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Dermatoglyphic sexual dimorphism: Finger and palmar qualitative characteristics in five endogamous populations of West Bengal, India

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With 22 tables

Summary: Five hundred families from five different endogamous populations encompassing the main social rank in the caste hierarchy of the same geographical area of West Bengal, India, were analyzed to present variation in qualitative pattern types on fingers and palms. Sex dimorphism, homogeneous in all populations, suggests common characteristics of dermatoglyphic patterns. The pattern types are not uniformly distributed on 10 fingers and palmar configurational areas. However, most of these observations are homogeneous in nature, in both sexes among 5 populations. But the two sets of results on fingers and palms are not exactly the same. Palmar dermatoglyphic relationship reflects the better caste affinities, perhaps due to embryological development, having relatively a longer growth period compared to fingers (Cummins 1929). The present findings indicate that the qualitative dermatoglyphic affinities conform to the known ethnohistorical background of these populations, which correspond also to the results of quantitative dermatoglyphics as well as serological and biochemical markers of these populations. These observations indicate that these population groups have a common genetic background and thus traditional grouping of Indian populations on the basis of caste hierarchy may not be a reflection of the genetic origin of the population. In dermatoglyphic affinities, both qualitative and quantitative traits therefore may be quite useful in tracing the ethnohistorical background of these populations.

Key words: Qualitative dermatoglyphics, endogamous groups, West Bengal, India.

Zusammenfassung: Fünfhundert Familien aus fünf verschiedenen endogamen Populationen, die den Hauptrang in der Kastenhierarchie einnehmen und aus derselben geographischen Region von West-Bengalen (Indien) stammen, wurden hinsichtlich der Variabilität der qualitativen Hautleistenmerkmale von Fingern und Handflächen untersucht. Der in allen Populationen homogene Geschlechtsdimorphismus läßt gemeinsame Charakteristika der Hautleistenmuster annehmen. Die Mustertypen sind nicht gleichmäßig auf die 10 Finger und die Handflächenareale verteilt. Allerdings sind die meisten dieser Beobachtungen in beiden Geschlechtern der fünf Populationen gleichartig. Jedoch sind zwei der Merkmalssätze auf den Fingern und Handflächen nicht exakt gleich. Die palmaren Hautleistenmerkmale reflektieren die deutlicheren Beziehungen zur Kastengliederung, was möglicherweise mit der embryonalen Entwicklung zusammenhängt, in welcher die Palmae im Vergleich zu den Fingern eine relativ längere Wachstumsperiode besitzen (Cummins 1929). Die

Ergebnisse zeigen, daß die qualitativen Hautleistenmuster in Übereinstimmung mit dem ethnohistorischen Hintergrund dieser Populationen stehen. Sie entsprechen damit den Ergebnissen der Analyse der quantitativen Hautleistenmerkmale wie auch von serologischen und biochemischen Markern in diesen Populationen. Diese Beobachtungen lassen insgesamt annehmen, daß die untersuchten Populationen einen gemeinsamen genetischen Ursprung haben und daß die traditionelle Gruppierung der indischen Populationen auf der Basis der Kastenhierarchie nicht unbedingt den genetischen Ursprung dieser Populationen reflektieren muß. Bezüglich der Hautleistenmuster ergibt sich, daß sowohl die qualitativen als auch die quantitativen Merkmale bezüglich der Erforschung der Herkunftsgeschichte dieser Populationen bedeutsam sind.

Schlüsselwörter: Qualitative Hautleistenmerkmale, endogame Bevölkerungsgruppen, West-Bengalen, Indien.

Introduction

In continuation of our preceding studies (Karmakar et al. 2000 a,b) on quantitative dermatoglyphics in five different endogamous populations of West Bengal, we present herein the data on the main qualitative dermatoglyphic characteristics of the same population groups.

The use of dermatoglyphic traits as a tool of unique value for human genetics has been suggested by several studies due to it's special biological characteristics: genetically determined (Pons 1964, Holt 1968, Loesch 1971, Chakraborty & Malhotra 1981, Gilligan et al. 1985); phylogenetically stable (Newman 1960, Rothhammer 1977, Froehlich & Giles 1981); biogenetically determined rather than by the physical environment (Singh 1982); evolutionarily conservative (Sachs & Bat-Miriam 1957); thus dermatoglyphics are "highly advantageous population markers" (Froehlich & Giles 1981) in the evaluation of interpopulational distances (Micle & Kobyliansky 1985); and dermatoglyphic affinities conform to the known ethno-historical and geographical background (Sachs & Bat-Miriam 1957, Karmakar et al. 1989, Kamali & Mavalwala 1990, Arrieta et al. 1991, Reddy & Reddy 1992, Crawford & Duggirala 1992, Sanna & Floris 1995, Sanna et al. 1998, Floris et al. 1998). There is wide agreement that the heredity of most dermatoglyphic features conforms to a polygenic system with individual genes contributing a small additive effect and which are frequently used to characterize populations in anthropological research (Rife 1953, Newman 1960). According to Newman (1960) "since dermatoglyphic traits are polygenically controlled, putatively non-adaptive, and undergo no postnatal modifications they have distinct methodological advantages over either anthropometry or serology in clarifying the older and more basic relationships between human populations". Furthermore, Rudan et al. (1983) states that "these traits are less influenced by current evolutionary factors and migratory processes and thus distances estimated from the dermatoglyphic data are the last estimate of the differences that did or did not exist in the ancestral population". In general, the finger and palmar dermatoglyphics have shown a great deal of variations in the frequencies of various pattern types in different population groups (see among others, Rife 1953, Newman 1960, Cummins & Midlo 1961, Sarkar 1967, 1969, 1972, 1976, Singh 1978, Malhotra 1979, Ghosh 1982, 1985, Arrieta et al. 1990, 1991). There is a wide use of dermatoglyphic

traits also in medical genetics because certain karyotype anomalies are related with the frequency of different patterns, as well as with their distribution on different fingers and with the values of their ridge counts (Cummins & Midlo 1961, Schauman & Alter 1976). It is also known that dermatoglyphic sexual dimorphism differs in diverse populations (Cummins & Midlo 1961, Schwidetzky & Jantz 1979). Our simultaneous observations have revealed sex differences for some traits of quantitative dermatoglyphics among these populations, which compels us to examine further, the same information on qualitative traits. Moreover, these populations are also characterized by showing a high degree of similarities, concerning their dermatoglyphic traits, as well as their biochemical and serological markers, which fully correspond to their ethno-historical backgrounds (Mukherjee et al. 1974, 1987. Chakraborty et al. 1982, 1986, 1987, Chakraborty 1987, Karmakar et al. 2000 a,b). The objective of the present study is to provide information on (1) finger and palmar patterns; (2) symmetry of pattern types on homologous fingers; (3) sexual dimorphism; (4) relationship with the earlier suggestion of genetical influence on them i.e., ethno-historical relationship; (5) relationship between the results of qualitative and quantitative traits; and (6) finally a comparative observation with the earlier results of biochemical and serological markers of these populations.

Material and methods

A detailed description of the sample based on ethnohistorical background, biochemical and serological markers, methods of dermatoglyphic print collection and print analysis, were described in our earlier paper (Karmakar et al. 2000a). Herein, we provide only the information directly related to the aim of the present study and for convenience, the names of populations, their abbreviations and population-wise sample sizes are presented in Table 1.

Results

Digital pattern types

The percentage distribution of finger pattern types namely arches (A), radial loop (R), ulnar loop (U) and whorl (W), as well as their distribution on individual fingers are presented in Tables 2–6. Among the five populations, the highest frequency for *arches* is on the IInd finger: 13.9 % in BR for both sexes on the left hand; on the right: 11.3 % males in BR; 11.3 % females in BR and LO. The highest frequency of *radial loops* is on finger II, on the left hand: 9.7% males in BR, 10.3% females in LO and the right hand: 12.6 % males in LO, 6.7 % females in LO. In both sexes radial loops are relatively very rare on the remaining fingers or even absent. *Ulnar loops* occur at a highest frequency on digit V, left hand: 85.2 % males in BR, 79.0 % females in LO; on the right hand: 79.6 % males in LO, 82.1 % females in MA. *Whorls* appear with the highest frequency on digit V, left hand: 50.4 % males in PA, 48.3 % females in MU; on the right hand: 63.4 % males in PA, 51.0 % females in MU. For combined 5 fingers, the highest frequency of *arches*

Table 1. Sample description.

Population	Abbreviation	No. of family	No. of individual
Brahmin (Rarhi)	BR	100	449
Mahisys	MA	100	504
Padmaraj	PA	100	525
Muslim (Sunni)	MU	100	555
Lodha	LO	100	402
Total		500	2435

Table 2. Frequency in % of finger pattern types, by sex and hand. *Brahmin.* A = arches; R = radial loop; U = ulnar loop; W = whorls.

Pattern	Left fingers					Left	Right fingers					Right	Both
Type	I	II	III	IV	V	hand	I	II	III	IV	V	hand	hands
						Males							
A	3.0	13.9	4.8	2.2	2.2	5.2	0.4	11.3	4.8	1.7	2.2	4.1	4.7
R	–	7.8	–	–	–	1.6	–	11.7	0.9	1.3	–	2.8	2.2
U	60.0	43.0	67.0	50.0	85.2	61.0	52.2	43.9	73.0	35.7	77.4	56.4	58.7
W	37.0	35.2	28.3	47.8	12.6	32.2	47.4	33.0	21.3	61.3	20.4	36.7	34.4
						Females							
A	7.4	13.9	7.9	4.2	4.2	7.5	4.2	11.1	3.7	1.9	2.8	4.7	5.6
R	0.5	9.7	1.4	0.5	0.5	2.5	–	6.0	–	–	0.9	1.4	1.8
U	56.0	44.0	65.3	50.9	78.2	58.9	61.6	51.9	78.7	49.5	80.6	64.4	62.6
W	36.1	32.4	25.5	44.4	17.1	31.1	34.3	31.0	17.6	48.6	15.7	29.4	30.0

Table 3. Frequency in % of finger pattern types, by sex and hand. *Mahisys.*

Pattern	Left fingers					Left	Right fingers					Right	Both
Type	I	II	III	IV	V	hand	I	II	III	IV	V	hand	hands
						Males							
A	3.0	13.9	4.8	2.2	2.2	5.2	0.4	11.3	4.8	1.7	2.2	4.1	4.7
A	2.7	13.0	4.6	1.9	1.9	4.8	0.4	10.0	4.2	1.5	1.9	3.6	4.2
R	–	6.9	–	–	–	1.4	–	11.5	0.8	1.1	–	2.7	2.0
U	57.1	42.1	66.7	47.9	83.1	59.4	49.0	42.5	72.4	33.7	76.2	54.8	57.1
W	40.2	37.9	28.7	50.2	14.9	34.4	50.6	36.0	22.6	63.6	21.8	38.9	36.7
						Females							
A	7.1	13.8	7.9	3.8	3.8	7.3	3.8	10.8	4.2	1.7	2.5	4.6	5.5
R	0.4	9.6	1.3	0.4	0.4	2.4	–	5.4	–	0.4	0.8	1.3	1.7
U	55.4	42.1	65.0	49.6	79.2	58.3	61.3	52.1	77.1	47.5	82.1	64.0	62.1
W	37.1	34.6	25.8	46.3	16.7	32.1	35.0	31.7	18.8	50.4	14.6	30.1	30.8

Table 4. Frequency in % of finger pattern types, by sex and hand. *Padmaraj.*

Pattern	Left fingers					Left	Right fingers					Right	Both
Type	I	II	III	IV	V	hand	I	II	III	IV	V	hand	hands
						Males							
A	2.5	12.3	4.7	1.8	1.8	4.6	0.4	9.4	4.3	1.4	1.8	3.5	4.1
R	–	7.6	0.4	–	–	1.6	–	11.2	0.7	1.1	–	2.6	2.1
U	55.4	42.0	65.6	47.8	82.2	58.6	48.6	42.8	72.5	34.1	76.4	54.9	56.7
W	42.0	38.0	29.3	50.4	15.9	35.1	51.1	36.6	22.5	63.4	21.7	39.1	37.1
						Females							
A	6.8	14.1	8.0	4.0	3.6	7.3	4.0	11.2	4.4	1.6	2.4	4.7	5.6
R	0.4	10.0	1.2	0.4	0.4	2.5	–	5.2	–	0.4	0.8	1.3	1.7
U	55.0	41.0	64.3	48.2	78.7	57.4	60.2	51.4	77.5	47.4	81.9	63.7	61.6
W	37.8	34.9	26.5	47.4	17.3	32.8	35.7	32.1	18.1	50.6	14.9	30.3	31.1

Table 5. Frequency in % of finger pattern types, by sex and hand. *Muslim.*

Pattern	Left fingers					Left	Right fingers					Right	Both
Type	I	II	III	IV	V	hand	I	II	III	IV	V	hand	hands
						Males							
A	2.4	12.7	6.2	2.1	1.7	5.0	0.7	10.3	5.1	1.7	1.7	3.9	4.5
R	0.0	9.6	0.7	0.0	0.0	2.1	0.0	10.6	0.7	1.0	0.0	2.5	2.3
U	56.8	40.8	65.4	48.3	82.9	58.8	50.0	42.1	72.9	35.6	76.7	55.5	57.2
W	40.8	37.0	27.7	49.7	15.4	34.1	49.3	37.0	21.2	61.6	21.6	38.2	36.1
						Females							
A	6.5	13.7	8.0	3.8	3.4	7.1	3.8	10.6	4.6	1.5	2.3	4.6	5.4
R	0.4	9.9	1.1	0.8	0.4	2.5	0.0	4.9	0.0	0.4	0.8	1.2	1.6
U	55.9	41.1	64.6	47.1	79.8	57.7	61.2	51.7	77.2	47.1	81.7	63.8	61.8
W	37.3	35.4	26.2	48.3	16.3	32.7	35.0	32.7	18.3	51.0	15.2	30.4	31.2

Table 6. Frequency in % of finger pattern types, by sex and hand. Lodha.

Pattern	Left fingers					Left	Right fingers					Right	Both
Type	I	II	III	IV	V	hand	I	II	III	IV	V	hand	hands
						Males							
A	3.4	14.6	5.3	2.4	2.4	5.6	0.5	11.2	4.9	1.9	2.4	4.2	4.9
R	–	7.8	–	–	–	1.6	–	12.6	1.0	1.5	–	3.0	2.3
U	60.2	43.2	68.9	51.9	85.4	61.9	52.9	43.7	74.8	38.3	79.6	57.9	59.9
W	36.4	34.5	25.7	45.6	12.1	30.9	46.6	32.5	19.4	58.3	18.0	35.0	32.9
						Females							
A	6.7	12.8	8.2	4.1	4.6	7.3	4.1	11.3	3.6	1.5	3.1	4.7	5.6
R	0.5	10.3	1.5	0.5	0.5	2.7	–	6.7	–	–	1.0	1.5	1.9
U	57.4	45.6	65.6	50.8	79.0	59.7	61.0	51.3	79.0	49.7	81.0	64.4	62.8
W	35.4	31.3	24.6	44.6	15.9	30.4	34.9	30.8	17.4	48.7	14.9	29.3	29.7

occurs on the left hand: 5.6 % males in LO, 7.5 % females in BR; on the right: 4.2 % males in LO, 4.7% females in LO, PA and BR; for pattern *loop radial*, on the left: 2.1% (MU) in males, 2.7% (LO) in females; on the right: 3.0% males (LO); 1.5% females (LO); for pattern *ulnar loops* on the left: 61.9% males (LO), 59.7% females (LO) on the right: 57.9% males in LO, 64.4% females in LO and BR; for pattern *whorls*, left hand: 35.1% males in PA, 32.8% females in PA; on the right: 39.1% males in PA, 30.4% females in MU. The population trend is found when considering pattern types frequencies of 10 digits as the arch: males 4.9% (LO), females 5.6% (BR, PA, LO); loop radial: 2.3% males (LO, MU); 1.9% females (LO); loop ulnar: 59.9% males (LO), 62.8% females (LO); whorls: 37.1% males (PA), 31.2% females (MU), respectively. A digit-wise comparison concerning the highest frequency of principal pattern types among the 5 populations presents a kind of order in which the frequency decreases from finger to finger. In the case of the most frequent pattern ulnar loops (U) is on the left: V>III > I > IV > II, in both sexes; and on the right is slightly different: V > III > I > II > IV, the same in both sexes. For the whorls (W) the order is IV > I > II > III > V, the same for each hand in both sexes. Pattern arches (A) on the left is II > III > I > V > IV, the same in both sexes, while on the right somewhat different between males: II > III > V > IV > I and females: II > III > V > I > IV. The order of population groups with regard to different pattern types for both the hands considered (10 fingers) together is as follows: Arch: Male LO > BR > MU > MA > PA; Female LO = BR = PA > MA > MU; Ulnar Loop: Male LO > BR > PA > MU > MA; Female LO > BR > MA > MU > PA. Whorl: Male PA > MA > MU > BR > LO; Female MU > PA > MA > BR > LO.

Pattern combinations

Pattern combinations between homologous fingers are presented in Tables 7–11. The most common combination of patterns is U-U followed by W-W/U-W/A-A/A-U in both sexes among all populations. The remaining combinations are relatively rare or even absent. The greater frequency for the combination U-U is pronounced on the digital pair V-V, for W-W on IV-IV, for A-A on II-II and U-W on IV-IV (somewhat different in females for BR and LO on II-II) in all populations and both sexes. Among the 5 population groups the greatest frequency for U-U in males are among LO (79.0%) and in females among MA (80.6%); for W-W in males among PA (47.5%) and in females among MU (44.6%); for U-W in males and females among LO (21.1%) and (12.4%); and for A-A in males among LO (9.9%) and in females PA (11.1%), respectively.

The pattern type frequency of individuals with monomorphic hands, i.e., bearing the same pattern on all ten fingers are given in Tables 12–16. The majority of the individuals possess the highest frequency of combination U-W in both sexes among all populations: BR (M = 57.0%, F = 53.7%), MA (M = 59.4%, F = 55.0%), PA (M = 59.4%, F = 55.0%), MU (M = 59.9%, F = 55.9%) and LO (M = 56.8%, F = 54.4%), respectively. Out of all the possible combinations (total 15), 6 are absent in each population group.

Table 7. Pattern combinations (in %) on the pairs of right and left homologous fingers. *Brahmin.*

Pairs of fingers	Pattern combination									
	A-A	R-R	U-U	W-W	A-R	A-U	A-W	R-U	R-W	U-W
					Males					
I-I	–	–	47.9	33.6	–	0.5	0.9	–	–	17.1
II-II	9.8	4.9	36.1	30.1	0.5	3.8	–	3.3	0.5	10.9
III-III	3.0	–	68.7	19.2	–	2.5	–	1.0	–	5.6
IV-IV	1.4	–	31.8	44.4	–	0.5	0.5	0.5	–	21.0
V-V	0.9	–	76.8	11.2	–	1.3	0.4	–	–	9.4
Total	2.8	0.9	52.7	27.6	0.1	1.7	0.4	0.9	0.1	12.9
					Females					
I-I	3.3	–	54.1	29.8	–	1.7	–	–	–	11.0
II-II	10.2	4.2	40.7	26.9	0.6	2.4	–	1.8	1.2	12.0
III-III	2.8	–	74.4	17.0	–	1.1	–	–	–	4.5
IV-IV	1.5	–	44.6	41.0	–	–	0.5	–	0.5	11.8
V-V	1.5	–	78.9	11.3	–	1.5	–	0.5	–	6.2
Total	3.7	0.8	58.8	25.3	0.1	1.3	0.1	0.4	0.3	9.1

Table 8. Pattern combinations (in %) on the pairs of right and left homologous fingers. *Mahisys.*

Pairs of fingers	Pattern combination									
	A-A	R-R	U-U	W-W	A-R	A-U	A-W	R-U	R-W	U-W
					Males					
I-I	–	–	44.6	37.1	–	0.4	0.8	–	–	17.1
II-II	8.6	4.3	35.4	33.0	0.5	3.3	0.5	2.9	0.5	11.0
III-III	2.7	–	68.1	20.4	–	2.2	–	0.9	–	5.8
IV-IV	1.2	–	29.9	47.1	–	0.4	0.4	0.4	–	20.5
V-V	0.8	–	75.5	13.0	–	1.2	0.4	–	–	9.1
Total	2.5	0.8	51.1	30.0	0.1	1.5	0.4	0.8	0.1	12.8
					Females					
I-I	3.0	–	53.7	30.3	–	1.5	0.5	–	–	10.9
II-II	10.4	3.8	39.9	29.0	0.5	2.2	–	1.6	1.1	11.5
III-III	3.0	–	72.6	17.8	–	1.5	–	–	–	5.1
IV-IV	1.4	–	42.1	42.6	–	–	0.5	0.5	0.5	12.5
V-V	1.4	–	80.6	10.6	–	1.4	–	0.5	–	5.6
Total	3.7	0.7	58.1	26.1	0.1	1.3	0.2	0.5	0.3	9.1

Table 9. Pattern combinations (in %) on the pairs of right and left homologous fingers. *Padmaraj.*

Pairs of fingers	Pattern combination									
	A-A	R-R	U-U	W-W	A-R	A-U	A-W	R-U	R-W	U-W
					Males					
I-I	–	–	43.7	38.5	–	0.4	0.8	–	–	16.7
II-II	8.1	4.1	35.3	33.5	0.5	3.2	0.5	3.2	0.9	10.9
III-III	3.0	–	67.9	20.7	–	2.1	–	0.8	–	5.5
IV-IV	1.2	–	30.5	47.5	–	0.4	0.4	0.4	–	19.7
V-V	0.8	–	75.5	13.2	–	1.1	0.4	–	–	9.1
Total	2.4	0.7	50.9	30.6	0.1	1.4	0.4	0.8	0.2	12.5
					Females					
I-I	2.9	–	52.9	31.4	–	1.9	0.5	–	–	10.5
II-II	11.1	3.7	38.6	29.6	0.5	2.1	–	1.6	1.1	11.6
III-III	3.5	–	72.8	17.3	–	1.5	–	–	–	5.0
IV-IV	1.4	–	41.4	43.7	–	–	0.5	0.5	0.5	12.2
V-V	1.3	–	80.3	10.8	–	1.3	–	0.4	–	5.8
Total	3.8	0.7	57.6	26.6	0.1	1.3	0.2	0.5	0.3	9.0

Table 10. Pattern combinations (in %) on the pairs of right and left homologous fingers. *Muslim.*

Pairs of fingers	Pattern combination									
	A-A	R-R	U-U	W-W	A-R	A-U	A-W	R-U	R-W	U-W
					Males					
I-I	–	–	45.5	37.3	–	0.7	0.7	–	–	15.7
II-II	9.0	3.8	34.2	32.9	0.9	3.0	0.4	3.0	2.1	10.7
III-III	4.0	–	68.4	19.6	–	2.0	–	0.8	–	5.2
IV-IV	1.1	–	31.6	46.7	–	0.7	0.4	0.4	–	19.1
V-V	0.7	–	75.8	12.8	–	1.1	0.4	–	–	9.3
Total	2.8	0.7	51.5	29.8	0.2	1.5	0.4	0.8	0.4	12.1
					Females					
I-I	2.7	–	54.1	30.6	–	1.8	0.5	–	–	10.4
II-II	10.5	3.5	39.0	30.5	0.5	2.0	–	1.5	1.0	11.5
III-III	3.7	–	72.7	17.6	–	1.4	–	–	–	4.6
IV-IV	1.3	–	40.8	44.6	–	–	0.4	0.4	0.4	12.0
V-V	1.3	–	80.2	10.1	–	1.3	–	0.4	–	6.8
Total	3.7	0.5	57.8	26.6	0.1	1.3	0.2	0.5	0.3	9.0

Table 11. Pattern combinations (in %) on the pairs of right and left homologous fingers. *Lodha.*

Pairs of fingers	Pattern combination									
	A-A	R-R	U-U	W-W	A-R	A-U	A-W	R-U	R-W	U-W
					Males					
I-I	–	–	45.5	37.3	–	0.7	0.7	–	–	15.7
I-I	–	–	48.4	33.0	–	0.5	1.1	–	–	17.0
II-II	9.9	4.9	35.8	29.0	0.6	3.7	–	3.7	0.6	11.7
III-III	3.4	–	70.8	16.9	–	2.2	–	1.1	–	5.6
IV-IV	1.6	–	34.2	41.6	–	0.5	0.5	0.5	–	21.1
V-V	1.0	–	79.0	10.5	–	1.5	0.5	–	–	7.5
Total	2.9	0.9	54.2	26.0	0.1	1.6	0.4	1.0	0.1	12.6
					Females					
I-I	3.0	–	54.5	29.9	–	1.8	–	–	–	10.8
II-II	9.8	4.6	41.2	25.5	0.7	2.6	–	2.0	1.3	12.4
III-III	2.5	–	74.7	16.5	–	1.3	–	–	–	5.1
IV-IV	1.1	–	44.6	41.1	–	–	0.6	–	0.6	12.0
V-V	1.7	–	79.4	10.3	–	1.7	–	0.6	–	6.3
Total	3.5	0.8	59.1	24.8	0.1	1.4	0.1	0.5	0.4	9.3

Table 12. Frequency of pattern type combinations on the ten fingers; males and females. *Brahmin.*

Pattern	Males		Females	
	N.	%	N.	%
A only	–	–	–	–
R only	–	–	–	–
U only	12	5.2	16	7.4
W only	6	2.6	5	2.3
A + R	–	–	–	–
A + U	16	7.0	28	13.0
A + W	–	–	–	–
R + U	9	3.9	8	3.7
R + W	–	–	–	–
U + W	131	57.0	116	53.7
A + R + U	5	2.2	5	2.3
A + R + W	–	–	–	–
A + U + W	27	11.7	16	7.4
R+U+ W	23	10.0	14	6.5
A + R + U + W	1	0.4	8	3.7
Total	230	100.0	216	100.0

Table 13. Frequency of pattern type combinations on the ten fingers: males and females. *Mahisys.*

Pattern	Males		Females	
	N.	%	N.	%
A only	–	–	–	–
R only	–	–	–	–
U only	14	5.4	17	7.1
W only	7	2.7	6	2.5
A + R	–	–	–	–
A + U	16	6.1	29	12.1
A + W	–	–	–	–
R + U	9	3.4	9	3.8
R + W	–	–	–	–
U + W	155	59.4	132	55.0
A + R + U	5	1.9	5	2.1
A + R + W	–	–	–	–
A + U + W	28	10.7	18	7.5
R+U+ W	25	9.6	15	6.3
A + R + U + W	2	0.8	9	3.8
Total	261	100.0	240	100.0

Table 14. Frequency of pattern type combinations on the ten fingers; males and females. *Padmaraj.*

Pattern	Males		Females	
	N.	%	N.	%
A only	–	–	–	–
R only	–	–	–	–
U only	15	5.4	17	6.8
W only	8	2.9	6	2.4
A + R	–	–	–	–
A + U	16	5.8	30	12.0
A + W	–	–	–	–
R + U	10	3.6	9	3.6
R + W	–	–	–	–
U + W	164	59.4	137	55.0
A + R + U	5	1.8	5	2.0
A + R + W	–	–	–	–
A + U + W	28	10.1	19	7.6
R+U+ W	27	9.8	17	6.8
A + R + U + W	3	1.1	9	3.6
Total	276	100.0	249	100.0

Table 15. Frequency of pattern type combinations on the ten fingers; males and females. *Muslim.*

Pattern	Males		Females	
	N.	%	N.	%
A only	–	–	–	–
R only	–	–	–	–
U only	15	5.1	18	6.8
W only	8	2.7	6	2.3
A + R	–	–	–	–
A + U	20	6.8	30	11.4
A + W	–	–	–	–
R + U	12	4.1	11	4.2
R + W	–	–	–	–
U + W	169	57.9	147	55.9
A + R + U	7	2.4	5	1.9
A + R + W	–	–	–	–
A + U + W	28	9.6	20	7.6
R+U+ W	29	9.9	17	6.5
A + R + U + W	4	1.4	9	3.4
Total	292	100.0	263	100.0

Table 16. Frequency of pattern type combinations on the ten fingers; males and females. *Lodha.*

Pattern	Males		Females	
	N.	%	N.	%
A only	–	–	–	–
R only	–	–	–	–
U only	10	4.9	13	6.7
W only	4	1.9	4	2.1
A + R	–	–	–	–
A + U	16	7.8	25	12.8
A + W	–	–	–	–
R + U	9	4.4	8	4.1
R + W	–	–	–	–
U + W	117	56.8	106	54.4
A + R + U	5	2.4	5	2.6
A + R + W	–	–	–	–
A + U + W	23	11.2	13	6.7
R +U+ W	21	10.2	13	6.7
A + R + U + W	1	0.5	8	4.1
Total	206	100.0	195	100.0

Palmar patterns

The percent incidence of *palmar patterns* in terms of pattern, present and absent in five configurational areas are shown in Tables 17–21. The order of magnitude of occurrence of true patterns among five populations on combined hands is IV > III > Hyp > II > Th in males and IV > Hyp > III > II > Th in females. With respect to sexual variation, the patterns are more frequent in Hyp and IV areas in females than in males, while in the other areas males dominate over the females. This trend is found in all populations in the case of R+L hands, while on the other hand, considering the right and left side separately, the incidence of patterns is higher in males than in females except the Hyp area. In general, bilateral differences are more pronounced on the right palm than on the left except the II interdigital area. These characteristics are true for all five populations. The overall incidences of palmar patterns among five population groups are reflected as homogeneous in nature. Although non-significant heterogeneity among the groups is observed – the palmar and digital – the two sets of results are not exactly the same; palmar dermatoglyphic relationships reflect the better caste affiliations.

Sex comparisons were set out in Table 22. Pattern frequencies between sexes show some variations, however, finger patterns on the right hand for all digits except III among 4 groups are significantly different; LO is homogeneous; finger pattern combination shows homogeneity except only PA for I-I combination; palmar pattern on IV interdigital areas are significantly different in all 5 populations; the remaining variables do not differ significantly, and overall 5 castes comparisons show homogeneity of dermatoglyphic sexual dimorphism for all variables.

Discussion

From the above presentation it appears that there is some variation in the distribution of pattern types on all fingers and palmar configurational areas between males and females; between the right and left sides. However, most of these observations show similarities in five population groups in spite of scattering of the digital and palmar configurational variabilities. The interpretation of these characteristics or apparent association or relatedness may be discussed in the light of (i) embryological or developmental consideration of dermatoglyphic traits, and (ii) ethno-historical background of the populations.

High frequencies of ulnar loops and whorls, and low frequencies of arches and radial loops which are not uniformly distributed on 10 fingers, appear in both sexes in all 5 populations, and are in accordance with earlier observations (Singh 1961, Rife 1964, 1972, Roberts et al. 1972, 1976, Newman 1974, Plato et al. 1975, Arrieta & Lostao 1988, Arrieta et al. 1989, 1990, 1991, Crawford & Duggirala 1992, Dittmar 1994, Daniela et al. 1995). According to Holt (1968) "certain patterns tend to occur more frequently on some digits than on others", which seems to be constant for any population. Qualitative dermatoglyphic traits is a complex outcome of a developmental process in which individual digits of the same genetic fields, but at different locations occur, as has also been suggested by earlier studies

Table 17. Percent distribution of palmar patterns in males (M) and females (F). *Brahmin.*

	Thenar		Hypothenar		Interdigital II		Interdigital III		Interdigital IV	
	M	F	M	F	M	F	M	F	M	F
On both palms:										
Absent	94.3	96.8	50.4	43.5	92.1	94.4	37.4	47.2	28.7	23.1
Present	0.9	0.5	27.8	29.2	2.6	0.5	29.6	25.5	40.0	54.6
Same pattern	0.4	0.5	19.1	23.1	2.6	0.5	29.6	25.0	37.8	50.9
Different pattern	0.4	–	8.7	6.0	–	–	–	0.5	2.2	3.7
Bilateral symmetry	94.8	97.2	69.6	66.7	94.8	94.9	67.0	72.2	66.5	74.1
Pattern only on:										
Left palm	3.9	2.8	12.2	13.4	0.9	0.9	5.7	3.7	24.8	16.2
Right palm	0.9	–	9.6	13.9	4.4	4.2	27.4	23.6	6.5	6.0

Table 18. Percent distribution of palmar patterns in males (M) and females (F). *Mahisys.*

	Thenar		Hypothenar		Interdigital II		Interdigital III		Interdigital IV	
	M	F	M	F	M	F	M	F	M	F
On both palms:										
Absent	95.0	97.1	48.7	44.6	91.9	94.1	36.4	45.4	27.2	22.9
Present	0.8	0.4	28.0	29.2	2.3	0.8	29.5	27.1	41.0	54.2
Same pattern	0.4	0.4	18.8	22.9	2.3	0.8	29.5	26.7	37.5	50.0
Different pattern	0.4	–	9.2	6.3	–	–	–	0.4	3.4	4.2
Bilateral symmetry	95.4	97.5	67.4	67.5	94.2	95.0	65.9	72.1	64.8	72.9
Pattern only on:										
Left palm	3.4	2.5	13.4	13.8	1.5	0.8	5.4	4.2	24.5	16.7
Right palm	0.8	–	10.0	12.5	4.2	4.2	28.7	23.3	7.3	6.3

Table 19. Percent distribution of palmar patterns in males (M) and females (F). *Padmaraj.*

	Thenar		Hypothenar		Interdigital II		Interdigital III		Interdigital IV	
	M	F	M	F	M	F	M	F	M	F
On both palms:										
Absent	94.6	97.2	48.9	45.0	91.6	93.5	36.6	44.6	27.5	24.1
Present	1.4	0.4	28.3	29.7	2.2	1.2	29.7	28.1	41.3	53.0
Same pattern	1.1	0.4	19.6	23.7	2.2	1.2	29.7	27.7	38.0	49.0
Different pattern	0.4	–	8.7	6.0	–	–	–	0.4	3.3	4.0
Bilateral symmetry	95.7	97.6	68.5	68.7	93.8	94.8	66.3	72.3	65.6	73.1
Pattern only on:										
Left palm	3.3	2.4	13.0	13.3	1.5	0.8	5.1	4.0	23.6	16.5
Right palm	0.7	–	9.8	12.0	4.7	4.4	28.6	23.3	7.6	6.4

Table 20. Percent distribution of palmar patterns in males (M) and females (F). *Muslim.*

	Thenar		Hypothenar		Interdigital II		Interdigital III		Interdigital IV	
	M	F	M	F	M	F	M	F	M	F
On both palms:										
Absent	94.2	97.3	48.6	46.0	92.1	93.9	36.3	45.2	27.4	23.6
Present	1.4	0.4	28.4	29.3	2.1	1.1	29.1	27.8	41.1	53.6
Same pattern	1.0	0.4	20.2	23.6	2.1	1.1	29.1	27.4	38.0	49.8
Different pattern	0.3	–	8.2	5.7	–	–	–	0.4	3.1	3.8
Bilateral symmetry	95.2	97.7	68.8	69.6	94.2	95.0	65.4	72.6	65.4	73.4
Pattern only on:										
Left palm	3.8	2.3	13.4	12.9	1.4	0.8	5.1	4.9	24.0	16.3
Right palm	0.7	–	9.6	11.8	4.5	4.2	29.5	22.1	7.5	6.5

Table 21. Percent distribution of palmar patterns in males (M) and females (F). *Lodha.*

	Thenar		Hypothenar		Interdigital II		Interdigital III		Interdigital IV	
	M	F	M	F	M	F	M	F	M	F
On both palms:										
Absent	94.7	96.9	49.0	46.2	92.7	93.8	38.3	46.7	27.2	23.6
Present	1.0	0.5	28.6	29.2	2.9	0.5	28.2	26.2	41.3	53.8
Same pattern	0.5	0.5	19.9	23.1	2.9	0.5	28.2	25.6	38.8	49.7
Different pattern	0.5	–	8.7	6.2	–	–	–	0.5	2.4	4.1
Bilateral symmetry	95.1	97.4	68.9	69.2	95.6	94.3	66.5	72.3	66.0	73.3
Pattern only on:										
Left palm	3.4	2.6	12.1	13.3	1.0	1.0	5.3	3.6	25.7	16.9
Right palm	1.0	–	10.2	11.3	3.4	4.6	28.2	23.6	5.8	5.6

(Roberts & Coope 1975, Roberts 1982). Furthermore, Karlin et al. (1983) show that total finger ridge count (determined by polygenes) and digital intercorrelations indicate that these affect more than a single digit, while on the other hand, pattern types on one digit affects the ridge count not only on that digit but also on others, as suggested by Kobyliansky et al. (1983). In view of this, embryological considerations suggest that developmentally dermatoglyphic traits are likely to be interlocked and thus genetic or environmental factors affecting the development of one may well be expected to affect the development of others. Similarly, qualitative palmar dermatoglyphic traits are genetically controlled (Pons 1954, Glanville 1965, Kumbnani 1969, Vrydagh-Laoureux 1971, Kloepfer 1978, Loesch 1978, Morgan et al. 1978, Karev 1991); and it has also been known that the embryological environment plays a role in the development of epidermal

Table 22. Sex and intercaste comparisons, by χ^2 test of finger and palmar patterns.

Variables	d.f.	Sex comparisons Brahmin	Mahisys	Padmaraj	Muslim	Lodha	5 Caste comparisons d.f.	Male	Female
Finger pattern									
L I	3	4.44	6.43	6.74	6.70	1.43	12	5.50	0.44
II	„	0.74	1.55	1.56	0.22	0.68	„	2.90	1.84
III	„	3.19	6.01	3.75	1.01	1.95	„	4.23	0.41
IV	„	1.70	3.09	3.30	3.52	0.73	„	4.31	1.71
V	„	3.61	3.12	2.78	2.72	1.72	„	5.29	0.78
All	„	7.63	2.20	2.38	1.22	0.55	„	1.94	0.49
R I	„	13.34*	17.63*	18.40*	15.92*	5.07	„	4.50	2.82
II	„	5.68	8.63*	8.89*	9.17*	2.46	„	2.41	1.08
III	„	1.83	3.12	3.15	2.57	1.16	„	1.36	3.30
IV	„	9.20*	10.54*	10.34*	7.94*	3.61	„	2.06	1.10
V	„	2.06	6.35	5.92	5.78	1.13	„	4.43	0.60
All	„	28.61*	6.09	6.20	5.45	1.38	„	1.35	0.18
10 Fingers	„	15.33*	2.31	2.63	2.05	0.32	„	1.39	0.38
Pattern combinations									
I-I	9	15.23	16.83	18.37*	15.87	12.49	16	5.25	3.54
II-II	„	3.62	5.06	5.36	5.63	3.20	„	10.71	3.33
III-III	„	4.42	3.40	3.38	2.92	2.63	„	4.10	3.07
IV-IV	„	6.76	12.87	11.27	10.33	9.72	„	3.91	4.18
V-V	„	3.84	5.75	4.83	4.39	1.86	„	3.95	2.48
Pattern Comb. 10 fingers	8	14.93	14.24	12.79	9.36	12.78	28	4.99	1.47
Palmar patterns									
Hyp	3	2.64	1.02	3.35	4.21	2.27	12	1.18	0.28
Th-I	„	3.09	1.23	1.11	0.89	0.40	„	0.50	1.02
II	„	3.18	2.37	1.38	1.37	3.70	„	1.59	1.31
III	„	4.79	4.51	3.95	5.71	3.28	„	0.62	1.42
IV	„	10.43*	9.37*	7.94*	9.61*	9.44*	„	–	–

* Marked differences are significant when $p < 0.05$.

ridge configurations (Babler 1978, 1987, 1990; Sorenson Jamaison 1990, Hauser 1991). Interpopulation variability in qualitative palmar dermatoglyphic traits has also been ascertained (Pons 1952, Schwidetzky 1966, Plato 1970, Plato & Wertelecki 1972, Plato et al. 1975, Vrydagh-Laoureux 1979, Fox & Plato 1987), and has been considered as suitable for biological affinities between populations and sub-populations (Rothhammer et al. 1977, Hoff et al. 1981, Karmakar et al. 1989, Karmakar 1990, Kamali et al. 1990, Kamali & Mavalwala 1990, Reddy 1990, Dittmar 1993, Sanna & Floris 1995, Floris et al. 1998). Moreover, that the palmar variables are better interpopulation discriminators than fingers, has also been revealed (Jantz & Chopra 1983, Reddy et al. 1988, Karmakar et al. 1989, Karmakar 1990). The present results perfectly correspond with these observations, the overall incidences of palmar patterns in 5 groups are reflected as homogeneous. The

above phenomenons can be interpreted in the light of developmental theory of dermatoglyphic topology. The pattern forms relatively early on the fetal pads of palmar interdigital areas, while relatively late on the fingers and palmar areas, and then attain greater growth (Cummins 1929). Thus, environmental factors may act for a longer time on the palmar area compared to the digits, which could result in a smaller heritability value of the palmar trait (Arrieta et al. 1992). The ontogenetic differences which underlie population and digital or palmar differences in dermatoglyphic traits are suggested by Suter (1982).

In this context, it may be indicated that the palmar dermatoglyphic pattern of affinities correspond better than fingers to the caste affiliations, or in other words, the ethno-historic background of the populations. The quantitative results were presented as dendrograms for males and females (Fig. 1a, 1b, 2a and 2b), in our previous papers (2000 a,b) which depict relationships among 5 populations being in perfect agreement with their ethno-historical background. The present study clearly indicates that the qualitative dermatoglyphic affinities conform to the known ethno-historical background of the populations (for details, see Karmakar et al. 2000 a,b).

A comparison can be made between our previous results (Karmakar et al. 2000a,b) of quantitative traits and the present findings. These comparisons reveal a similarity i.e., the present results support the results of quantitative traits with very few exceptions in both sexes. Sex dimorphism is homogeneous in nature among 5 populations for qualitative and quantitative variables which indicates common characteristics between two sets of dermatoglyphic traits, although there exist some discrepancies between the right and left sides. However, overall homogeneity is well pronounced among the 5 groups of the same geographical area of West Bengal. Therefore, the overall homogeneity among 5 populations with respect to sex dimorphism and population affinities reflected as dermatoglyphic characteristic may be related to their ethno-historical background. These characteristic features have also been suggested by earlier studies on serological and biochemical markers (Mukherjee et al. 1974, 1987, Chakraborty et al. 1986, 1987, Banerjee et al. 1992) of these groups and suggested that these population groups originate from a common genetic background. On the basis of these observations, it may be concluded that the traditional grouping of Indian populations on the basis of caste hierarchy may not be a reflection of genetic origin of the population and therefore provides biologically relevant information which is essential in studies of interpopulation variation.

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