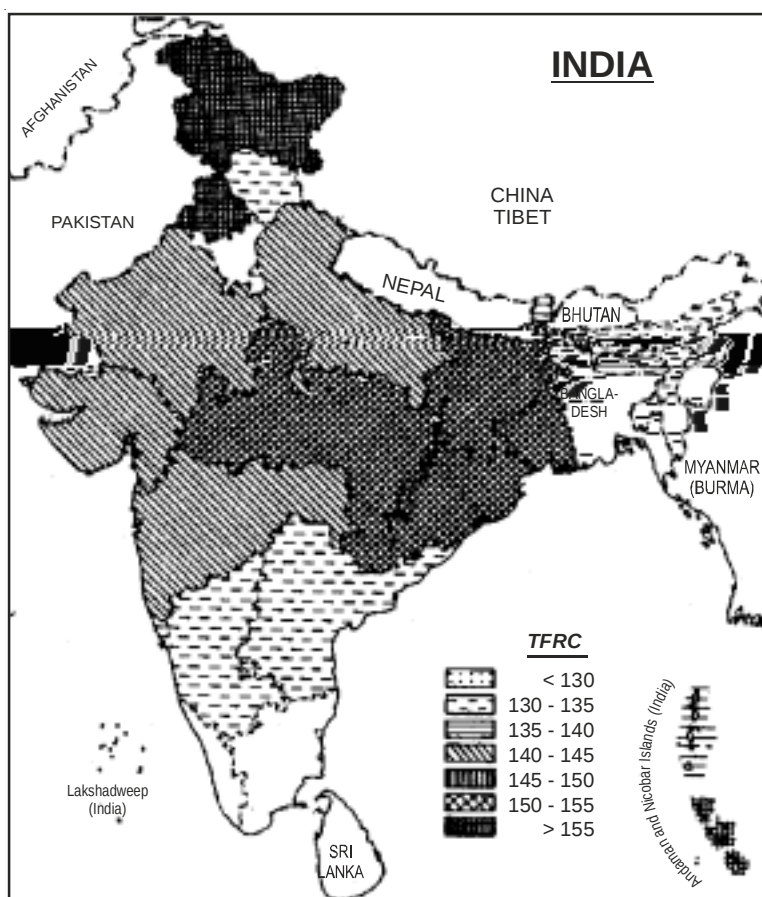


Fig. 5. Mean values of TFRC in different regions of India

Table 2: Total finger ridge-count (mean values)

Table 2: Total finger ridge-count (mean values)						
Particulars	Subjects studied	No. of studies	Mean Value TFRC			Max
			Mean	Min	Max	
1.1. NATURAL REGION						
Himalayan Mountain Complex	3162	44	136.81	110.90	160.40	
Indus-Ganga-Brahmaputra Plains	8843	84	145.20	107.60	165.90	
Peninsular Plateau	14906	123	139.74	110.20	166.70	
Islands	74	2	167.97	135.40	183.60	
2. CLIMATIC REGION						
Monsoon Type with Short Dry Season	365	5	142.95	133.50	183.60	
Monsoon Type with Dry Season	3006	22	130.08	110.20	158.50	
Tropical Savannah Type	10065	81	142.99	114.30	166.70	
Semi Arid Steppe Type	1162	12	136.45	123.00	148.00	
Hot Desert Type	-	0	-	-	-	
Monsoon Type with Dry Winters	12264	132	142.83	107.60	165.90	
Cold Humid Winters with Short Summers	-	0	-	-	-	
Polar Type	123	1	157.10	157.10	157.10	
3. POLITICAL DIVISION OF INDIA						
I. NORTH INDIA						
A. Western Himalaya (S. No. 1, 2)						
1. Jammu and Kashmir	123	1	157.10	157.10	157.10	
2. Himachal Pradesh	1686	23	132.64	110.90	157.00	
3. Punjab	86	1	157.30	157.30	157.30	
4. Chandigarh UT	-	0	-	-	-	
5. Haryana	-	0	-	-	-	
6. Delhi UT	106	1	107.60	107.60	107.60	
B. Central Himalaya (S. No. 7, Eight Districts of Uttar P radesht)						
7. Uttar Pradesh	4837	39	143.59	124.90	165.60	
8. Rajasthan	560	6	142.48	137.80	148.00	
II. WEST INDIA						
9. Gujarat	776	5	141.04	137.20	155.40	
10. Maharashtra	5647	42	141.85	122.20	164.30	
11. Goa, Daman and Diu UT	291	3	136.59	133.50	140.50	
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	826	14	132.15	114.30	164.00	
15. Nagaland	-	0	-	-	-	
16. Manipur	-	0	-	-	-	
17. Mizoram	-	0	-	-	-	
18. Tripura	-	0	-	-	-	
19. Meghalaya	292	4	139.25	135.10	149.30	
20. Sikkim	645	14	139.98	112.90	160.40	
21. West Bengal	3786	36	150.15	112.00	165.90	
Particulars						
22. Bihar	218	3	154.88	149.30	166.70	
23. Orissa	839	7	150.08	141.90	155.90	
IV. CENTRAL INDIA						
24. Madhya Pradesh	1202	12	151.91	134.80	163.30	
V. SOUTH INDIA						
25. Karnataka	602	6	130.84	123.00	137.30	
26. Andhra Pradesh	4346	34	131.57	110.20	162.00	
27. Tamil Nadu	-	0	-	-	-	
28. Kerala	-	0	-	-	-	
29. Pondicherry UT	-	0	-	-	-	
VI. ISLANDS						
30. Lakshadweep UT	-	0	-	-	-	
31. Andman Islands and Nicobar Islands UT	24	1	135.40	135.40	135.40	
	50	1	183.60	183.60	183.60	
3A. ZONES OF INDIA						
I. North India	7398	71	140.88	107.60	165.60	
II. West India	6714	50	141.53	122.20	164.30	
III. East India	6606	78	146.57	112.00	166.70	
IV. Central India	1202	12	151.91	134.80	163.30	
V. South India	4991	40	131.48	110.20	162.00	
VI. Islands	74	2	167.97	135.40	183.60	
INDIA (TOTAL)	26985	253	141.26	107.60	183.60	
3B. REGIONS OF HIMALAYA						
A. Western Himalaya	1809	24	134.30	110.90	157.10	
B. Central Himalaya	708	6	140.35	128.70	154.20	
C. Eastern Himalaya	1763	32	136.19	112.90	164.00	
HIMALAYA (TOTAL)	4280	62	136.08	110.90	164.00	
NON-HIMALAYAN REGIONS						
	22705	191	142.24	107.60	183.60	
4. ETHNIC GROUP						
A. ZONES OF INDIA						
I. NORTH INDIA						
Caste	3660	32	143.97	120.90	157.30	
Scheduled Caste	898	10	138.49	116.40	152.10	
Scheduled Tribe	1326	11	130.73	110.90	147.60	
Community	1514	18	143.73	107.60	165.60	
II. WEST INDIA						
Caste	673	6	144.36	138.00	157.60	
Scheduled Caste	3534	22	141.45	126.60	164.30	
Scheduled Tribe	1147	12	138.24	122.20	153.30	
Community	1360	10	143.08	133.50	153.60	

Table 2: Contd.....

Particulars	Subjects studied	No. of studies	Mean Value of TFR		Particulars	Subjects studied	No. of studies	Mean Value of TFR	
			Mean	Max				Mean	Max
III. EAST INDIA									
Caste	2139	23	148.28	118.00	Warfare	1306	13	143.47	124.00
Scheduled Caste	2127	21	147.90	114.30	Trade and Commerce	2159	18	146.81	118.00
Scheduled Tribe	1792	24	145.12	112.00	Agriculture	5980	41	137.64	107.60
Community	548	10	139.49	112.90	Animal Husbandry	1012	7	142.51	121.90
IV. CENTRAL INDIA					Artisans	15	1	152.10	152.10
Caste	-	0	-	-	Menial Workers	2942	27	143.92	114.30
Scheduled Caste	-	0	-	-	No Information	10527	115	141.13	110.20
Scheduled Tribe	1202	12	151.91	134.80					183.60
Community	-	0	-	-					
V. SOUTH INDIA					6. LANGUAGE GROUP				
Caste	2573	20	129.50	116.10	I. AUSTRO-ASIATIC FAMILY				
Scheduled Caste	574	4	136.40	125.50	Mon Khmer Group	292	4	139.25	135.10
Scheduled Tribe	1383	12	134.81	114.30	Munda Group	679	8	143.47	112.00
Community	461	4	126.30	110.20					166.70
VI. ISLANDS					II. TIBETO-CHINESE FAMILY				
Caste	-	0	-	-	(i) Siamese-Chinese Sub-Family	56	1	199.10	119.10
Scheduled Caste	-	0	-	-	Tai Group				
Scheduled Tribe	74	2	167.97	135.40	(ii) Tibeto-Burman Sub-Family				
Community	-	0	-	-	Bhotia Group	347	4	141.23	128.50
INDIA					Himalayan Group	457	10	141.26	112.90
Caste	9045	81	140.91	116.10	North East Frontier Group	97	2	137.72	134.10
Scheduled Caste	7133	57	142.60	114.30	Bodo Group	400	4	149.59	117.50
Scheduled Tribe	6924	73	140.59	110.90	Naga Group	-	0	-	-
Community	3883	42	140.83	107.60	Kachin Group	-	0	-	-
B. REGIONS OF HIMALAYA					Kuki Chin Group	-	0	-	-
A. Western Himalaya					III. DRAVIDIAN FAMILY				
Caste	1000	15	139.31	120.90	South Dravidian Group	4304	33	132.34	110.20
Scheduled Caste	85	3	124.41	116.40	Central Dravidian Group	2484	22	145.03	114.30
Scheduled Tribe	568	4	122.38	110.90	North Dravidian Group	61	1	149.30	149.30
Community	156	2	151.03	128.40	IV. INDO-EUROPEAN FAMILY				
B. Central Himalaya					Dard Group	-	0	-	-
Caste	326	3	138.45	128.70	North Western Group	-	0	-	-
Scheduled Caste	-	0	-	-	Southern Group	4343	31	142.19	122.20
Scheduled Tribe	382	3	141.97	136.20	Eastern Group	-	0	-	-
Community	-	0	-	-	Bihari	3939	41	148.06	114.30
C. Eastern Himalaya					Central Group	7283	58	142.25	107.60
Caste	218	4	139.83	118.00	Pahari Group	1473	23	136.67	116.40
Scheduled Caste	351	6	126.98	114.30	Unspecified	429	4	130.81	127.00
Scheduled Tribe	761	13	139.08	117.50	Other Languages	163	4	151.03	132.20
Community	433	9	136.75	112.90	No Information	177	3	127.67	124.00
5. TRADITIONAL OCCUPATION									130.80
Priesthood	3044	31	140.91	120.90	6A. LANGUAGE FAMILY				
				158.50	I. Austro Asiatic Family	971	12	142.20	112.00
					II. Tibeto Chinese Family	1357	21	142.54	112.90
					III. Dravidian Family	6850	56	137.10	110.20
					IV. Indo European Family	17467	157	142.79	107.60
					Other Languages	163	4	151.03	132.20
					No Information	177	3	127.68	124.00

(131.48) as compared to other zones, and the value of TFRC is high among scheduled castes (136.40) and scheduled tribes (134.81) as compared to other ethnic groups. From Nicobar Islands, highest value is observed among Nicobarese with Mongoloid affinities (183.60). Among Onges, the value is 135.40 which is high as compared to African Negroes.

The mean value of TFRC is low among the populations with Mongoloid admixture as compared to that of Mongoloid origin, as observed from Himalayan mountain complex. In general among Indian populations the value is low among scheduled tribes as compared to other ethnic groups, but from the states of Bihar, Orissa (East India) and Madhya Pradesh (Central India), the TFRC value is quite high among scheduled tribes. From South India also, some of the tribes are having high values (Table 2, Fig. 5).

The correlations of mean value of TFRC with various climatic factors and altitude by different ethnic groups though showing significant differences are not high (Table 6).

Among the various traditional occupational groups, the value of TFRC is almost similar among warfare (143.47), animal husbandry (142.51), menial workers (143.92), followed by priesthood group (140.91), which shows gene flow among these groups as observed in other traits also (Bhasin et al. 1994; Bhasin and Walter 2001).

The mean value of TFRC is low among speakers of Mon Khmer group (139.25) of Austro-Asiatic, Tai group (119.10), North East Frontier group (157.72) of Tibeto-Chinese and Pahari group (136.67) of Indo-European languages from Himalayan region. Among the speakers of Munda group (Austro-Asiatic family) and Central Dravidian group (Dravidian family) the mean value is high as observed generally among scheduled tribes. However, in general, the differences for mean values are small among the speakers of all the languages except Dravidian family where the value is quite low (137.10) due to low values observed mainly among caste groups (129.53) (Bhasin et al. 1994; Bhasin and Walter 2001).

The mean value of TFRC is 141.26 from India and a low value has been observed among scheduled tribes as compared to other ethnic groups. However, quite high values are observed from the states of Bihar, Orissa and Madhya Pradesh for scheduled tribes. From the various zones of India, high mean values are reported

from Islands (167.97) and Central India (151.91) from where only scheduled tribes have been investigated, followed by East (146.57), West (141.53), North (140.88) and South (131.48) India. The value is low among the populations of Himalayan region (136.08) as compared to non-Himalayan region (142.24). From the different zones of India and regions of Himalayas in general high mean values are observed for caste or scheduled caste groups. No correlations with climatic factors and altitude with different ethnic groups are observed. From the language families, high mean value of TFRC is found in Indo-European language family (142.79) and low for Dravidians (137.10). It may be concluded that the value of TFRC is high in Indus-Ganga-Brahmaputra plains region and then gradually starts declining towards north (Himalayan mountain complex) and south (Peninsular plateau) India.

2. PALMAR DERMATOGLYPHICS

2.1. Main Line Formulae of Wilder

Wilder (1922) observed that the three most common main line formulae in various populations with different racial elements were 11.9.7.-, 9.7.5.- and 7.5.5.- and concluded that the 11.9.7.- type is essentially the European formula and the 7.5.5.- type the African formula. The frequencies of three main line formulae as observed among different populations are as follows (after Steggerda et al. 1936).

Europeans: 11.9.7.- (28 to 31 per cent) > 9.7.5.- (17 to 26 per cent) > 7.5.5.-

(9 to 10 per cent)

Africans: 7.5.5.- (35 to 45 per cent) > 9.7.5.- (16 to 22 per cent) > 11.9.7.-

(10 to 13 per cent)

Mongoloids: 7.5.5.- (24 to 35 per cent) > 9.7.5.- (19 to 32 per cent) > 11.9.7.-

(9 to 23 per cent)

American Indians: 9.7.5.- (36 per cent) > 11.9.7.- (21 per cent) > 7.5.5.- (18 per cent)

The total number of studies available from India on the main line formulae were 194, of which 124 were from Himalayan region (74 from Eastern Himalayan region); of all studies as many as 93 were on scheduled tribes. Among populations of India the frequency of 11.9.7.- is high followed by 7.5.5.- and 9.7.5.- and similar distribution is

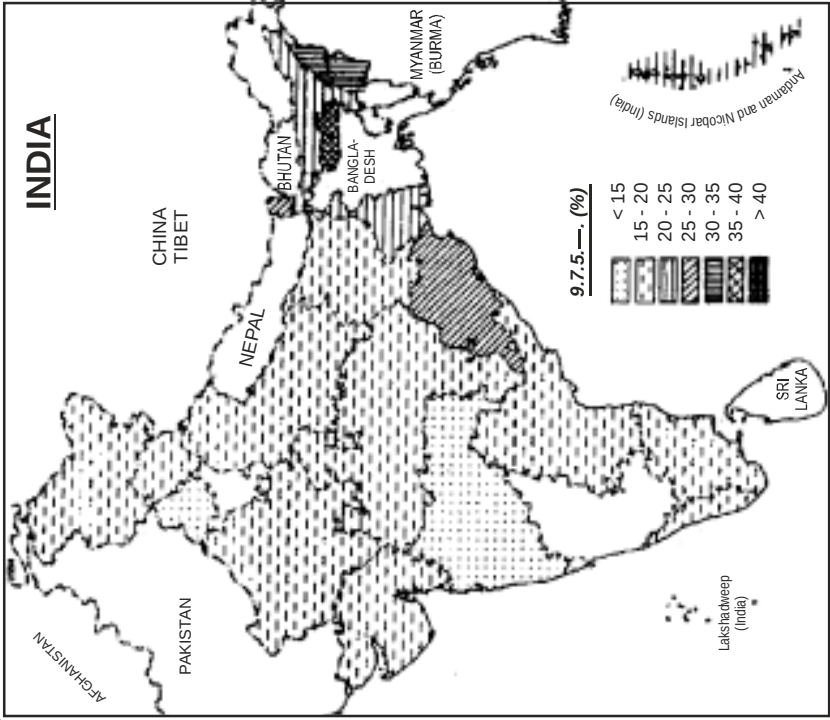


Fig. 7. Frequencies in percentage of 9.7.5.-. palmar main line in different regions of India

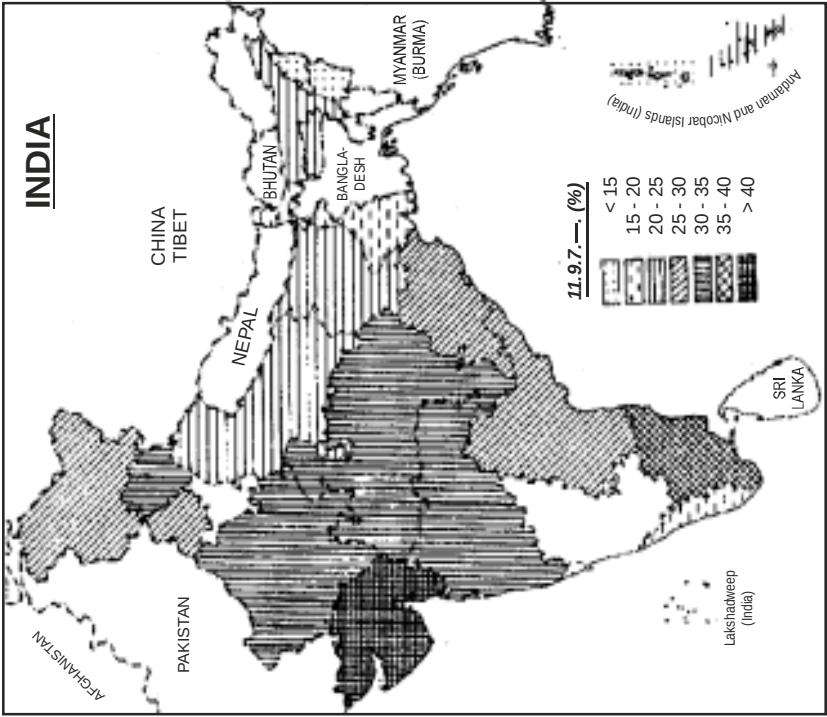


Fig. 6. Frequencies in percentage of 11.9.7.-. palmar main line in different regions of India

observed from Central and South Indian zones, Western and Central Himalayan regions and scheduled caste and community ethnic groups.

In the natural regions, the frequencies of 7.5.5.-. and 9.7.5.-. are high in the Himalayan mountain complex and these gradually start decreasing towards Peninsular region whereas the frequency of 11.9.7.-. is low in the region and starts increasing towards Peninsular region. From the climatic regions the order of preponderance for main line formulae is 7.5.5.-.>9.7.5.-.>11.9.7.-. from monsoon type with dry winters and 11.9.7.-.>7.5.5.-.>9.7.5.-. in tropical savannah type region from where maximum number of studies are reported (Bhasin et al. 1994; Bhasin and Walter 2001).

From the states of Assam, Nagaland, Manipur, Meghalaya, Sikkim among the population groups of Mongoloid affinities (Eastern Himalayan region) the order of preponderance for main line formulae is 7.5.5.-.>9.7.5.-.>11.9.7.-. and this is also seen among tribals of West Bengal who are having Mongoloid admixture in varying degree (Figs. 6-8).

Among the population groups of North India the frequency of main line 11.9.7.-. is high as compared to 9.7.5.-. and 7.5.5.-. and similar pattern is observed from the Western and Central Himalayan regions, albeit among the population groups with Mongoloid affinities the order of preponderance is 7.5.5.-.>9.7.5.-. and 11.9.7.-.

Only five studies are available from West India where also the frequency of 11.9.7.-. is highest, but while in Gujarat state it is followed by 9.7.5.-. in Maharashtra state by 7.5.5.-.

From Central India and state of Bihar from where most of the studies are among scheduled tribes, the frequency of 11.9.7.-. is highest followed by 7.5.5.-. and 9.7.5.-. whereas from the state of Orissa the frequencies of all the main line formulae are almost similar [(9.7.5.-.> (27.66)>7.5.5.-. (26.90)>11.9.7.-. (26.24)].

Among the population groups from South India, from where most of the studies are among the tribals, the order of preponderance is 11.9.7.-.>7.5.5.-.>9.7.5.-. and similar pattern is also observed among the different ethnic groups. However, from the state of Kerala among the tribals, the main line frequency of 7.5.5.-. is highest as compared to 11.9.7.-. and 9.7.5.-. (Kadar and Urali - 40.30 per cent each). From Tamil Nadu among Toda and Kota quite high frequency of 11.9.7.-. is observed (68 and 54.86 per cent,

respectively). However, presence of such high frequency of 11.9.7.-. among tribal groups from Nilgiri Hills of Australoid affinities indicates admixture with other ethnic groups which have Caucasoid (Dravidian) affinities.

Among Onges of Andaman, the frequency 7.5.5.-. is highest followed by 9.7.5.-. and 11.9.7.-., whereas among Nicobarese the order of preponderance is 9.7.5.-.>11.9.7.-.>7.5.5.-.

Among Indian populations, the frequency of main line formula 11.9.7.-. is high followed by 7.5.5.-. and 9.7.5.-. and similar pattern is observed from Central and South Indian populations, whereas from North and West India zones the order of preponderance is 11.9.7.-.>9.7.5.-.>7.5.5.-. which is same as found among populations from Western and Central Himalayan regions. From East India zone and Eastern Himalayan region the frequency is high for 7.5.5.-. followed by 9.7.5.-. and 11.9.7.-. and from Islands the order of preponderance is 9.7.5.-.>11.9.7.-.>7.5.5.-. Among the different ethnic groups the order of preponderance is 7.5.5.-.>9.7.5.-.>11.9.7.-. for scheduled tribes of India which is similar to that observed from East India but among tribals from Bihar (East India), Central India and South India the frequency of 11.9.7.-. is high followed by 7.5.5.-. and 9.7.5.-. and among caste groups the order of preponderance is 11.9.7.-.>9.7.5.-. ≥ 7.5.5.-. in general (Table 3, Figs. 6-8) (Bhasin et al. 1994; Bhasin and Walter 2001).

The frequencies of Wilder's main line formulae correlations with various climatic factors and altitude by different ethnic groups though showing significant differences are not high (Table 6).

Among the different occupational groups, the main line formula 11.9.7.-. frequency is high as compared to 9.7.5.-. and/or 7.5.5.-. as follows:

Priesthood, Warfare, Agriculture, Animal Husbandry 11.9.7.-. > 9.7.5.-. > 7.5.5.-.

Trade and Commerce, Artisans, Menial Workers 11.9.7.-. > 7.5.5.-. > 9.7.5.-. or 7.5.5.-. ≥ 9.7.5.-.

This pattern of distribution indicates gene flow among these groups, particularly from the higher to lower occupational groups as also observed for other biological traits described earlier.

Among the speakers of Tibeto-Chinese languages (Bhotia group, Himalayan group, Bodo group, Naga group, Kuki Chin group), the frequency of 7.5.5.-. is high followed by 9.7.5.-.

and 11.9.7.-, whereas in speakers of North East Frontier group of Tibeto-Chinese the frequency of 9.7.5.-. is quite high (34.15) as compared to 7.5.5.-. (23.13) and 11.9.7.-. (22.08) and among the speakers of Mon Khmer group of Austro-Asiatic languages the frequency of 9.7.5.-. is almost similar to 7.5.5.-. (30.69 and 30.18, respectively) than 11.9.7.-. (20.35) from the Himalayan region among the populations with Mongoloid affinities. The frequencies of 11.9.7.-., 9.7.5.-. and 7.5.5.-. are almost similar among speakers of Munda group of Austro-Asiatic and North Dravidian group of Dravidian languages. The order of preponderance of main line formulae among South and Central Dravidian groups of Dravidian and Bihari group of Indo-European languages is 11.9.7.-.>7.5.5.-. and 9.7.5.-., whereas among the Southern group, Central group and Pahari group of Indo-European

languages speakers the order is 11.9.7.-.>9.7.5.-.>7.5.5.-.

The order of preponderance observed for three main line formulae among different zones, regions, ethnic groups and speakers of various languages is well marked as may be observed from the summarized distribution as follows:

Zone: North and West India

Region: Western and Central Himalaya

Ethnic Group: Castes, scheduled castes and communities

Language: Indo-European Family

11.9.7.-. > 9.7.5.-. > 7.5.5.-. or 9.7.5.-. ≥ 7.5.5.-.

Zone: Central and South India

Ethnic Group: Scheduled tribes (also of Bihar state)

Language: Dravidian Family

11.9.7.-.>7.5.5.-.>9.7.5.-.

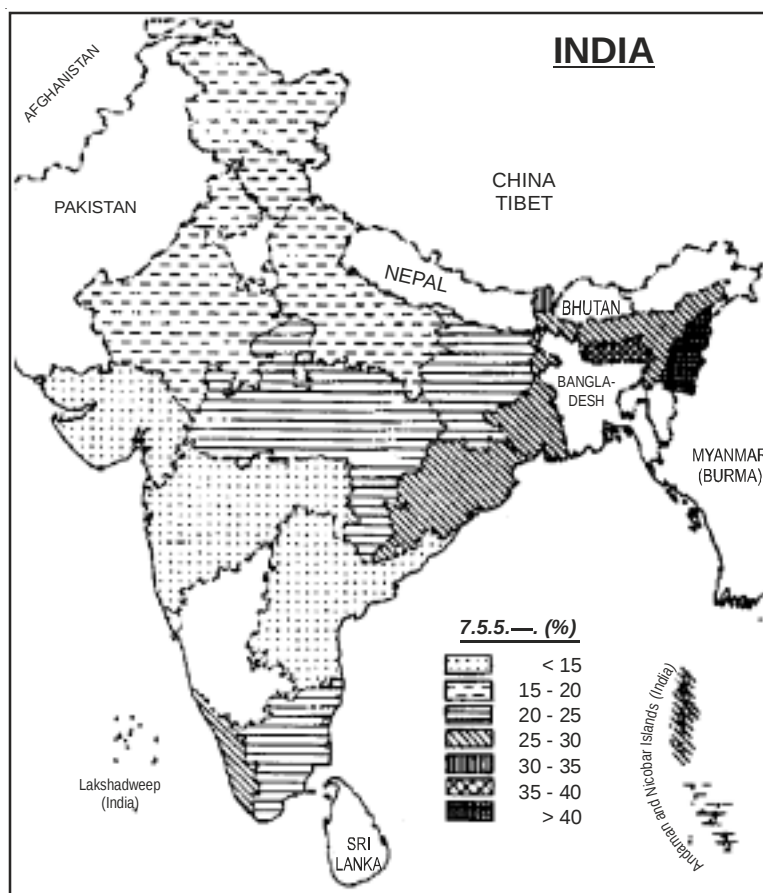


Fig. 8. Frequencies in percentage of 7.5.5.-. palmar main line in different regions of India

Table 3: Palmar Main Line Formulae (in per cent)

Particulars	Subjects studied	No. of studies	11.9.7			9.7.5			7.5.5			Others		
			Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1. NATURAL REGION														
Himalayan Mountain Complex	7082	85	22.71	0.00	60.50	24.42	5.10	46.60	27.52	0.00	75.00	25.36	0.00	52.52
Indus-Ganga-Brahmaputra Plains	4507	46	22.82	4.20	40.00	22.38	8.70	44.10	24.36	4.00	53.60	30.43	11.00	67.40
Peninsular Plateau	6549	60	30.78	9.20	68.00	18.74	5.60	47.00	20.94	2.00	44.60	29.54	0.00	50.00
Islands	254	3	19.93	10.90	21.00	23.94	21.70	33.30	18.61	16.70	26.10	37.52	30.00	41.30
2. CLIMATIC REGION														
Monsoon Type with Short Dry Season	509	6	20.67	10.90	47.70	19.52	5.60	33.30	21.25	11.10	40.30	38.56	26.90	45.10
Monsoon Type with Dry Season	400	4	33.88	32.50	35.50	11.38	7.50	15.50	12.50	8.00	15.00	42.25	37.50	48.50
Tropical Savannah Type	3453	30	30.89	12.90	48.40	18.60	7.50	47.00	19.67	11.30	35.50	30.84	0.00	50.00
Semi Arid Steppe Type	1732	16	36.17	13.20	68.00	15.70	9.00	20.10	20.67	2.00	40.30	27.46	16.90	42.90
Hot Desert Type	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Monsoon Type with Dry Winters	12298	138	22.52	0.00	60.50	24.12	5.10	46.60	26.59	0.00	75.00	26.77	0.00	67.40
Cold Humid Winters with Short Summers	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Polar Type	-	0	-	-	-	-	-	-	-	-	-	-	-	-
3. POLITICAL DIVISION OF INDIA														
I. NORTH INDIA														
A. Western Himalaya (S. No. 1, 2)														
1. Jammu and Kashmir	75	1	30.00	30.00	30.00	18.00	18.00	18.00	15.30	15.30	15.30	36.70	36.70	36.70
2. Himachal Pradesh	2530	32	33.62	15.90	60.50	18.65	5.10	32.20	16.13	0.00	31.80	31.60	9.80	52.50
3. Punjab	195	2	26.00	23.90	28.00	13.37	10.60	16.00	15.21	12.80	17.50	45.42	38.50	52.70
4. Chandigarh UT	-	0	-	-	-	-	-	-	-	-	-	-	-	-
5. Haryana	-	0	-	-	-	-	-	-	-	-	-	-	-	-
6. Delhi UT	100	1	22.00	22.00	22.00	19.00	19.00	19.00	9.00	9.00	9.00	50.00	50.00	50.00
B. Central Himalaya (S. No. 7, Eight Districts of Uttar Pradesh)														
7. Uttar Pradesh	1795	23	23.60	10.40	32.00	19.27	10.50	36.50	18.66	7.00	34.30	38.47	16.00	52.00
8. Rajasthan	287	4	31.56	31.10	32.00	16.23	14.60	20.10	15.27	10.80	19.00	36.94	31.10	42.90
II. WEST INDIA														
9. Gujarat	545	2	44.62	39.20	47.30	19.81	17.40	24.70	14.53	14.00	15.60	21.04	20.50	21.30
10. Maharashtra	390	3	31.18	25.30	34.30	12.98	10.30	16.60	14.28	11.30	19.70	41.55	38.40	44.10
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	3662	34	22.05	4.90	40.00	24.89	11.00	44.10	26.24	4.00	53.60	26.82	11.00	47.00
15. Nagaland	611	6	11.05	0.00	15.00	34.62	12.50	46.60	40.41	28.20	75.00	13.91	5.80	19.10
16. Manipur	1717	14	12.10	3.60	19.10	30.75	16.70	41.40	44.67	27.80	60.00	12.48	0.00	20.20
17. Mizoram	-	0	-	-	-	-	-	-	-	-	-	-	-	-
18. Tripura	-	0	-	-	-	-	-	-	-	-	-	-	-	-
19. Meghalaya	333	5	22.96	9.20	31.70	35.16	27.70	43.40	38.26	24.90	44.60	3.61	0.00	18.50
20. Sikkim	757	15	18.96	4.50	40.90	28.87	17.30	41.40	32.23	12.70	54.30	19.93	7.60	29.40
21. West Bengal	469	4	17.14	4.20	24.40	20.20	8.70	25.00	25.64	4.30	33.30	37.03	26.30	67.40
22. Bihar	461	6	23.55	18.90	31.40	19.82	12.90	28.80	21.32	12.10	27.20	35.32	32.40	48.60
23. Orissa	343	5	26.24	12.90	44.00	27.66	16.40	47.00	26.90	15.40	35.00	19.20	0.00	40.70

Table 3: Contd....

Particulars	Subjects studied	No. of studies	11.9.7			9.7.5			7.5.5			Others		
			Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
IV. CENTRAL INDIA														
24. Madhya Pradesh	1403	13	30.71	18.00	48.40	16.52	7.50	26.00	21.71	12.50	35.50	31.05	19.10	50.00
V. SOUTH INDIA														
25. Karnataka	-	0	-	-	-	-	-	-	-	-	-	-	-	-
26. Andhra Pradesh	765	6	29.36	22.50	35.50	15.74	7.50	22.80	14.33	8.00	17.60	40.56	37.10	48.50
27. Tamil Nadu	1398	12	38.70	30.00	68.00	15.14	5.60	20.00	20.43	2.00	31.00	25.73	16.90	35.60
28. Kerala	302	3	16.36	13.20	20.20	17.32	12.60	19.50	29.63	20.40	40.30	36.69	26.90	45.10
29. Pondicherry UT	-	0	-	-	-	-	-	-	-	-	-	-	-	-
VI. ISLANDS														
30. Lakshadweep UT	-	0	-	-	-	-	-	-	-	-	-	-	-	-
31. Andaman Islands and Nicobar Islands UT	24 230	1 2	10.90 20.87	10.90 20.00	10.90 21.00	21.70 24.17	21.70 22.80	21.70 33.30	26.10 17.83	26.10 16.70	26.10 18.00	41.30 37.13	41.30 30.00	41.30 38.20
3A. ZONES OF INDIA														
I. North India	4982	63	29.31	10.40	60.50	18.52	5.10	36.50	16.80	0.00	34.30	35.37	9.80	52.70
II. West India	935	5	39.02	25.30	47.30	16.96	10.30	24.70	14.42	11.30	19.70	29.59	20.50	44.10
III. East India	8353	89	18.94	0.00	44.00	27.15	8.70	47.00	31.81	4.00	75.00	22.11	0.00	67.40
IV. Central India	1403	13	30.71	18.00	48.40	16.52	7.50	26.00	21.71	12.50	35.50	31.05	19.10	50.00
V. South India	2465	21	33.06	13.20	68.00	15.59	5.60	22.80	19.66	2.00	40.30	31.68	16.90	48.50
VI. Islands	254	3	19.93	10.90	21.00	23.94	21.70	33.30	18.61	16.70	26.10	37.52	30.00	41.30
INDIA (TOTAL)	18392	194	25.37	0.00	68.00	21.89	5.10	47.00	24.28	0.00	75.00	28.26	0.00	67.40
3B. REGIONS OF HIMALAYA														
A. Western Himalaya	2605	33	33.52	15.90	60.50	18.63	5.10	32.20	16.10	0.00	31.80	31.75	9.80	52.70
B. Central Himalaya	1392	17	22.72	10.40	32.00	20.53	12.50	36.50	19.50	7.00	32.50	37.25	16.00	52.00
C. Eastern Himalaya	7080	74	18.40	0.00	40.90	28.06	11.00	46.60	33.14	4.00	75.00	20.40	0.00	47.00
HIMALAYA (TOTAL)	11077	124	22.50	0.00	60.50	24.90	5.10	46.60	27.42	0.00	75.00	25.19	0.00	52.50
NON-HIMALAYAN REGIONS	7315	70	30.23	4.20	68.00	17.34	5.60	47.00	19.53	2.00	40.30	32.91	0.00	67.40
4. ETHNIC GROUP														
A. ZONES OF INDIA														
I. NORTH INDIA														
Caste	3246	40	29.26	13.80	54.80	16.58	5.10	26.50	16.29	6.70	34.30	37.87	14.30	52.70
Scheduled Caste	306	6	34.03	27.00	60.50	18.05	11.00	27.00	14.04	0.00	18.60	33.87	15.00	50.00
Scheduled Tribe	914	8	28.96	10.40	43.30	23.46	14.90	31.30	17.55	7.00	31.80	30.02	16.20	47.20
Community	516	9	27.42	11.90	45.60	22.26	9.60	36.50	20.30	9.00	32.50	30.01	9.80	50.00
II. WEST INDIA														
Caste	365	1	47.30	47.30	47.30	17.40	17.40	17.40	14.00	14.00	14.00	21.30	21.30	21.30
Scheduled Caste	115	1	25.30	25.30	25.30	16.60	16.60	16.60	19.70	19.70	19.70	38.40	38.40	38.40
Scheduled Tribe	180	1	39.20	39.20	39.20	24.70	24.70	24.70	15.60	15.60	15.60	20.50	20.50	20.50
Community	275	2	33.65	31.90	34.30	11.47	10.30	14.60	12.01	11.30	42.87	42.37	39.60	44.10
III. EAST INDIA														
Caste	554	7	32.95	27.00	40.90	19.32	11.70	28.00	19.52	4.00	24.10	28.21	24.90	32.40
Scheduled Caste	1223	11	24.92	15.00	40.00	21.07	13.00	25.00	23.89	12.00	49.00	30.13	23.00	42.80
Scheduled Tribe	5348	57	14.79	0.00	44.00	29.29	8.70	47.00	36.21	4.30	75.00	19.71	0.00	67.40
Community	1258	14	24.92	4.70	40.10	27.19	11.00	40.20	25.92	10.00	45.30	21.96	7.60	44.00

Table 3: Contd....

Particulars	Subjects studied	No. of studies	11.9.7			9.7.5			7.5.5			Others		
			Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
IV. CENTRAL INDIA														
Caste	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Scheduled Caste	42	1	34.50	34.50	34.50	25.00	25.00	25.00	21.40	21.40	21.40	19.10	19.10	19.10
Scheduled Tribe	1311	11	30.62	18.00	48.40	15.89	7.50	18.60	21.71	12.50	35.50	31.78	21.20	50.00
Community	50	1	30.00	30.00	30.00	26.00	26.00	26.00	22.00	22.00	22.00	22.00	22.00	22.00
V. SOUTH INDIA														
Caste	400	4	33.88	32.50	35.50	11.38	7.50	15.50	12.50	8.00	15.00	42.25	37.50	48.50
Scheduled Caste	110	1	34.80	34.80	34.80	15.20	15.20	15.20	17.40	17.40	17.40	32.60	32.60	32.60
Scheduled Tribe	1583	13	32.95	13.20	68.00	16.87	5.60	22.80	20.93	2.00	40.30	29.25	16.90	45.10
Community	372	3	32.18	29.50	37.60	14.81	14.50	15.20	22.66	13.00	29.30	30.35	18.60	43.00
VI. ISLANDS														
Caste	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Scheduled Caste	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Scheduled Tribe	254	3	19.93	10.90	21.00	23.94	21.70	33.30	18.61	16.70	26.10	37.52	30.00	41.30
Community	-	0	-	-	-	-	-	-	-	-	-	-	-	-
INDIA														
Caste	4535	52	31.55	13.80	54.80	16.50	5.10	28.00	16.14	4.00	34.30	35.81	14.30	52.70
Scheduled Caste	1796	20	27.32	15.00	60.50	20.00	11.00	27.00	21.49	0.00	49.00	31.19	15.00	50.00
Scheduled Tribe	9590	93	21.89	0.00	68.00	24.63	5.60	47.00	29.07	2.00	75.00	24.41	0.00	67.40
Community	2471	29	27.61	4.70	45.60	22.53	9.60	40.20	22.63	9.00	45.30	27.23	7.60	50.00
B. REGIONS OF HIMALAYA														
A. Western Himalaya														
Caste	1726	22	32.64	23.10	54.80	16.51	5.10	26.50	15.44	6.70	26.90	35.31	14.30	52.50
Scheduled Caste	134	4	40.00	27.00	60.50	19.94	11.00	27.00	9.00	0.00	12.00	31.05	15.00	50.00
Scheduled Tribe	605	4	33.27	15.90	43.30	23.63	19.50	31.30	18.84	10.00	31.80	24.27	16.20	32.80
Community	140	3	39.29	27.50	45.60	20.60	9.50	32.20	19.21	16.10	25.00	20.90	9.80	27.30
B. Central Himalaya														
Caste	902	10	24.20	13.80	32.00	18.17	12.50	25.00	19.24	11.00	25.00	38.39	28.80	52.00
Scheduled Caste	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Scheduled Tribe	309	4	20.54	10.40	28.00	23.13	14.90	30.00	15.04	7.00	22.00	14.29	35.00	47.20
Community	181	3	19.05	11.90	28.30	27.90	15.00	36.50	28.40	20.80	32.50	24.65	16.00	35.90
C. Eastern Himalaya														
Caste	470	6	33.13	27.00	40.90	19.57	11.70	28.00	19.57	4.00	24.10	27.73	24.90	31.60
Scheduled Caste	989	10	25.91	15.00	40.00	20.14	13.00	23.10	22.92	12.00	49.00	31.04	23.00	42.80
Scheduled Tribe	4363	44	13.23	0.00	31.70	31.02	12.50	46.60	39.00	17.70	75.00	16.75	0.00	47.00
Community	1258	14	24.92	4.70	40.10	27.19	11.00	40.20	25.92	10.00	45.30	21.96	7.60	44.00
5. TRADITIONAL OCCUPATION														
Priesthood	1382	19	32.81	13.80	54.80	17.88	6.80	26.50	16.53	6.70	24.10	32.79	14.30	52.00
Warfare	1687	16	31.11	18.50	47.30	17.36	5.10	28.00	16.79	4.00	26.90	34.74	21.30	52.50
Trade and Commerce	461	6	31.60	18.60	40.60	12.83	10.50	17.10	15.01	8.50	34.30	40.56	30.00	52.70
Agriculture	1189	13	29.62	18.90	60.50	16.87	7.50	27.00	15.97	0.00	23.50	37.53	15.00	50.00
Animal Husbandry	45	1	31.10	31.10	31.10	21.10	20.10	20.10	17.70	17.70	17.70	31.10	31.10	31.10
Artisans	174	3	28.15	28.00	28.60	16.38	15.00	25.00	17.84	7.60	20.80	37.63	35.90	38.80
Menial Workers	1024	10	26.95	15.00	40.00	20.14	13.00	25.00	23.08	12.00	49.00	30.18	23.00	40.40
No Information	12430	126	23.26	0.00	68.00	23.99	5.60	47.00	27.51	2.00	75.00	25.23	0.00	67.40

Table 3: Contd....

Particulars	Subjects studied	No. of studies	11.9.7		9.7.5		7.5.5		Others	
			Mean	Max	Mean	Max	Mean	Max	Mean	Max
6. LANGUAGE GROUP										
I. AUSTRO-ASIATIC FAMILY										
Mon Khmer Group	540	6	20.35	13.70	30.69	23.40	30.18	38.70	18.79	38.20
Munda Group	882	11	23.75	12.90	22.34	8.70	24.94	35.00	28.98	67.40
II. TIBETO-CHINESE FAMILY										
(i) Siamese-Chinese Sub-Family										
Tai Group	50	1	6.00	6.00	29.00	29.00	40.00	40.00	25.00	25.00
(ii) Tibeto-Burman Sub-Family										
Bhotia Group	263	4	15.40	12.50	25.26	19.50	31.17	37.50	28.17	40.00
Himalayan Group	680	13	16.18	4.50	27.72	14.90	29.34	7.00	26.76	47.20
North East Frontier Group	415	6	22.08	16.30	34.35	31.00	23.13	27.70	20.45	24.90
Bodo Group	968	9	10.96	4.20	28.24	17.80	34.93	53.60	25.87	47.00
Naga Group	928	8	10.61	0.00	32.65	12.50	42.29	75.00	14.44	19.10
Kachin Group	-	0	-	-	-	-	-	-	-	-
Kuki Chin Group	1400	12	12.63	3.60	31.18	16.70	44.39	60.00	11.80	20.20
III. DRAVIDIAN FAMILY										
South Dravidian Group	2200	20	34.34	13.20	14.73	5.60	19.91	40.30	31.02	48.50
Central Dravidian Group	1238	7	27.24	18.00	17.16	7.50	21.86	24.80	33.74	50.00
North Dravidian Group	226	2	21.17	18.90	22.55	22.50	21.73	23.70	34.55	34.80
IV. INDO-EUROPEAN FAMILY										
Dard Group	75	1	30.00	30.00	18.00	18.00	15.30	15.30	36.70	36.70
North Western Group	-	0	-	-	-	-	-	-	-	-
Southern Group	570	4	33.72	25.30	16.68	10.30	14.69	19.70	34.91	44.10
Eastern Group	20	1	27.50	27.50	12.50	12.50	22.50	22.50	37.50	37.50
Bihari	2163	19	27.00	9.20	21.55	11.00	23.47	4.00	27.98	44.00
Central Group	3182	35	31.07	13.80	18.49	10.50	17.27	8.50	33.17	52.70
Pahari Group	2296	32	33.63	23.10	18.12	5.10	15.73	0.00	32.51	9.80
Unspecified	72	1	10.40	10.40	25.70	25.70	20.10	20.10	43.80	43.80
Other Languages	224	2	19.92	10.90	22.68	21.70	18.87	26.10	38.53	41.30
No Information	-	0	-	-	-	-	-	-	-	-
6A. LANGUAGE FAMILY										
I. Austro Asiatic Family	1422	17	22.46	12.90	25.51	8.70	26.93	38.70	25.11	67.40
II. Tibeto Chinese Family	4704	53	13.32	0.00	30.29	12.50	37.19	7.00	19.20	47.20
III. Dravidian Family	3634	29	31.13	13.20	16.03	5.60	20.68	40.30	32.16	50.00
IV. Indo European Family	8378	93	30.70	9.20	19.10	5.10	18.30	49.00	31.90	52.70
Other Languages	224	2	19.92	10.90	22.68	21.70	18.87	26.10	38.53	41.30
No Information	-	0	-	-	-	-	-	-	-	-

Zone: East India

Region: Eastern Himalaya

Ethnic Group: Scheduled tribes

Language: Austro-Asiatic and Tibeto-Chinese Families

7.5.5.->9.7.5.->11.9.7.-.

Zone: Islands

Ethnic group: Scheduled tribes (Also of Orissa state)

9.7.5.->11.9.7.-. or 7.5.5.-.

In India, the order of preponderance for the three main line formulae is 11.9.7.->7.5.5.->9.7.5.-. in Central and South India, whereas in North and West India it is 11.9.7.->9.7.5.->7.5.5.-. and similar pattern is observed from Western and Central Himalayan regions. From East India the order is 7.5.5.->9.7.5.->11.9.7.-. and similar distribution is found in Eastern Himalayan region. From Islands, the tribal groups show the order 9.7.5.->11.9.7.->7.5.5.-. Among the caste groups the order is 11.9.7.->9.7.5.->7.5.5.-. and in scheduled tribe groups 11.9.7.->7.5.5.->9.7.5.-., whereas among the population groups from Eastern Himalayan region the order is 7.5.5.->9.7.5.->11.9.7.-. and similar pattern is observed from different language families *i.e.* among speakers of Indo-European languages the order is 11.9.7.->9.7.5.->7.5.5.-., among Dravidian speakers it is 11.9.7.->7.5.5.->9.7.5.-. and among Tibeto-Chinese and Austro-Asiatic speakers the preponderance is of main line formula 7.5.5.-. followed by 9.7.5.-. and 11.9.7.-. No significant correlations with climatic factors and altitude with different ethnic groups are observed.

2.2. Palmar Patterns

The frequency of patterns present in the hypothhenar area is highest among European

populations - around 34.5 per cent (varies from 21 to 52 per cent) followed by Africans - 25 per cent (range 15 to 32 per cent) and lowest among American Indians - 13.8 per cent (ranges from 5 to 28 per cent). In the populations from Southeast Asian and East Asian regions the values are between 9 and 30 per cent with average frequency about 20 per cent. For the thenar/first interdigital area the frequency for the presence of patterns is low and similar among populations from Europe (10 per cent), South-East Asia and East Asia (each 10 per cent) and Indian Region (less than 12 per cent). Among Africans the frequency is high (19 per cent), whereas highest frequency is observed among American Indians (33.2 per cent). For the second interdigital area, the frequency for the presence of patterns is lowest than rest of the palmar pattern areas. Highest frequency is observed among Africans - around 4 to 29 per cent (average 14 per cent) and lowest among American Indians (average 1.4 per cent), whereas among European and Indian region populations, the frequencies are about 5 and 4 per cent, respectively, and among Southeast Asian and East Asian populations, it is around 2.5 per cent.

In the third interdigital area the frequency for the presence of patterns is highest in the Indian region (around 52 per cent) followed by European populations (around 43 per cent) and African populations (39 per cent), whereas among Southeast Asian and East Asian populations, the frequencies are lowest from 7 to 24 per cent (average around 16 per cent) and low frequency is also observed among American Indians (about 25 per cent). The frequency of the patterns in the fourth interdigital area is highest among the African populations (around 81 per cent, range 68 to 91 per cent), and lowest among European populations (about 54 per cent, varying from 37

Table 4: Distribution of palmar patterns

Population	Presence of patterns		
	High	Intermediate	Low
Europeans	Hypothenar, Third Interdigital	Thenar/First Interdigital and Second Interdigital	Fourth Interdigital
Africans	Thenar/First Interdigital, Second and Fourth Interdigitals	Hypothenar and Third Interdigital	
Mongoloids		Fourth Interdigital	Hypothenar, Thenar/First Interdigital, Second and Third Interdigitals
American Indians	Thenar/First Interdigital	Third and Fourth Interdigitals	Hypothenar, Second Interdigital

to 68 per cent). Among the Southeast Asian and East Asian populations the frequencies are between 55 and 84 per cent (average around 70 per cent) and a little lower but similar frequency is observed among American Indians (67 per cent). From Indian region, the frequencies are almost similar to that observed among Europeans (average 55 per cent, ranges from 49 to 61 per cent) (Fleischhacker 1951; Plato 1983).

The important trends which emerge are that the Europeans have high pattern frequency on hypothenar and third interdigital areas, and low frequency on the fourth interdigital and intermediate frequencies on thenar/first interdigital and second interdigital areas (Table 4). Africans have the highest frequencies on areas thenar/first interdigital, second and fourth interdigital and intermediate frequencies on areas hypothenar and third interdigital, while Mongoloids display intermediate frequency on fourth interdigital area and lowest on all other areas. The American Indians deviate from the Mongoloids by showing highest frequency on thenar/first interdigital area (Rife 1954).

1. Hypothenar Area: The frequency of presence of patterns on hypothenar area is 33 per cent among Indian populations and highest frequency is observed among the scheduled tribes (35.4 per cent) as compared to other ethnic groups among whom the frequencies are almost similar (scheduled caste - 29.0, community - 29.9 and caste - 30.1 per cent). The frequency from the Himalayan mountain complex region is low as compared to Indus-Ganga-Brahmaputra plains and peninsular plateau. However, from Meghalaya among different Khasi groups, Das (1968) reported very high frequency (83.8 per cent) and such high frequency is not observed among any other population group from India except among Car Nicobarese (100 per cent) studied by Krishan et al. (1977, 1983), whereas among the populations from East and Southeast Asia the frequency varies from 9 to 30 per cent.

From Western Himalayan region in the state of Jammu and Kashmir the frequency of patterns present on hypothenar area is low (25.2 per cent, among Ladakhis - 21.27 per cent) as compared to Himachal Pradesh (29.8 per cent) and also from Central Himalayan region the frequency is high as most of the studies are reported among the different caste groups (Table 5). However, among the populations with Mongoloid affinities the frequency is low (*e.g.* Bhotia - 15.0 per cent).

Among the populations with Mongoloid affinities from the state of Assam and Sikkim, the frequencies are quite low (18.7 and 13.0 per cent, respectively).

The frequency for the presence of patterns is high among the scheduled tribes from Bihar (28.9 per cent), Madhya Pradesh (33.6 per cent) from the states of South India from where quite high values are reported among Toda (80 per cent) and Kota (46 per cent), whereas from the state of Orissa the frequency is low (22.2 per cent) among tribals with Australoid affinities.

A few studies are available from West India among scheduled caste (Mahar), communities (Parsis, Maharashtrians), caste (Rajputs) and scheduled tribe (Kolis) among whom the differences are low.

In general, barring a few exceptional cases the Khasis of Meghalaya and Nicobarese of Islands, the frequency for the presence of patterns on hypothenar area is low among populations with Mongoloid affinities and high in scheduled tribes, whereas among other ethnic groups the differences are not large. The frequency is low in the Himalayan region and gradually starts increasing towards peninsular region (Fig. 9).

The frequency is quite high among the speakers of Mon Khmer group (72.6 per cent) of Austro-Asiatic as compared to Tibeto-Chinese (24.7 per cent) from Himalayan region. Among speakers of Munda group of Austro-Asiatic languages the frequency is lower (27.4) than in Dravidian speakers (31.8) belonging mainly to scheduled tribes, whereas among most of the speakers of Indo-European languages the frequency is 30 per cent, and they are mainly from different castes and communities (Bhasin et al. 1994; Bhasin and Walter 2001).

From India, the frequency of patterns in the hypothenar area is 33 per cent and it is high from East India (36.5 per cent) and low in South India (29.9 per cent). From the Western and Central Himalayan regions, the frequency is more than 25 per cent as compared to Eastern Himalaya where it is 20 per cent. Among the ethnic groups, the frequency for the presence of patterns is high among scheduled tribes (35.4 per cent) as compared to rest of the ethnic groups, in which it is almost similar (caste - 30.1 per cent; scheduled caste - 29.0 per cent and community - 29.9 per cent). Among various linguistic groups, a little low frequency is observed among Indo-European language family (30.0 per cent) followed by Dravidian language family (31.8 per cent) and low

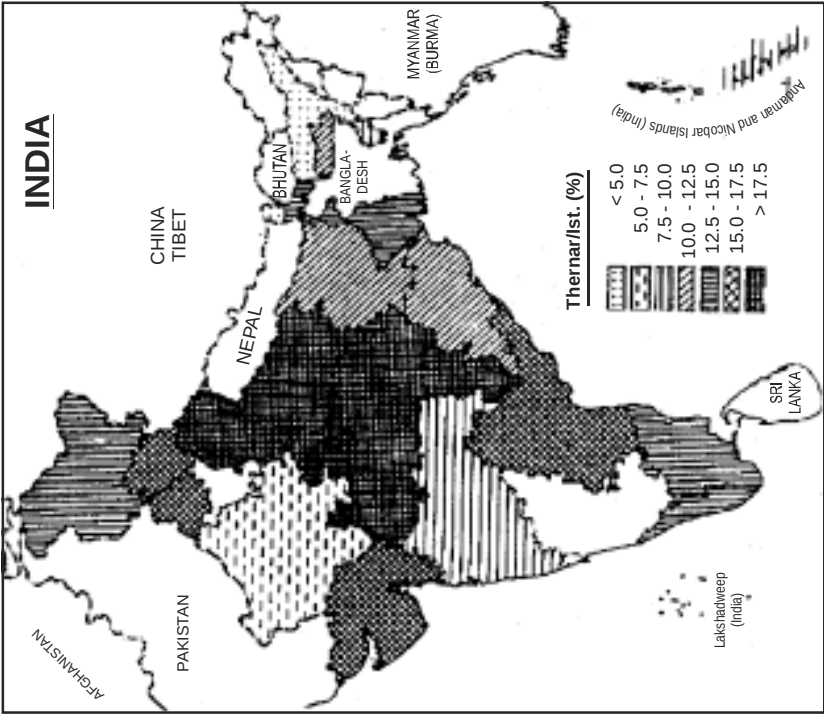


Fig. 10. Frequencies in percentage of patterns on thenar/1st interdigital palmar area in different regions of India

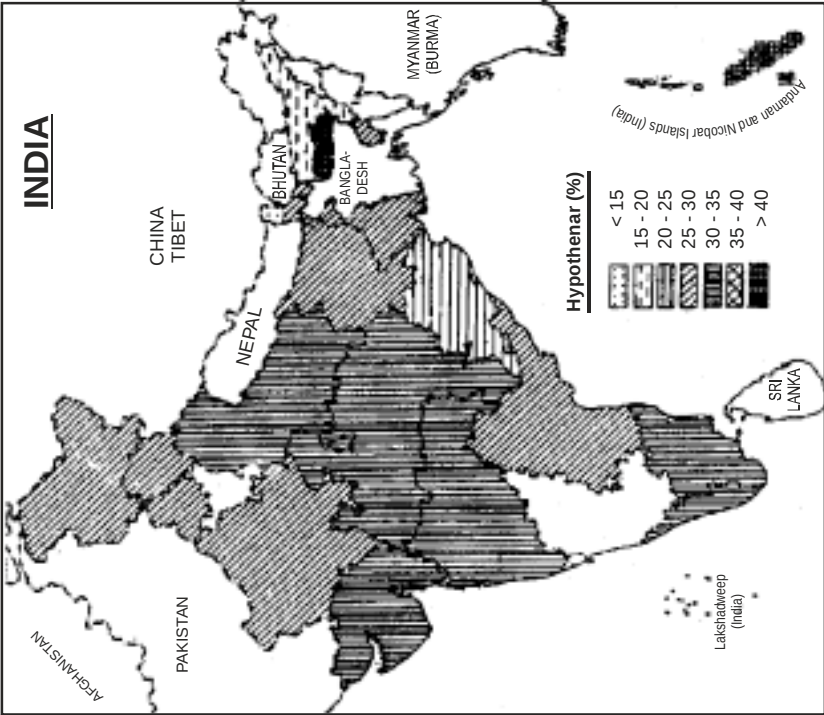


Fig. 9. Frequencies in percentage of patterns on hypothenar palmar area in different regions of India

frequency is found in Tibeto-Chinese language family (24.7 per cent). In general, the frequency is low among populations with Mongoloid affinities and high among scheduled tribes from Central and South India, whereas among other ethnic groups the frequencies are almost similar.

2. Thenar/First Interdigital Area: The frequency for the presence of patterns in thenar/first interdigital area among Indian population is 15 per cent, which is high as compared to Europeans and Asian Mongoloids. The patterns are present in low frequency among the scheduled tribes (14.4 per cent) as compared to other ethnic groups (caste - 15.9 per cent; community - 15.9 per cent and scheduled caste - 15.2 per cent). The frequency is low in the Himalayan mountain complex as compared to other regions.

The frequencies are low from the states of Assam (3.3 per cent), Mizoram (8.3 per cent), Sikkim (2.6 per cent) from the Eastern Himalayan region among the populations with Mongoloid affinities as compared to Western (Jammu and Kashmir - 15 per cent, Himachal Pradesh - 16.5 per cent) and Central (about 17 per cent) Himalayan region but in these regions also, the frequencies are low among populations with Mongoloid affinities (Ladakhis - 7.41 per cent, Bhotias - 8.00 per cent).

The frequencies are low from the states of Bihar (11.8 per cent), Orissa (10.8 per cent) from East India and from Tamil Nadu (13.9 per cent) and Kerala (13.9 per cent) as compared with states of Madhya Pradesh (17.7 per cent) and Andhra Pradesh (16.9 per cent) from where most of the studies are on scheduled tribes.

From North India in all the states the frequency for the presence of patterns is above 15 per cent except from Rajasthan (7.2 per cent) where low frequencies are observed among Dangis (7.90 per cent) and Raigers (8.33 per cent). Among Mahar and Maharashtrians from Maharashtra the frequencies are low (10.87 and 2.66 per cent, respectively) as compared to different ethnic groups (Kolis, Rajputs and Parsis) from Gujarat who are having high frequency (16.5 per cent).

In general, the frequencies are low among populations with Mongoloid affinities and among scheduled tribes except from Central India and Andhra Pradesh. The frequency is low in East and then it starts increasing in all directions (Table 5, Fig. 10).

The speakers of Mon Khmer group of Austro-Asiatic family and Himalayan and Bodo group of

Tibeto-Chinese family from Himalayan region with Mongoloid affinities show low frequencies as compared to Indo-European speakers among whom quite high frequencies are observed. Whereas among tribals belonging to Munda group, the frequency is low (12.7 per cent) as compared to Dravidians (15.8 per cent). The differences are prominent among populations with Mongoloid affinities, tribals with Austroloid and Caucasooid (Dravidian) affinities and speakers of Indo-European languages (Aryans) (Bhasin et al. 1994; Bhasin and Walter 2001).

The presence of patterns in the thenar/first interdigital area among Indian populations is 15 per cent. From Central India, the high frequency is observed (17.7 per cent) followed by North (16.5 per cent) and South India (15.1 per cent). From the Western and Central Himalayan regions, the frequency is more than 15 per cent as compared to Eastern Himalayan region where it is less than 10 per cent. Among the different ethnic groups, low frequency is observed in scheduled tribe (14.4 per cent). Among the speakers of Indo-European and Dravidian languages the frequencies are high (16.2 and 15.8 per cent, respectively) as compared to the Austro-Asiatic (10.4 per cent) and Tibeto-Chinese (9.6 per cent) language families.

3. Second Interdigital Area: In the second interdigital area, the frequency for the presence of patterns among Indian populations is 8.2 per cent which is highest from the Central India (16.9 per cent) and lowest in East India (3.3 per cent), whereas among ethnic groups the differences are not high (varies from 6.6 per cent among community to 9.1 per cent among caste). The frequency is low in the Himalayan mountain complex as compared to other regions (Bhasin et al. 1994; Bhasin and Walter 2001).

Among Central India populations the frequency is highest (16.9 per cent), which is high among scheduled tribes (for example Murias - 22.73 per cent, Marias - 19 per cent; Binghwar - 19 per cent) as compared to community (Sunni Muslims - 9.00 per cent) and scheduled castes (Katiya - 2.38 per cent and Mehtar - 9.52 per cent) and also from the state of Andhra Pradesh in South India (10 per cent), where among scheduled tribes very high frequencies are reported (Bagathas - 14.77 to 28.96 per cent). From the states of Bihar, Orissa (East India) and Tamil Nadu and Kerala (South India) the frequencies are quite low 4.6, 4.0, 2.9 and 2.5 per cent, respectively.

From the Eastern Himalayan region among the

populations with Mongoloid affinities, the frequencies are quite low as observed from the state of Assam (1.1 per cent), Tripura (2.1 per cent), Meghalaya (2.7 per cent), Sikkim (absent) as compared to Western and Central Himalayan regions, where the frequencies are quite high except among populations of Mongoloid origin like Ladakhis (1.85 per cent). Among Nicobarese also, the frequency is high (4.3 per cent). From rest of the states from West India and North India, the frequencies are high (about 8 per cent or more). In general, the frequency is low from East and South India zones and high in Central, West and North India zones (Table 5, Fig. 11).

The frequency is low among the populations with Mongoloid affinities from Himalayan region, who speak languages of Mon Khmer group (2.8 per cent) of Austro-Asiatic family; Bhotia group (3.7 per cent), Himalayan group (4.1 per cent) and Bodo group (2.1 per cent) of Tibeto-Chinese family. The frequencies are also low among tribals speaking languages of Munda group (4.6 per cent) of Austro-Asiatic family and South Dravidian group (5.2 per cent) of Dravidian family. In general, the frequencies are quite high in Dravidian and Indo-European language speakers (9.2 and 8.3 per cent, respectively) as compared to other languages (Bhasin et al. 1994; Bhasin and Walter 2001).

Among the various Indian groups, the frequency is 8.2 per cent for the presence of patterns on the second interdigital area. From the different zones, a low frequency is observed from East (3.4 per cent) and South (3.7 per cent) India. In the Himalayan regions, the frequency is low in Eastern region (about 2 per cent) among the populations with Mongoloid affinities as compared to Western and Central regions (8.5 per cent). Among the various ethnic groups the frequency is high among castes (9.1 per cent). In the language families, high frequency is observed among Dravidian (9.2 per cent) and Indo-European (8.3 per cent) as compared to Tibeto-Chinese (3.4 per cent) and Austro-Asiatic (3.7 per cent) speakers.

4. Third Interdigital Area: Among Indian populations, the frequency for presence of patterns on the third interdigital area is 43.1 per cent and in general, the frequency is low among scheduled tribes (40.4 per cent) as compared to castes (49.1 per cent) and communities (46.3 per cent), albeit among scheduled castes a little lower frequency is observed (39.2 per cent) as compared

to scheduled tribes. The frequency is low in the Himalayan mountain complex as compared to other regions (Bhasin et al. 1994; Bhasin and Walter 2001).

Most of the studies on scheduled tribes are from the states of Kerala and Tamil Nadu of South India zone, and from East India zone where the frequencies are low (24.8, 33.5 and 33.4 per cent, respectively) as compared to Andhra Pradesh, Orissa and Madhya Pradesh states from where the frequencies are quite high among the populations which are mostly scheduled tribes (43.9, 43.6 and 57.3 per cent, respectively).

Among the population groups from Eastern Himalayan region, mostly tribals with Mongoloid affinities, the frequencies are also low (Assam - 30.4 per cent, Tripura - 18.9 per cent, Meghalaya - 31.4 per cent, Sikkim - 6.8 per cent), but low frequencies are also observed among the populations with Mongoloid affinities from Western (Ladakhis - 27.78 per cent) and Central (Bhotia - 30 per cent) Himalayan regions. From rest of the states the frequencies are high as observed from West India (Gujarat - 67.0 per cent and Maharashtra - 47.7 per cent) and North India (Punjab - 53.2 per cent; Rajasthan - 55.5 per cent).

Among Nicobarese, the frequency is low (27.5 per cent). The frequency is in general low in East India and South India (Kerala and Tamil Nadu) as compared to other regions where frequencies are quite high (Table 5, Fig. 12).

The frequencies are low among the speakers of Tibeto-Chinese (24.7 per cent; Bhotia group - 3.18 per cent, Himalayan group - 20.2 per cent and Bodo group 18.9 per cent) and Austro-Asiatic (Mon Khmer group - 29.9 per cent) languages from Himalayan region with Mongoloid affinities, followed by speakers of Munda group (Austro-Asiatic family) and South Dravidian group (Dravidian family) with average frequencies of 33.9 and 34.9 per cent, respectively, which are mostly tribals. The highest frequency is reported among Indo-European language speakers (49.5 per cent) (Bhasin et al. 1994; Bhasin and Walter 2001).

From India, the frequency of the patterns on the third interdigital area is 43.1 per cent. The frequency is low in East (31.1 per cent) and South India (36.1 per cent) as compared to Central (57.3 per cent), West (53.8 per cent) and North (47.7 per cent) India. From the Himalayan region, the frequency is about 40 per cent in Western and Central regions, whereas in the Eastern region it is quite low (about 25 per cent). Among the ethnic

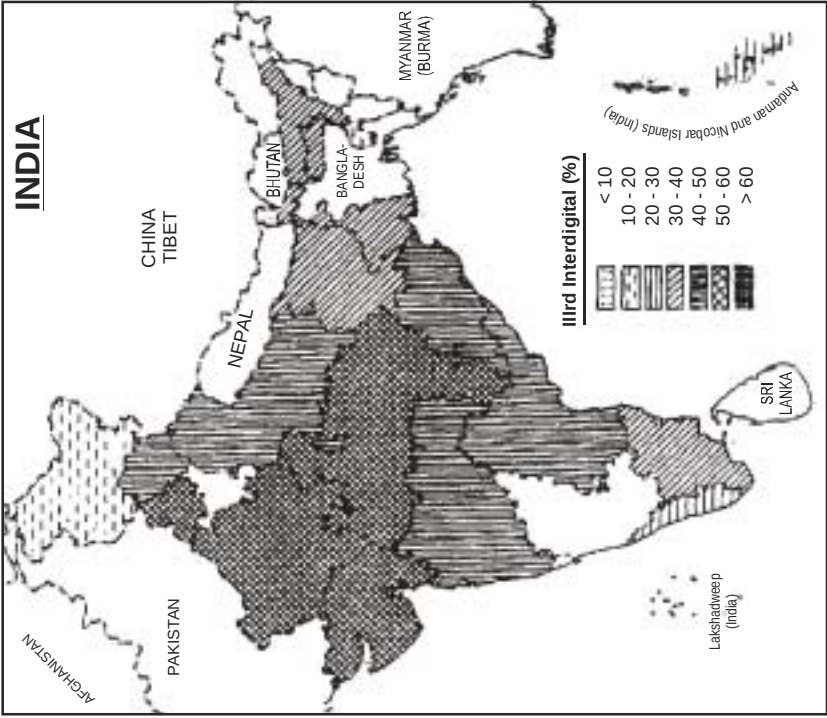


Fig. 12. Frequencies in percentage of patterns on IIIrd interdigital palmar area in different regions of India

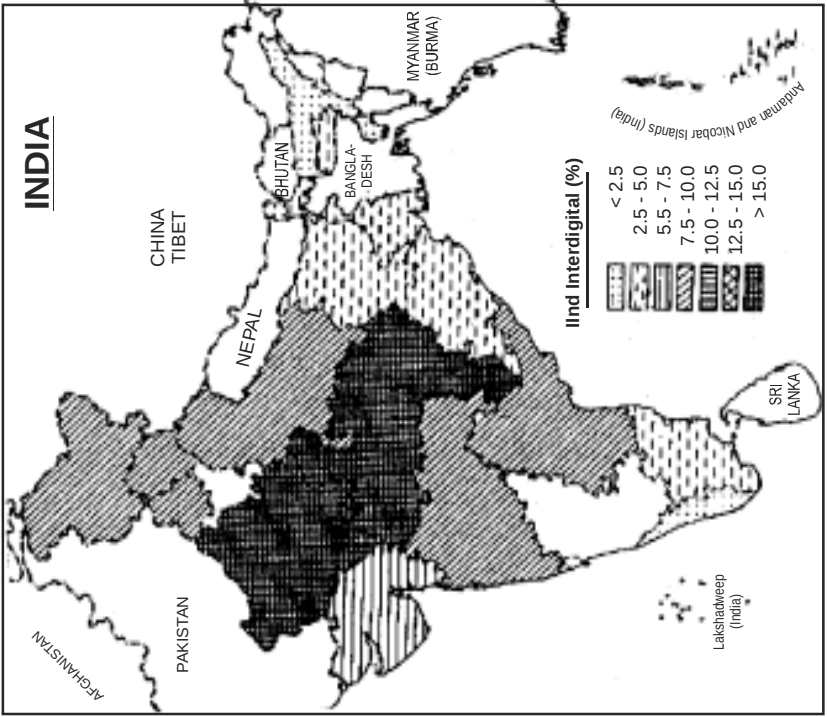


Fig. 11. Frequencies in percentage of patterns on IInd interdigital palmar area in different regions of India

groups, the frequency for the presence of patterns is high in caste (49.1 per cent) and community (46.3 per cent) as compared to scheduled tribe (40.4 per cent) and scheduled caste (39.2 per cent). The frequency of patterns is low in groups with Mongoloid affinities of Tibeto-Chinese languages (24.7 per cent), Munda group of Austro-Asiatic (33.9 per cent) and Southern Dravidian of Dravidian (34.8 per cent) speaking languages (who are mostly tribals) and highest in Indo-European language speakers (49.5 per cent).

5. Fourth Interdigital Area: The frequency for presence of patterns on the fourth interdigital area is 60.7 per cent among Indian populations, which is high as compared to Europeans. The frequency is high among scheduled tribes (61.4 per cent) whereas similar high frequencies are

observed among castes (61.7 per cent) and scheduled castes (61.4 per cent). Lowest frequency is reported among Toda (4 per cent) by Chakravarti (1963). The frequency is quite high in the Himalayan mountain complex region and starts declining gradually towards peninsular region (Bhasin et al. 1994; Bhasin and Walter 2001).

Among all the palmar pattern areas described earlier, the frequency for the presence of patterns is quite low among the populations with Mongoloid affinities from the Himalayan region, whereas in interdigital fourth area, the frequency is quite high as observed from the state of Tripura (75.7 per cent), Meghalaya (75.7 per cent) and Sikkim (79.6 per cent) from Eastern Himalayan region and from Western and Central Himalayan regions also the frequency is high among the populations with Mongoloid affinities.

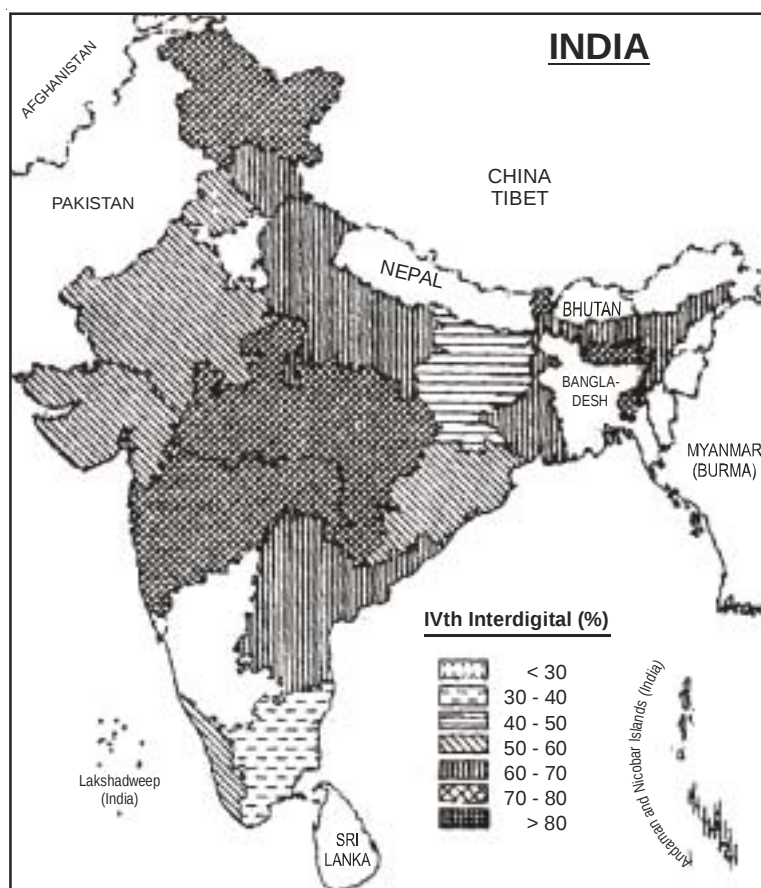


Fig. 13. Frequencies in percentage of patterns on IVth interdigital palmar area in different regions of India

From the states of Madhya Pradesh (Central India) quite high frequency is observed (73.2 per cent) followed by Andhra Pradesh (64.9 per cent), Kerala (53.6 per cent) of South India and Orissa of East India (58.7 per cent) as compared to Tamil Nadu (South India) and Bihar (East India) where frequencies are low (35.8 and 48.4 per cent, respectively), and in these states most of the studies are among scheduled tribes (Table 5, Fig. 13).

The frequency is quite high from the state of Maharashtra (73.3 per cent, Mahar, a scheduled caste - 78.20 per cent) as compared to Gujarat (51.7 per cent) from where among Parsis, Rajputs and Kolis the frequencies are quite low (55.63, 51.90 and 48.00 per cent, respectively). Similar low frequencies are also found from Punjab (52.0 per cent), Delhi (52.1 per cent) and Rajasthan (53.0 per cent). Among Nicobarese, the frequency is 60.1 per cent (Fig. 13). In general the frequency is high in the Himalayan region and low towards South Indian zone.

The speakers of Tibeto-Chinese languages from the Himalayan region (Eastern Himalaya) with Mongoloid affinities show quite high frequency (76.4 per cent) as compared to speakers of other languages—Austro-Asiatic (Munda group - 56.5

per cent), Dravidian (56.0 per cent) and Indo-European (59.4 per cent) families (Bhasin et al. 1994; Bhasin and Walter 2001).

The frequency for the presence of patterns on the fourth interdigital area from India is 60.7 per cent. From various zones, the frequency is observed high from Central (73.2 per cent) followed by East (64.8 per cent), North (63.5 per cent), West (59.0 per cent) and South (56.0 per cent) India. From the Himalayan region, a high frequency is present in Eastern region (75 per cent) as compared to Western and Central (65 per cent) regions. Among the various ethnic groups, the frequencies are almost similar (caste - 61.7; scheduled caste - 60.9; and scheduled tribe - 61.4 per cent) except among community (54.9 per cent). Among the linguistic groups, the highest frequency is observed in populations with Mongoloid affinities who speak Tibeto-Chinese languages (76.4 per cent) and low in Dravidian (56.0 per cent) and Austro-Asiatic (Munda group - 56.5 per cent) language speakers who are mostly tribals (Bhasin et al. 1994; Bhasin and Walter 2001).

In general the pattern of distribution for the presence of patterns in different palmar areas among speakers of various language families is as follows:

Language	Presence of patterns		
	High	Intermediate	Low
Tibeto-Chinese	Fourth Interdigital	—	Hypothenar, Thenar/First Interdigital, Second and Third Interdigitals
Munda group (Austro-Asiatic)	—	Hypothenar, Thenar/First Interdigital, Second and Third Interdigitals	Fourth Interdigital
Dravidian	Hypothenar, Third Interdigital	Thenar/First Interdigital	Fourth Interdigital
Indo-European	Hypothenar, Third Interdigital	Thenar/First Interdigital	Fourth Interdigital

3. GENETIC DISTANCES

Population geneticists have used frequencies of biogenetical traits for studying variation in different human population groups. These studies were based on one or more genetical, dermatoglyphic and somatometric traits. Later on it was realised that the comparison of frequencies of genetical and morphological traits to study variation among the population groups for just one or two traits was not reliable as each trait had a different geographical distribution. Only when a large number of traits are examined together does the genetic relationship among

populations become clear. The present study, we believe, is based on data from the largest number of polygenic traits like dermatoglyphic.

Dendrograms generated on the basis of dermatoglyphic traits on the various Indian populations (after Hiernaux 1965). For analysis, the Indian populations were categorized into various zones (North, West, East, Central and South India), various ethnic groups (caste, scheduled caste, scheduled tribe and community) and four language families (Austro-Asiatic, Tibeto-Chinese, Dravidian and Indo-European) as represented in figures 14 - 16. Further, the dendrograms have been drawn taking together

various zones and ethnic groups (Fig. 17) and language families and ethnic groups (Fig. 18).

For dermatoglyphic traits, maximum studies are reported from East India followed by North India, out of which more than 50 per cent are from the Himalayan Region (Western, Central and Eastern), next comes South India, whereas from West and Central India only a few studies are available (For details see Bhasin et al., 1992). The dendrograms generated on the basis of dermatoglyphic for various Indian populations subdivided by zones (North, West, East, Central and South India) is represented in figure 14. Clustering of various zones based on these distances yields the following picture.

In the dendrogram based on dermatoglyphic distances, it is observed that North, Central and South India form one main cluster while East India clearly separates out from this cluster. Again the Central and South India zones show small distance as mentioned earlier and that this may be due to the maximum number of studies reported among scheduled tribes. North India zone is also showing small distance with these zones and it has been observed that maximum studies reported from this zone are from Western and Central Himalayan Regions, where Mongoloid admixture has been observed among the population groups of inner and middle Himalayas which show somewhat similar pattern of distribution of dermatoglyphic traits as observed among the scheduled tribe groups. Next comes West India, from where almost all the studies are among scheduled tribes. The East India zone is falling apart and it has been observed that about 55 per cent studies are from Eastern Himalayan region and as many studies are from scheduled tribes. It has been found that the distribution of patterns of various dermatoglyphic traits among population groups of East India is quite different from the rest of the zones.

Figure 15 shows dendrograms for various Indian populations based on social ranking.

It is observed that caste group is invariably clustered with the scheduled caste and the community, while the scheduled tribe is distinct from all. An explanation of this phenomenon can be found in the fact that the scheduled castes may have in them a substantial contribution of gene flow from the higher castes in past generations (Majumdar, 1965). Since the communities are grouped on the basis of religion,

occupation etc. they represent a fairly heterogeneous group. The distribution of major ethnic components may be present in the proportions similar to those observed in caste groups as the groups forming the communities in one way or the other are the offshoot of the major Indian ethnic stock (mainly the groups based on *Varna* system of Manu) at different periods of time in Indian history. The scheduled tribes, who represent mainly the Australoid (Pre-Dravidian), or Mongoloid strain, understandably are distinct from all the other groups subdivided by social ranking. Similar findings have also been reported by many other investigators (for example Balakrishnan 1978; Bhasin et al. 1986; Char et al. 1989; Chakraborty et al. 1986; Danker-Hopfe et al. 1988; Mukherjee et al. 1979, 1989; Roychoudhury 1984; Saha et al. 1976; Walter et al. 1993).

The dendrograms for different Indian populations subdivided by language families are presented in figure 16. It is observed that Indian population groups classified by Austro-Asiatic, Dravidian and Indo-European linguistic categories form one major cluster, while those classified by Tibeto-Chinese category stand out from them.

Given the history of Indian populations, it is worthwhile to mention as proposed by Hutton (1981) that Austro-Asiatic speakers represent the earliest inhabitants of the Indian subcontinent and are descendants of two early migrations into South Asia from Central Asia. These Austro-Asiatic speakers were followed by Dravidian speakers. Though currently concentrated in Southern India south of the Godavari river, recent linguistic analyses suggest that Dravidian languages once occupied a much larger area of Western and Southern India. Glottochronology studies (Gardner 1980) indicate that these languages in South Asia date no earlier than 3000 B.C. Linguistic connections between Dravidian languages of South India, Elamite of Iran, and Uralic in Central Asia suggest that the language family was brought to South Asia from the northwest (Fairervis and Southworth 1989; McAlpin 1975, 1981; Tyler 1967).

Indo-European languages are spoken by the vast majority of South Asians and are primarily concentrated in Northern and Western India. They represent a relatively recent introduction from the West, not earlier than the latter half of the second millennium B.C. This date has been established on

Table 6: Correlations with climatic factors and ethnic groups

Ethnic groups	Finger Patterns				Total Finger Ridge-Count	Wilder's Main Line Formulae			
	Whorls	Ulnar Loops	Radial Loops	Total		Arches	11.9.7.-.	9.7.5.-.	7.5.5.-.
Mean Annual Temperature									
Caste	-0.460 ³	0.363 ²	-0.074	0.518 ³	-0.058	0.322 ¹	0.152	-0.269	-0.032
Scheduled Caste	-0.133	0.028	-0.016	0.105	0.114	-0.408	-0.031	0.428	0.162
Scheduled Tribe	-0.197 ¹	0.154	-0.071	0.145	0.313 ³	0.133	-0.241 ¹	-0.319 ²	0.424 ³
Community	-0.375 ²	0.287	-0.061	0.312 ¹	0.214	0.161	-0.287	-0.553 ²	0.558 ²
Total	-0.304 ³	0.220 ³	-0.035	0.282 ³	0.217 ³	0.110	-0.174 ¹	-0.205 ²	0.256 ³
Mean Annual Rainfall									
Caste	0.359 ³	-0.167	0.142	-0.350 ³	-0.067	0.231	0.234	-0.038	-0.368 ²
Scheduled Caste	0.230	0.044	-0.260	-0.128	-0.334 ¹	0.217	0.302	-0.086	-0.291
Scheduled Tribe	0.203 ²	-0.143	-0.156	-0.161 ¹	-0.300 ³	0.198	0.445 ³	0.360 ³	-0.296 ²
Community	0.324 ¹	-0.135	0.052	-0.274 ¹	-0.182	-0.212	0.416 ¹	0.330	-0.484
Total	0.292 ³	-0.148 ¹	-0.135 ¹	-0.254 ³	-0.261 ³	-0.171 ¹	0.385 ³	0.202 ²	-0.352 ³
Mean Annual Humidity									
Caste	-0.194	0.211	-0.107	0.231 ¹	-0.063	0.185	0.256	0.106	-0.284 ¹
Scheduled Caste	0.064	0.137	-0.304	-0.053	-0.073	-0.136	-0.090	0.425	-0.133
Scheduled Tribe	0.183 ¹	-0.117	-0.059	-0.129	-0.330 ³	0.139	0.245 ¹	0.334 ²	-0.243 ¹
Community	0.163	0.052	-0.101	-0.115	-0.229	-0.390 ¹	0.383 ¹	0.546 ²	-0.442 ¹
Total	0.144 ²	-0.031	-0.102	-0.086	0.290 ³	-0.288 ³	0.351 ³	0.442 ³	-0.395 ³
Mean Altitude									
Caste	0.334 ²	-0.347 ²	0.139	-0.395 ³	0.117	-0.290 ¹	0.038	0.170	0.152
Scheduled Caste	0.011	-0.052	0.238	-0.001	0.017	0.486 ¹	0.023	-0.578 ²	-0.110
Scheduled Tribe	0.095	-0.072	0.058	-0.069	-0.152	0.049	0.020	0.186	-0.343 ³
Community	0.231	-0.371 ¹	0.115	-0.176	-0.176	0.014	0.160	0.350	-0.438 ¹
Total	0.227 ³	-0.210 ³	0.052	-0.223 ³	-0.118 ¹	-0.027	0.024	0.066	-0.154 ¹

1. Significant at P<0.05

2. Significant at P<0.01

3. Significant at P<0.001

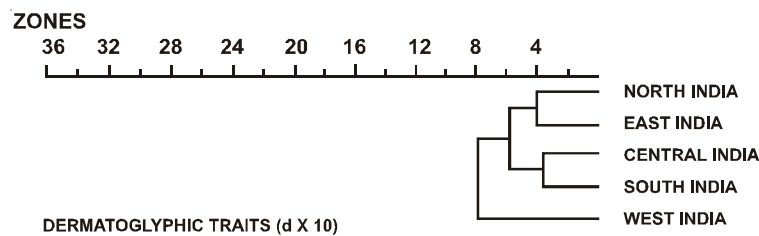


Fig. 14. Dendrograms of dermatoglyphic traits, according to different zones of India

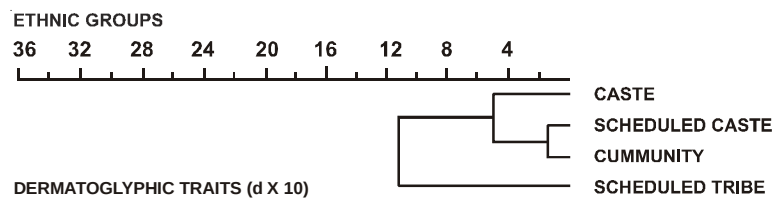


Fig. 15. Dendrograms of dermatoglyphic traits, according to different ethnic groups of India

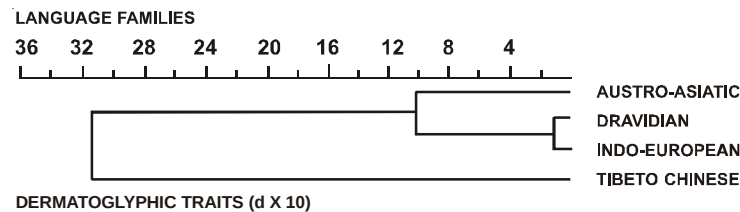


Fig. 16. Dendrograms of dermatoglyphic traits according to different language families of India

the basis of archaeological, linguistico-textual, and glottochronological evidence.

The distribution of language families in the subcontinent suggests that Indian populations are the product of interaction between at least three different population substrates as also suggested by Hutton (1981).

The Tibeto-Chinese languages are spoken by the Indian populations along the northern and northeastern (Himalayan region) periphery of the subcontinent and these populations are the product of differential admixtures between northern Mongoloids and three distinct populations, namely speakers of Austro-Asiatic, Dravidian and Indo-European languages.

As observed, from the dendrogram, the speakers of Tibeto-Chinese languages stand separately from the speakers of rest of the languages. It is reasonable to believe that the

current population of Indian Region is the product of differential admixture of Austro-Asiatic with Dravidian, Dravidian with Indo-Aryan and Tibeto-Chinese with Indo-European and also with Dravidian and Austro-Asiatic.

The dendrograms generated on the basis of dermatoglyphic for Indian population groups subdivided by regions and social ranking is presented in figure 17, from the dendrogram of dermatoglyphics, in general, it is rather difficult to evaluate the position of the ethnic groups according to their social ranks and their distribution into various zones. Rothhammer et al. (1977) reported that even though no significant correlation existed between genetic and dermatoglyphic distances at the two lower levels it was nevertheless found at the tribal and racial levels. From these results they concluded that "polygenic (dermatoglyphic) traits evolve at a

slower rate than monogenic systems, and are thus less susceptible to evolutionary forces, particularly genetic drift". However, in general, it has been observed that the ethnic groups from North India show small distances while scheduled caste of North India are nearer to the scheduled caste of South India. This may be due to contacts with Caucasoid (Dravidians) who came from North-West and moved Southward. With the arrival of the Aryans, and among caste and scheduled caste of East India it has been observed that the non-tribal population of East India, who speak Indo-European languages are closer to the people of Northwestern India (also speakers of Indo-European languages). In turn, it has also been observed that caste groups of East India show small differences with South India community and scheduled tribe, which may be due to variable number of studies reported in the literature from these divisions. Another cluster shows close relationships between different ethnic groups of West India with South India (Caste and Community). On the basis of odontometric analysis also, Hemphill et al. (1992) observed that Maharashtrians bear affinities with South Indian groups. Therefore, the closeness of the West

Indians and the South Indians is not surprising as noted by Malhotra (1984) and Malhotra et al. (1978) and the unique position of Maharashtra as the boundary between Indo-European and Dravidian speaking regions of India results in wide variations in marital patterns and village endogamy. It has been suggested by Hemphill et al. (1992) that this may simply reflect Maharashtra's position as the 'gate way' between Dravidian and Indo-European India. Lastly, the scheduled tribe and community groups of India fall closer to each other.

The dendrogram obtained on the basis of dermatoglyphic distance for population groups classified by language families and social ranking is presented in figure 18. The results clustering of Dravidian speaking people with those of Indo-European speaking people further substantiates the ethnohistory of Indian population that Dravidian has received certain amount of Aryan blood in their veins while Tibeto-Chinese who show Mongoloid affinities are comparatively more distinct. Clustering of groups by their social ranking in a broad sense, confirm traditional social groupings.

The dendrograms based on social ranking and

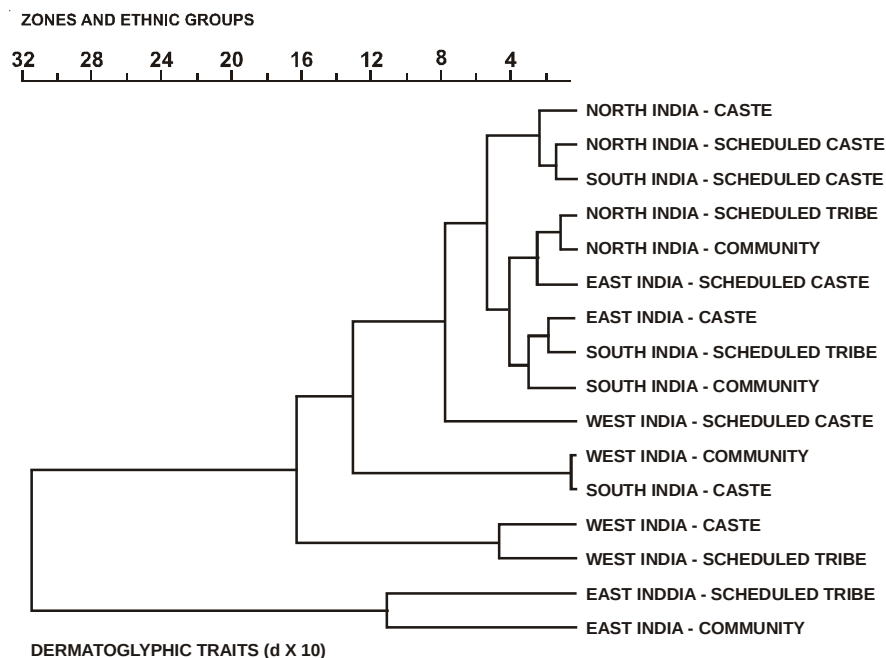


Fig. 17. Dendrogram of dermatoglyphic traits according to different zones and ethnic groups of India

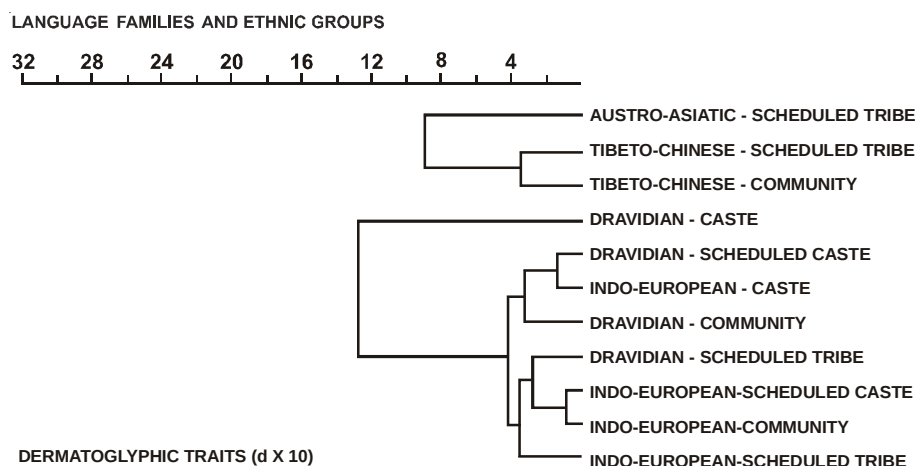


Fig. 18. Dendrogram of dermatoglyphic traits according to different language families and ethnic groups of India

morphological traits show that the scheduled tribes are distant from all the other groups and caste group is invariably clustered with the scheduled caste and the community, which shows that scheduled caste population may have in them a substantial trace of gene flow from upper castes or/and from communities, who are grouped on the basis of religion, occupation, region, etc. Considering now India as a whole, the biological trait distribution is seen to follow a simpler pattern than that might have been expected from the complex history of its people. The scheduled tribe groups stand out as a uniform and unique population, showing less similarity with the neighbouring peoples and certainly much less when compared to the caste groups of India. From the dendrograms based on different linguistic groups, it has been observed that Austro-Asiatic, Dravidian and Indo-European linguistic categories form one cluster and Tibeto-Chinese category stand out separately. It may be concluded that the current population of India is the product of differential admixture between three distinct population entities viz., Austro-Asiatic (Australoid or Pre-Dravidian), Dravidian and Indo-European (Caucasoid) linguistic groups, whereas the Tibeto-Chinese linguistic group along the northeastern and northern peripheries of the subcontinent is the product of admixture between Mongoloids and Australoid and Caucasoid populations in varying degrees.

It may be evaluated from the above discussion that there is distinct genetic diversity of caste

and tribal population groups and the linguistic groups and this is well established as reported by Bhasin et al. (1994), Bhasin and Walter (2001), Cordaux et al. (2004) Bhasin (2006a, b, c, e) among others.

NOTES

1. Three more states have come into existence recently. Now Bihar has been divided into Bihar and *Jharkhand*; from Madhya Pradesh have resulted the states of Madhya Pradesh and *Chattisgarh*; the earlier state of Uttar Pradesh is now divided into Uttar Pradesh and *Uttaranchal*. The states in italics are newer ones. India at present comprises 28 states.
2. The frequency distributions for the State of Goa and Union Territory of Daman and Diu have been listed under Goa, Daman and Diu.

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