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PAPER

CRIMINALISTICS

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A Comparison of Palmar Dermatoglyphics in Two Ethnic Indian Populations of North Bengal, India*

ABSTRACT: Dermatoglyphic print comparisons can be utilized to establish personal identification in forensic cases. The northern part of the state of West Bengal, India, is the home to many ethnic populations. Two such populations are the Rajbanshi and the Mech. Palm prints were collected from 192 adult Rajbanshi (105 men and 87 women) and 100 adult Mech (50 men and 50 women) individuals for print comparison using the standard ink and roll print method. The dermatoglyphic variables studied were mainline formulae, termination of mainline, positional variation of axial triradii, and true pattern of hypothenar and thenar configuration area. There were differences between the Rajbanshi and Mech individuals with respect to these dermatoglyphic variables. The uses of these variables appear to be limited only to ethnic identification, not personal identification. The present investigation further highlights the racial affinity, sex, and bilateral differences among Rajbanshi individuals using dermatoglyphic palmar variables.

KEYWORDS: forensic science, forensic anthropology, palmar dermatoglyphics, print comparison, India, Rajbanshi, Mech

The identification of human remains is essential for both legal and social reasons in forensic science. Various reliable methods of identification fundamentally employ the process of comparison, and fingerprinting is considered to be the most accurate and precise method of identification (1). The word "dermatoglyphics" refers to the study of epidermal ridge pattern on fingers, palm, and soles. Epidermal ridge patterns are constant and individualistic and thereby form a reliable criterion for identification. The types and classifications of fingerprints slowly became standardized with the contributions of many researchers (2–9). Scientific interest in the field of dermatoglyphics began to grow, and significant contributions have been subsequently made in the distribution of various dermatoglyphic patterns, personal identification in forensic science, inheritance of anomalous patterns, and medicolegal aspects (10–21). Evidence of personal identity, often based solely on the comparison of a single finger impression, or fragment of an impression began to be accepted by courts of law at all levels in a number of countries. Dermatoglyphic identifications are now routinely used by police forces worldwide for the identification of latent fingermarks left at crime scenes and for ensuring accuracy in the criminal record system (22).

Dermatoglyphic traits have also traditionally played a significant role in assessing ethnic affinities and have been extensively utilized in comparative studies of human population variation for the simple reason that they are under genetic control (23,24) and not under the influences of ecological and climatic pressure (25). A significant number of contributions are available in the field of dermatoglyphics and population variations (26–34). Following Schlauginhaufen (35) who was one of the pioneers in studying dermatoglyphic patterns among various Indian populations, important contributions have also been made in this field from India (36–43).

It is now a well-accepted fact that the Indian population is made up of a large number of ethnic and indigenous elements having significant amount of ethnic and genetic diversity (44–46). This extensive diversity among the Indian population is nurtured to a large extent by the varied topography of the country (47). It has been opined that the Indian population comprises of more than a billion people and consists of 4693 communities with several thousand endogamous groups (48). As a result, it is not possible to have a standardized dermatoglyphic pattern for the Indian population as a whole. Each ethnic group will undoubtedly need its own dermatoglyphic standards. This becomes very important from the standpoint of personal identification in forensic science, and this is where dermatoglyphic studies on print comparisons between different ethnic groups of India are required. Such studies on both finger and palmar prints are, however, rare in the existing literature.

The present investigation is an attempt to compare the palmar dermatoglyphic prints of two ethnic populations (the "Rajbanshi" and the "Mech") residing in the northern part of West Bengal, India. The basic question that is being addressed is whether an individual can be identified as a Rajbanshi or a Mech based on the characteristics of his/her palmar print and also whether palmar prints can be used for individual identification. The present investigation further attempts to document the sex and bilateral differences among Rajbanshi individuals with respect to various palmar dermatoglyphics variables and also their ethnic affinities.

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Materials and Methods

Study Area, Ethnic Background, and Subjects

The northern part of the state of West Bengal is popularly known as North Bengal and comprises the districts of Malda, Uttar Dinajpur, Dakshin Dinajpur, Darjeeling, Cooch Behar, and Jalpaiguri. A number of tribal populations (such as Lepcha, Rabha, Meche, Toto, Oraon, Santal, and Munda) and caste populations (such as Rajbanshi and Bengali) reside in this area. All these populations have their own distinct social, linguistic, and biologic identities (49). Ethnically, they belong to both Mongoloid and Caucasoid stocks and show variations in anthropometry characters, genetic markers, and dermatoglyphics (21,50–53).

The Rajbanshis are the kins of the Koch population of the neighboring state of Assam. It is conjectured that they belong to a mixed race of Austroasian/Dravidian and Mongolian (54). According to Dalton (55), they belong to a Dravidian stock that came in contact with the Mongoloid racial strain of Assam. Again, Waddel (56) considered them to be a heterogeneous Mongoloid population, while Das (57) considered them to be a conglomerate of various tribes who were converted to Hindus and in the process became an admixture of certain caste groups. A recent study on genetic markers has identified the Rajbanshi to be a semi-Hinduized caste group located in between the cluster of Caucasoid caste populations and the cluster of Mongoloid tribal populations (49). The Mech is a tribal Indo-Mongoloid group of the same region having similarities with the Bodo group (58). It has been further opined that the Mech is a Tibeto-Burman speaking Indo-Mongoloid tribal group (59).

The present investigation was undertaken on adult Rajbanshi and Mech individuals aged between 18 and 60 years from a village called "Phansidewa" located in Phansidewa Block and the villages "Kaluajote" and "Dhaknajote" located in Naxalbari Block, respectively. Both these villages are situated in district Darjeeling, West Bengal, India (Fig. 1). Initially, 226 prints were collected from unrelated adult Rajbanshi individuals by random sampling during the period from September 2007 to January 2008. Finally, a total of 192 palm prints of adult Rajbanshi individuals (105 men and 87 women) were analyzed. Palm prints were subsequently collected from 114 unrelated adult Mech individuals during the period from September 2009 to October 2009. Finally, a total of 100 palm prints (50 men and 50 women) were selected from the Mech for this investigation. The palm prints were collected after obtaining an informed consent from the individuals. The investigation was conducted in accordance with the ethical guidelines of human experiment as laid down in the Helsinki Declaration of 2004 (60).

Procedure of Recording the Dermatoglyphic Prints and the Variables Used

The dermatoglyphic prints were collected following the standard ink and roll print method of Cummins and Midlo (61). Kores duplicating ink, glass plate, roller, and chart paper were utilized for collection of the prints. While taking the prints, pressure was exerted on the central region of the palms and knuckles. The principal mainline formulae, termination of mainlines, positional variations of axial triradii, and hypothenar and thenar configuration

Fig. 1—Map of northeastern India showing the location of Darjeeling district of West Bengal, India.

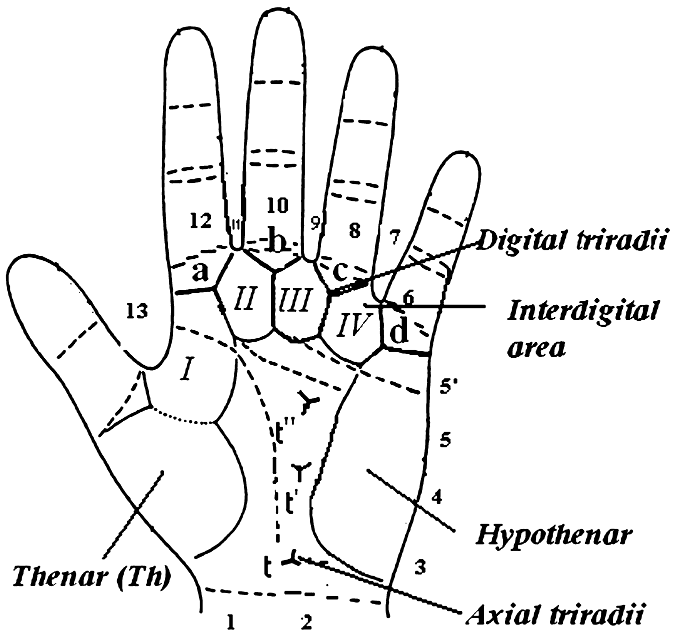

Fig. 2—A palm showing the dermatoglyphic variables analyzed in the present investigation.

areas were analyzed from the prints by utilizing the standard methodology of Cummins and Midlo (61).

The palm is sequentially numbered from 1 to 13. The digital triradii (a, b, c, d) are being numbered in the order of 12, 10, 8, 6 positions. The determination of principal mainline formulae is based on the number of the sequences of position around the periphery of the palms, and each traced line is described by the position in which it terminates (61). The mainline terminates in definite points of the proximal, ulnar, distal, and radial borders of the palms. After tracing the four mainlines, the symbols for their terminations are recorded in order D, C, B, and A, for the formulation of mainline formulae (Fig. 2). The axial triradius is usually located in the proximal part of the palm in between the thenar and hypothenar eminences and is in alignment with the fourth metacarpal. The positional variation of the axial triradius also bears significance. Its occurrence in the proximal part of the palm is recorded as *t*, while a distally placed axial triradius near to the center of the palm is called t''. The triradius found in the intermediate level of these triradii is considered as t' (61).

The hypothenar area on the palm constitutes the entire hypothenar eminences where only configurations (such as whorl, loop, and tented arch) are primarily found in its proximal portion (5). The thenar area constitutes the first, second, third, and fourth interdigital areas and the eminence in the first interdigital area. The configuration of an interdigital area is known as true pattern and includes whorl and loop or vestiges or an open field (61). The positions of these variables on the palm are depicted in the Fig. 2.

Statistical Analysis

Chi-square analysis was utilized to assess the sex and bilateral differences with respect to the palmar dermatoglyphic patterns among the Rajbanshi male and female individuals. Chi-square analysis was also employed to find out the differences between Rajbanshi and Mech individuals on the frequencies of the earlier described palmar dermatoglyphic variables. A p-value of <0.05 was considered to be statistically significant. Dendrogram analysis based on mainline formula has been used to understand the ethnic affinity of the Rajbanshis. The results of the present investigation were compared with those already published among other tribal and caste populations of northeastern India to understand the racial affinity of the Rajbanshi population. The statistical analysis was carried out by using Statistical Package for Social Sciences (SPSS version 15.0, Chicago, IL).

Results

The Principal Palmar Mainline Formulae

The frequency of principal mainline formula among the Rajbanshi and Mech individuals in the present investigation is shown in Table 1a and b.

Among the Rajbanshi, the most frequently occurring principal mainline formula in all the prints (right and left) that were examined was 11.9.7.–, followed by 9.7.5.– and 7.5.5.–. Among the male individuals, the most frequently distributed mainline formula was 11.9.7.– (34.29%), followed by 7.5.5.– (30.00%) and 9.7.5.– (26.19%). Among the female individuals, the most frequently occurring mainline formulae were 11.9.7.– (36.78%), followed by 9.7.5.– (24.71%) and 7.5.5.– (17.82%). Thus, the highest incidence

TABLE 1—*Frequency of principal mainline formulae among the (a) Rajbanshi and (b) Mech population.*

		Principal Mainline Formulae			
Sex	Palm	11.9.7.–	9.7.5.–	7.5.5.–	Others
(a)					
Male (N = 105)	Left	30 (28.57)	24 (22.86)	38 (36.19)	13 (12.38)
	Right	42 (40.00)	31 (29.52)	25 (23.81)	7 (6.67)
	Left + Right	72 (34.29)	55 (26.19)	63 (30.00)	20 (9.52)
Female (N = 87)	Left	27 (31.07)	17 (19.54)	21 (24.14)	22 (25.29)
	Right	37 (42.53)	26 (29.89)	10 (11.49)	14 (16.09)
	Left + Right	64 (36.78)	43 (24.71)	31 (17.82)	36 (20.69)
(b)					
Male (N = 50)	Left	4 (8.00)	16 (32.00)	21 (42.00)	9 (18.00)
	Right	6 (12.00)	13 (26.00)	25 (50.00)	6 (12.00)
	Left + Right	10 (10.00)	29 (29.00)	46 (46.00)	15 (15.00)
Female (N = 50)	Left	5 (10.00)	16 (32.00)	19 (38.00)	10 (20.00)
	Right	6 (12.00)	15 (30.00)	22 (44.00)	7 (14.00)
	Left + Right	11 (11.00)	31 (31.00)	41 (41.00)	17 (17.00)

Values in parentheses indicate percentages.

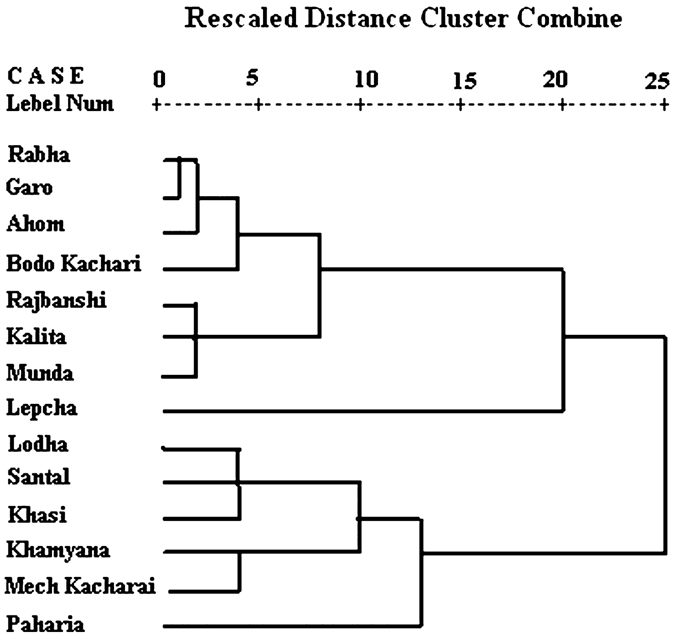

Fig. 3—Dendrogram using average linkage (between groups) based on mainline formulae.

of 11.9.7.– has been observed for the combined prints in both men and women. It has been further observed that bilateral differences existed in the principal mainline formula (Table 1a). A highest incidence of 11.9.7.– was observed in right palms of men (40.00%) and women (42.53%). Similarly, the incidence of 9.7.5.– was also found to be the highest in right palms in both the sexes, but the frequency of 7.5.5.– was observed to be the highest in the left palm of male and female individuals (36.19% and 24.14%, respectively). While the male individuals exhibited statistically insignificant bilateral differences (chi-value: 7.37; d.f. 3; $p > 0.05$), the differences were statistically significant in the case of females (chi-value: 9.12; d.f. 3; $p < 0.05$). Sex differences were found to be statistically not significant ($p > 0.05$) for both left palms (chi-value: 6.94; d.f. 4) and for right palms (chi-value: 7.90; d.f. 4; $p > 0.05$). However, for the combined prints (left and right), there was a significant statistical difference between men and women (chi-value: 14.15; d.f 4; $p < 0.05$).

The most frequently occurring mainline formulae among the Mech were 7.5.5.–, followed by 9.7.5.–, and finally 11.9.7.–. The highest incidence of 7.5.5.– was observed in right palms (men: 50.00% and women: 44.00%), but the highest incidence of 9.7.5.– was found to be identical in the left palms of both men and women (32.00%). The sex differences were not statistically significant for both left (chi-value: 0.26; d.f. 3; $p > 0.05$) and right (chi-value: 0.41; d.f. 3; $p > 0.05$) palms. The difference was also statistically not significant for the combined prints (chi-value: 0.53; d.f. 3; $p > 0.05$).

The dendrogram drawn on the basis of the mainline formula is shown in Fig. 3. It has been drawn on the basis of the frequency distribution of various populations of northeastern India and the Rajbanshi population in the present investigation. The dendrogram shows that the Rajbanshi are placed in between Kalita and Munda tribal populations and separated from the populations having the Mongoloid affinities of tribal populations of northeast India.

Frequency in Termination of Mainlines

The terminations of mainlines D, C, B, and A in the different palmar areas among the Rajbanshi individuals are shown in Table 2.

Mainline D—The highest frequency of termination of D line was in position 11 followed by 9 and 7 among both male and female Rajbanshi individuals. The frequency of termination at position 11 was higher in the case of women than in men (45.48% and 36.19%, respectively). The termination at position 11 was observed to be more frequent in right palms, while termination at position 7 was more frequent in left palms among both sexes. It was further observed that the left palms among the men show more variation than the women with respect to mainline D termination.

Mainline C—The highest frequency of termination of mainline C was found in position 9 followed by positions 7 and 5′. The incidences of termination in position 9 were 32.86% and 38.51% among the male and female individuals, respectively. The abortive

TABLE 2—*Frequency of termination of principal mainlines among the Rajbanshi population.*

		Male (n = 105)			Female (n = 87)		
Lines	Termination Ends	Left	Right	Left + Right	Left	Right	Left + Right
D	11	33 (31.43)	43 (40.95)	76 (36.19)	37 (42.53)	43 (49.43)	80 (45.98)
	9	38 (36.19)	35 (33.33)	73 (34.76)	28 (32.18)	33 (37.93)	61 (35.06)
	7	34 (32.38)	27 (25.71)	61 (29.05)	22 (25.29)	11 (12.64)	33 (18.97)
C	9	29 (27.62)	40 (38.10)	69 (32.86)	30 (34.48)	37 (42.53)	67 (38.51)
	7	37 (35.24)	34 (32.38)	71 (33.81)	31 (35.63)	35 (40.23)	66 (37.98)
	5′	37 (35.24)	27 (25.71)	64 (30.48)	18 (20.64)	10 (11.49)	28 (16.09)
	5	0 (0.00)	1 (0.95)	1 (0.48)	1 (1.15)	0 (0.00)	1 (0.57)
	X	0 (0.00)	1 (0.95)	1 (0.48)	3 (3.45)	3 (3.45)	6 (3.45)
	x	2 (1.90)	2 (1.90)	4 (1.90)	4 (4.60)	2 (2.30)	6 (3.45)
B	7	31 (29.52)	40 (38.10)	71 (33.81)	36 (41.38)	44 (50.57)	80 (45.98)
	5′	28 (26.67)	29 (27.62)	57 (27.14)	23 (26.44)	27 (31.03)	50 (28.74)
	5	46 (43.81)	36 (34.29)	82 (39.05)	28 (32.18)	16 (18.39)	44 (25.29)
A	5′	1 (0.95)	1 (0.95)	2 (0.95)	0 (0.00)	1 (1.15)	2 (1.15)
	5	46 (43.81)	61 (59.05)	107 (50.95)	36 (41.38)	52 (59.77)	88 (50.57)
	4	9 (8.57)	15 (14.29)	24 (11.43)	11 (12.64)	15 (17.24)	26 (14.94)
	3	42 (40.00)	26 (24.76)	68 (32.38)	21 (24.14)	11 (12.64)	33 (18.97)
	2	4 (3.81)	2 (1.90)	6 (2.86)	14 (16.09)	8 (9.20)	22 (12.64)
	1	3 (2.86)	0 (0.00)	3 (1.43)	5 (5.75)	0 (0.00)	5 (2.87)

Values in parentheses indicate percentages.

type of mainline C has also been observed in both men ($X = 0.48\%$ and $x = 1.90\%$) and women ($X = 3.45\%$ and $x = 3.45\%$). The left and right palm showed more variation in terms of termination of mainline C in positions 9 and 5′ among both sexes.

Mainline B—The highest frequency of termination of this mainline was observed in position 7 among both sexes. The lowest incidence among men was in position 5′ (27.14%), while for women, it was in position 5 (25.29%). The right palm showed more variation in termination of mainline B in positions 7 and 5′ in both male and female individuals.

Mainline A—The mainline A terminated at position 5 for a majority of the male and female individuals (50.95% and 50.57%, respectively). The lowest incidence was observed in positions 2, 1, 5′. The right palm showed more variability in position 5 among both sexes.

Frequency of Axial Triradius

The frequencies of the variations in position of medially placed axial triradius among the Rajbanshi and Mech individuals in the present investigation are shown in Table 3a and b.

Among the Rajbanshi, the majority of the individuals (both men and women) possessed the axial triradius at position *t* in the most proximal side between the thenar and hypothenar areas. The incidences were higher in men than in women (73.81% and 70.69%, respectively), and the differences were found to be statistically not significant ($p > 0.05$). The other frequently encountered combination types in both sexes were *t*′, *t*″, *tt*′, and *t*′*t*″. The position of axial triradius in position *t* was relatively higher in men than in women. The left palms showed higher incidences of proximal *t* than the right palms in both sexes. The lowest observed frequency was found in cases of *t*′*t*″ (0.48%) and *tt* (1.15%) among the male and female individuals, respectively. Chi-square analysis showed a statistically insignificant difference (chi-value: 4.19; d.f. 7; $p > 0.05$) with respect to the frequency of position variation of medially placed axial triradius between the male and female individuals.

The highest frequency of the axial triradii among the Mech was found in the *t* position followed *t*′, and *t*″. The highest incidences were found in left palm among both men (74.00%) and women (70.00%). A high frequency of the *t*′ was also encountered in the right palm prints among men (28.00%) and women (32.00%). The frequency of *t*″ was found to be identical for the combined prints. The sex difference was not determined because of the absence of axial triradius in some positions among the Mech individuals.

When the frequency of medially placed axial triradii of the Rajbanshi was compared with the Mech individuals, the incidence of axial *t* was found higher among them for the combined prints. However, the frequency of *t*′ was found to be higher in both sexes among the Mech individuals when compared to the Rajbanshi (Table 3a and b). There were statistically insignificant differences in *t*, *t*′, and *t*″ types between the Rajbanshi and Mech individuals of both sexes (male chi-value: 3.18; d.f., 3; $p > 0.05$, female chi-value: 2.97; d.f., 3; $p > 0.05$).

Frequency of True Pattern on Palmar Configuration Areas

The frequency of true patterns on the palmar configuration areas among the Rajbanshi individuals is depicted in Table 4a. The frequency of presence of true pattern on the hypothenar area was observed to be the highest among the female than the male individuals (23.56% vs. 21.90%). The incidence was higher on the right palms than the left palms in both sexes. It was also observed that among the true patterns on the interdigital areas, the highest incidence was in the case of the fourth interdigital area, while the lowest frequency was observed in the case of second interdigital area in both male and female individuals. The observed incidence of the fourth interdigital area was higher among men than among women (67.62% and 60.34%, respectively). The general observed trend in the incidence of palmar configuration is as follows: IV interdigital > III interdigital > hypothenar areas > thenar/interdigital I > II interdigital. This trend was identical for both male and female individuals. Statistically insignificant bilateral differences have been observed in terms of true patterns of palmar configuration area utilizing chi-square analysis (male chi-value: 1.17; d.f. 4; $p > 0.05$; female chi-value: 2.52; d.f. 4; $p > 0.05$). The sex differences were found to be statistically not significant for both left (chi-value: 1.56; d.f. 5; $p > 0.05$) and right (chi-value: 0.43; d.f. 5; $p > 0.05$) palmar true configuration areas. Statistically insignificant sex differences were also noticed with respect to true patterns of palmar configuration for the combined prints (chi-value: 1.27; d.f. 5; $p > 0.05$).

The frequency of the true palmar configuration area among the Mech is shown in Table 4b. The frequency true pattern of hypothenar configuration was found to be identical for the male and female

TABLE 3—*Frequency variation of the position of axial triradii among the (a) Rajbanshi and (b) Mech population.*

		Types of Axial Triradii						
Sex	Palm	*t*	*t*′	*t*″	*tt*	*tt*′	*tt*″	*t*′*t*″
(a)								
Male (*N* = 105)	Left	78 (74.28)	17 (16.19)	3 (2.86)	0 (0.00)	4 (3.31)	3 (2.86)	0 (0.00)
	Right	77 (73.33)	16 (15.24)	5 (4.76)	0 (0.00)	4 (3.31)	2 (1.90)	1 (0.95)
	Left + Right	155 (73.81)	33 (15.71)	8 (3.81)	0 (0.00)	8 (3.81)	5 (2.38)	1 (0.48)
Female (*N* = 87)	Left	62 (71.26)	14 (16.09)	3 (3.45)	0 (0.00)	5 (5.75)	3 (3.45)	0 (0.00)
	Right	61 (70.11)	17 (19.54)	3 (3.45)	2 (2.30)	3 (3.45)	1 (1.15)	0 (0.00)
	Left + Right	123 (70.69)	31 (17.82)	6 (3.45)	2 (1.15)	8 (4.60)	4 (2.30)	0 (0.00)
(b)								
Male (*N* = 50)	Left	37 (74.00)	11 (22.00)	1 (2.00)	0 (0.00)	1 (2.00)	0 (0.00)	0 (0.00)
	Right	34 (68.00)	14 (28.00)	2 (4.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	Left + Right	71 (71.00)	25 (25.00)	3 (3.00)	0 (0.00)	1 (1.00)	0 (0.00)	0 (0.00)
Female (*N* = 50)	Left	35 (70.00)	12 (24.00)	2 (4.00)	0 (0.00)	1 (2.00)	0 (0.00)	0 (0.00)
	Right	33 (34.00)	16 (32.00)	1 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	Left + Right	68 (68.00)	28 (28.00)	3 (3.00)	0 (0.00)	1 (1.00)	0 (0.00)	0 (0.00)

Values in parentheses indicate percentages.

TABLE 4—*Distribution of true pattern on palmar configuration areas among the (a) Rajbanshi and (b) Mech population.*

			Thenar (Th)/Interdigital Areas			
Sex	Palm	Hypothenar	Th/I	Th/II	Th/III	Th/IV
(a)						
Male (N = 105)	Left	22 (20.95)	13 (12.38)	4 (3.81)	38 (36.19)	73 (69.52)
	Right	24 (22.86)	10 (9.52)	4 (3.81)	45 (42.86)	69 (65.71)
	Left + Right	46 (21.90)	23 (10.95)	8 (3.81)	83 (39.52)	142 (67.62)
Female (N = 87)	Left	18 (20.69)	14 (16.09)	2 (2.30)	32 (36.78)	51 (58.62)
	Right	23 (26.44)	8 (9.20)	3 (3.45)	35 (40.23)	54 (62.07)
	Left + Right	41 (23.56)	22 (12.64)	5 (2.87)	67 (38.51)	105 (60.34)
(b)						
Male (N = 50)	Left	12 (24.00)	4 (8.00)	2 (4.00)	17 (34.00)	31 (62.00)
	Right	10 (20.00)	5 (10.00)	1 (2.00)	14 (28.00)	28 (56.00)
	Left + Right	22 (22.00)	9 (9.00)	3 (3.00)	31 (31.00)	59 (59.00)
Female (N = 50)	Left	9 (18.00)	6 (12.00)	1 (2.00)	18 (36.00)	25 (50.00)
	Right	13 (26.00)	4 (8.00)	1 (2.00)	15 (30.00)	28 (56.00)
	Left + Right	22 (22.00)	10 (10.00)	2 (2.00)	33 (33.00)	53 (53.00)

Values in parentheses indicate percentages.

combined prints (22.00%). The highest frequency was observed in the case of the fourth interdigital area (men: 59.00%; women: 53.00%), whereas the lowest frequency was encountered in the case of the second interdigital configuration area in the combined prints. Statistically insignificant sex differences were observed in the true palmar configuration on left (chi-value: 1.45; d.f. 4; $p > 0.05$) and right (chi-value: 0.46; d.f. 4; $p > 0.05$) palmar prints. There was a statistically insignificant sex difference in the case of the combined prints with respect to true palmar configurations (chi-value: 0.57; d.f. 4; $p > 0.05$) among the Mech individuals.

The true pattern of palmar configuration on the thenar and hypothenar areas of the Rajbanshi individuals has been compared with the Mech individuals. A higher prevalence was found in combined hypothenar and thenar among the Rajbanshi individuals when compared to Mech in both sexes except in the male hypothenar category. Statistically insignificant sex differences have been observed in the true configuration on thenar and hypothenar areas between these individuals utilizing chi-square analysis (male chi-value: 1.41; d.f., 5; $p > 0.05$, female chi-value: 0.90; d.f., 5; $p > 0.05$).

Discussion

The most frequently occurring principal mainline formula in all the prints (right and left) that were examined was 11.9.7.–, followed by 9.7.5.– and 7.5.5.– among the Rajbanshi (Table 1a). While the male individuals exhibited statistically insignificant bilateral differences, the differences were statistically significant in the case of women. Sex differences were found to be statistically not significant ($p > 0.05$) for both palms. The most frequently occurring mainline formulae among the Mech were 7.5.5.–, followed by 9.7.5.– and finally 11.9.7.– (Table 1b). The highest incidence of 7.5.5.– was observed in the right palms (men: 50.00%; women: 44.00%), but the highest incidence of 9.7.5.– was found to be identical in the left palms of Mech males and females. The sex differences were statistically not significant among them. When the principal mainline formulae of the Rajbanshi individuals were compared with Mech, it was observed that the frequency of 9.7.5.– and 7.5.5.– was higher among the Mech when compared to the Rajbanshi individuals. The frequency of 11.9.7.– was found to be higher among the Rajbanshi individuals when compared to the Mech individuals (Table 1a and b). There were significant statistical differences in the frequency of the principal mainline formulae between Rajbanshi and Mech individuals for the combined prints.

When the frequency of medially placed axial triradii of the Rajbanshi was compared with the Mech individuals, the incidence of axial t was found higher among them for the combined prints. However, the frequency of t' was found to be higher in both sexes among the Mech when compared to the Rajbanshi (Table 3a and b). There were statistically insignificant differences in t, t', and t'' types between the Rajbanshi and Mech individuals of both sexes for the combined prints.

The true pattern of palmar configuration on the thenar and hypothenar areas of the Rajbanshi individuals has been also compared with the Mech individuals. A higher prevalence was found in combined hypothenar and thenar among the Rajbanshi individuals when compared to Mech in both sexes except in the male hypothenar category. Statistically insignificant sex differences have been observed in the true configuration on the thenar and hypothenar areas between these individuals. Hence, it may be concluded that using the palmar dermatoglyphic variables, it is possible to some extent to identify the ethnic group of a suspect in a forensic investigation. However, their utility appears to be limited in the case of establishing personal identity.

Until 2007, a total of 194 studies have focused on the mainline formula among various Indian populations. Among these studies, 74 studies were from the eastern Himalayan region and 93 studies were on the scheduled tribes (62). It is evident from Table 1a that the highest frequency of principal mainline formulae among the Rajbanshi individuals in the present investigation was 11.9.7.–, followed by 9.7.5.– and 7.5.5.–. Significant differences were also observed within the palms and among male and female individuals in the mainline formula. Available studies on palmar dermatoglyphics in India report that the incidence of principal mainline formula 11.9.7.– was the highest, followed by 7.5.5.– and 9.7.5.–. The populations from the northeastern states having Mongoloid affinities showed highest frequencies of 7.5.5.–, followed by 9.7.5.– and finally 11.9.7.–. It has been opined (62,63) that among the Mongoloid populations of northeastern India (such as Mech, Bodo, Rabha, and Garo), the frequencies of the mainline formula 7.5.5.– and 9.7.5.– were higher than 11.9.7.– and that the frequency of 7.5.5.– was higher or equal to 9.7.5.–. The order of preponderance for mainline formulae among these populations was 7.5.5.– followed by 9.7.5.– and 11.9.7.–, and this has been also observed among the tribes of West Bengal that have Mongoloid affinities. The other tribal populations of West Bengal generally showed a highest frequency of 11.9.7.–, when compared to 7.5.5.– and 9.7.5.–. The frequency of palmar mainline formulae of some northeastern populations of India is shown in Table 5. It is apparent from the available mainline frequencies from different ethnic communities of northeast that the Rajbanshi exhibited a higher frequency of 11.9.7.– than the Mongoloid tribal populations, which includes the Mech Kachari, Bodo Kachari, Rabha, Garo, and Miri (40) but lower than the Lepcha (64). The frequency of mainline formulae 9.7.5.– among the Rajbanshi populations was observed to be lower than Mech Kachari, Bodo Kachari, Ahom, Garo, and Miri (40,65) and higher than the Proto-Australoid tribal populations (Santal, Munda) of West Bengal. The frequencies of the mainline 7.5.5.– were found to be higher than the Mongoloid tribal populations of northeast India but lower than Lepchas, Lodha, Paharia, Khasi, and Kalita (64,66–68) (Table 5).

Hence, based on the mainline formula, it has been observed that the Rajbanshis were not related to the Mongoloid tribal populations of northeastern India and that they were closer to other tribal populations of India. It is evident from the dendrogram given in Fig. 3 that the Rajbanshis were more related to the Kalita and Munda tribal populations, but separated from the populations that show Mongoloid affinities (such as Rabha, Bodo, and Garo). It has also been opined by Kumar et al. (49) that the Rajbanshi populations were originally tribal but now have become a semi-Hinduized caste groups and also included the Chutia and Ahom (49).

Among the Rajbanshi, the highest frequency of the termination of D line is at 11, followed by 9, and finally 7. For the termination of mainline C, the highest incidence was at position 9 followed by 7, and finally 5′ (Table 2). Similarly for mainline B, the highest frequency of termination was at point 7, while for mainline A, it was in position 5. A thorough search of the existing literature has failed to reveal any notable studies on the termination of mainline among various Indian populations, especially those from North Bengal and northeastern India. The results of the present investigation need to be compared and analyzed in light of fresh data from such populations.

The frequency distribution of true pattern palmar configuration areas among the Rajbanshi male and female individuals (Table 4a) showed that the overall combined frequency of true hypothenar pattern was 21.90% and 23.56%, respectively, and the differences were found to be statistically insignificant ($p > 0.05$). It has been generally agreed that the presence of a true hypothenar pattern was found to be the highest among scheduled tribe (33.00%) and scheduled caste (29.00%) populations. However, Bhasin (62) has reported that populations with Mongoloid affinities from Assam and Sikkim exhibit a low frequency of a true hypothenar pattern (18.70% and 13.00%, respectively). The frequency of the pattern of hypothenar configuration among the Rajbanshi individuals in the present investigation was higher than the values among the above-mentioned populations with Mongoloid affinities. The frequency distributions of true pattern on thenar/first interdigital area of the palms revealed lower incidence patterns among male (10.95%) and female (12.64%) individuals. In general, the frequencies were observed to be low (<10.00%) among the populations with Mongoloid affinities and scheduled tribes from the eastern Himalayan region (62). However, the results of the present investigation are within the reported values from the Indian caste populations by Reddy (69). The results of the present investigation further showed that the Rajbanshis were more inclined toward the scheduled caste populations.

The second interdigital area of palms also exhibited low incidences in the present investigation (men: 3.81%; women: 2.87%). This frequency is also found to be low among populations with Mongoloid affinities from the Himalayan region. These populations include the Bhutia (3.70%) and the Bodo populations (2.10%) (62).

TABLE 5—*Frequency of palmar mainline formulae of some northeastern populations of India.*

Population	Sex	No. of Subjects	Mainline Formulae (percentages) 11.9.7.–	9.7.5.–	7.5.5.–	References
Rajbanshi	M	105	34.3	26.2	30.0	Present investigation
	F	87	36.8	24.7	17.8	
Khamyana	M	50	6.0	29.0	40.0	65
	F	60	5.8	29.2	32.5	
Kalita	M	90	18.9	16.1	22.2	66
	F	84	22.0	18.4	16.1	
Khasi	M	42	24.4	23.3	13.8	64
	F	75	24.6	24.0	12.0	
Mech Kachari	M	72	5.6	40.3	43.1	40
	F	50	12.0	22.0	62.0	
Bodo Kachari	M	138	11.6	17.8	53.6	40
	F	104	4.8	25.0	50.0	
Rabha	M	132	10.6	31.8	33.5	40
	F	100	9.0	24.0	49.0	
Ahom	M	112	18.7	33.5	27.7	40
	F	110	13.1	32.4	33.3	
Garo	M	134	17.2	41.0	26.9	40
	F	104	9.6	22.1	34.6	
Lepchas	M	112	42.8	23.2	4.5	64
	F	42	44.0	20.0	7.3	
Lodha	M	62	31.5	8.7	4.3	67
	F	48	22.0	7.3	13.4	
Santal	M	62	24.4	11.4	33.3	72
	F	61	25.6	14.1	31.4	
Munda	M	112	25.9	12.9	27.2	73
	F	101	24.0	13.5	29.5	
Pahira	M	23	24.2	28.8	12.1	68
	F	21	16.7	31.0	9.5	
Miri	M	110	29.6	31.4	17.7	40
	F	112	23.7	45.5	28.1	
Lalung	M	106	15.1	26.9	36.6	40
	F	132	9.9	28.8	40.2	
Juang	M	74	12.9	28.4	32.0	73
	F	17	13.3	10.0	43.9	

The frequency was however comparatively higher among the Indo-European (8.30%) and Dravidian (9.20%) groups (21,70) and different caste groups (69). With respect to the third interdigital area, the frequency pattern from Indian populations was 43.10%, with the frequency being the highest among the caste (49.10%) and different ethnic groups (46.30%) and lowest among the Mongoloid tribal populations (62,69,70). The result of the present investigation seems to indicate an affinity of the Rajbanshi toward the caste and tribal populations. The frequency of the fourth interdigital area was 67.62% and 60.34% among the male and female individuals, respectively (Table 4a). The frequency of true pattern in the fourth interdigital area was found to be the highest in almost all populations from India (69). In the present investigation, it was observed that the incidences were high and found to be within the values reported by Bhasin (62) for caste (61.70%), scheduled caste (61.40%), and scheduled tribal (61.40%) populations but significantly lower than the Mongoloid populations (79.60%) of Sikkim from the Himalayan region.

The ethnic affinity of the Rajbanshi population is not clear, with different views being advanced regarding the same (54–56,71). The Rajbanshis were hypothesized to be a mixture of different tribal groups who were converted to Hinduism and in the process became admixed with certain Caucasoid caste populations (71). The Mongoloid admixture among the Rajbanshis was first hypothesized by Risley (54), although later the Rajbanshis were recognized as a distinct Hindu caste (58). Later on, Kumar et al. (49) in their study based on genetic markers observed that the ethnic affiliation of Rajbanshi was ambiguous in nature and concluded that they were originally tribes but currently assumed semi-Hinduized caste status and belong to Indo-European language speaker family. Based on the dermatoglyphic palmar patterns in the present investigation, it may be opined that the Rajbanshi of North Bengal has an affinity more toward the scheduled caste and tribal populations and not the Mongoloid populations of northeastern India. However, further studies are needed to explore the true nature of the admixture among the Rajbanshis.

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