Variation in palmar interdigital ridge-counts among the 20 Dhangar castes of Maharashtra, India

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With 2 figures and 6 tables in the text

Summary: Bilateral palmar prints of 2927 males of 20 endogamous Dhangar castes of Maharashtra, India, were studied for the distributions of a-b, b-c and c-d interdigital ridge-counts. The ridge-counts have been utilized for examining the inter-population affinities among the Dhangar castes. The distribution of a-b ridge-count is symmetrical and normal in Dhangar castes. The distributions of b-c and c-d ridge-counts on both palms also show (nearly) normal distribution, but with a tendency of negative skewness and platykurtosis in c-d ridge-count. Equality of means and standard deviations depict significant heterogeneity. The decreasing order of magnitude of means of interdigital ridge-counts is a-b > c-d > b-c among all the Dhangar castes. Intercaste comparisons reveal a great deal of variations in all ridge-counts. The pattern of relationship between the Dhangar castes based on the three ridge-counts is in agreement with the expected patterns of affinities based on the known ethno-historical evidence. The significant finding of the study is that the palmar interdigital ridge-counts follow normal distribution and that they are useful in studying inter-population affinities.

Zusammenfassung: An den bilateralen Handabdrücken von insgesamt 2927 Männern, die 20 endogamen Kasten der Dhangar aus Maharashtra, Indien, angehören, wurden die Verteilungen der interdigitalen Leistenzahlen a-b, b-c und c-d bestimmt. An diesen wurden die Intergruppenähnlichkeiten zwischen diesen 20 Dhangar-Kasten analysiert. Die Verteilung der Leistenzahlen a-b ist in allen Kasten symmetrisch und normal. Auch die Verteilung der Leistenzahlen b-c und c-d ist auf beiden Handflächen ebenfalls (fast) normal, zeigt aber hinsichtlich der c-d-Werte eine Tendenz zu negativer Skewness und Platykurtosis. Alle Mittelwerte und Standardabweichungen lassen eine signifikante Heterogenität erkennen. In allen Dhangar-Kasten weisen die Mittelwerte der interdigitalen Leistenzahlen die folgende Reihenfolge bezüglich ihrer Ausprägung auf: a-b > c-d > b-c. Vergleiche zwischen den verschiedenen Kasten ergeben eine beträchtliche Variabilität bezüglich aller Leistenwerte. Die auf diesen drei interdigitalen Leistenwerten beruhenden Ähnlichkeitsmuster zwischen den Dhangar-Kasten stimmen mit den bekannten ethnohistorischen Zeugnissen überein. Die wichtigsten Ergebnisse dieser Untersuchung sind einmal, daß die interdigitalen Leistenzahlen der Handflächen normalverteilt sind und daß ihnen für die Analyse von Beziehungen zwischen Bevölkerungsgruppen eine beträchtliche Bedeutung zukommt.

Introduction

Compared to other dermatoglyphic configurational areas, the interdigital areas of the palm are quite distinct in their nature of pattern formation, in terms of size and shape and extent of variability. This has led to the formulation of a variety of

qualitative and quantitative dermatoglyphic characters for describing and differentiating human populations. For example, the qualitative characters like mainline types, c-line polymorphism, absence of triradius c or d, occurrence of accessory triradii, and interdigital pattern types have been extensively studied with respect to heritability (Abdullah 1979, Katayama 1980 etc.), their association with medical disorders (e. g., Schaumann & Alter 1976), and ethnic variation and genetic relationships between populations (e. g., Plato 1970, Hoff et al. 1981). A few studies have also examined the relationship of these traits with finger, palmar and other dermatoglyphic characters and with population structure variables etc., to infer the possible cause(s) of observed variation (e. g., Relethford & Blangero 1990).

The quantitative dermatoglyphic characters of the interdigital areas of palm, the ridge-count and ridge-breadth have been studied with respect to heritability, ethnic variation, asymmetry and developmental stability, quantitative genetic aspects (for example major gene effect), medical disorders, association with migration and other population structure variables (Bansal 1966, Tiwari & Bhasin 1969, Pateria 1974, Mate 1975, Chakraborty & Malhotra 1981, Loesch & Martin 1982, Chakrabory, Malhotra & Tateno 1982). A review of literature suggests that a number of studies has been concerned with a-b ridge-count in investigating the population affinities (e. g., Seth 1963, Bhasin 1966, Bansal 1966, Banerjee & Banerjee 1975, Garg & Chattopadhyay 1983, Ungria & Martin 1984). However some recent studies have also considered variations in b-c and c-d ridge-counts (Basu & Chattopadhyay 1967, Rogueka et al. 1971, Pateria 1974, Sculli & Rao 1975, Mathew 1980, Karmakar & Malhotra 1981, Malhotra et al. 1981, Sudhakar Babu 1983). While a number of studies has investigated the distribution of pattern intensity index and finger ridge-counts, the nature of the distribution of interdigital palmar ridge-counts has hardly been studied. However, a few investigators have reported the frequency distribution of interdigital ridge-counts (e. g., Pons 1964, Vrydagh-Laoureux 1971, Dennis 1977, Mathew 1980).

For several reasons, the study of the distribution of interdigital ridge-counts is of importance in anthropological genetics. In general, the dermatoglyphic characters are assumed to be polygenic and expected to follow normal distribution, however, Holt (1968) observed that the finger ridge-counts deviate from normality and suggested the possibility of a major gene effect (Jantz 1977, Harvey & Suter 1983). It is of immense interest to know whether the interdigital ridge-counts a-b, b-c and c-d also deviate from normality. There is at least, one more dimension of interdigital ridge-counts which needs to be studied. The embryonic studies indicate that the growth processes responsible for the pattern formation are unlikely to affect the specific areas of the palm, rather they affect the entire palmar surface (Cummins & Midlo 1961, Hauser & Abraham 1985). This influences the size and shape of the patterns in all interdigital areas simultaneously. This suggests a possible association between the distributional pattern of interdigital ridge-counts of a-b, b-c and c-d.

For the study of population affinities several biological characters including dermatoglyphics have been used. Numerous studies using dermatoglyphic phenotypes have shown that these characters are equally important in studying inter-population affinities. Since the interdigital ridge-counts depict high heritabilities, it is of interest to investigate, whether these ridge-counts alone are sufficient to reflect the ethnic affinities among populations and how this corresponds with the pattern of variation observed on the basis of dermatoglyphic, anthropometric, and serological characters. The above considerations have been the basis for the present study

Table 1. Mean, SD and CV of a-b, b-c and c-d ridge-counts for right and left palms among the Dhangar castes; abbreviations see Table 6.

Dhangar Castes	N	a – b						Bl. diff.	b – c						Bl. diff.	c – d						Bl. diff.
		Right			Left				Right			Left				Right			Left			
		Mean	SD	CV	Mean	SD	CV	t-value	Mean	SD	CV	Mean	SD	CV	t-value	Mean	SD	CV	Mean	SD	CV	t-value
AH	267	33.9	5.6	16.5	36.5	5.5	15.1	5.30*	20.6	7.5	36.4	19.3	9.2	47.7	1.79	29.8	9.4	31.5	26.2	11.8	46.1	3.92*
DH	175	32.6	5.4	16.7	34.5	5.0	14.5	5.51*	19.6	6.8	34.9	18.3	8.0	43.9	1.73	28.9	9.3	32.0	25.9	10.6	40.8	2.81*
GD	101	35.4	4.9	13.9	37.8	5.4	14.4	3.26*	22.0	6.5	29.4	22.0	6.5	31.9	0.01	32.3	6.7	20.9	31.8	8.2	25.8	0.42
GN	85	35.5	4.8	13.7	38.2	5.1	13.5	3.46*	23.1	6.8	29.4	23.1	6.3	27.2	0.04	30.8	8.5	27.6	30.0	7.7	25.9	0.65
HA	85	32.1	4.2	13.2	34.3	3.9	11.5	3.56*	20.8	6.8	32.4	20.1	6.8	33.9	0.74	30.8	7.3	23.5	27.3	7.5	27.5	3.19*
HT	537	35.9	5.5	15.2	38.0	5.3	14.1	6.23*	23.4	7.0	29.9	22.1	8.1	36.8	2.82*	33.4	8.5	25.6	30.2	10.4	34.4	5.53
KA	83	34.0	4.7	13.8	35.4	7.0	19.7	1.64	23.1	6.9	30.2	21.9	7.3	33.2	1.01	34.4	7.1	20.7	31.6	9.2	29.1	2.27*
KH	160	34.9	5.8	16.6	35.5	5.4	15.2	0.92	19.8	7.9	39.8	20.7	7.6	31.0	0.91	30.2	10.5	34.9	29.5	9.1	30.9	0.57
KT	420	33.6	4.8	14.3	34.8	5.2	14.8	3.56*	20.5	6.6	32.3	19.6	7.9	40.6	1.86	30.7	8.4	27.4	28.1	10.2	36.2	4.07*
KU	83	33.4	5.7	17.2	35.6	6.0	16.9	2.44*	23.0	4.5	19.7	22.1	4.9	22.2	1.28	32.0	5.5	17.2	29.3	5.7	19.7	3.11*
LA	102	36.7	5.8	15.8	39.0	5.7	14.8	2.87*	24.9	7.7	31.1	24.2	9.0	37.4	0.98	33.6	8.3	24.6	30.3	10.3	33.9	1.70
ME	166	33.2	4.7	14.4	34.9	4.6	13.3	3.20*	21.4	7.2	33.6	20.1	8.6	42.9	1.49	29.1	8.7	29.9	25.3	10.4	40.9	3.60*
SA	81	35.6	5.9	16.5	37.1	5.9	15.9	2.0*	21.5	6.2	29.0	21.4	6.0	28.1	0.09	30.8	7.9	25.8	29.4	7.8	26.4	0.85
SU	82	31.6	5.5	17.3	34.2	5.5	16.0	2.95*	20.9	6.7	31.9	20.1	8.4	41.9	0.72	31.3	8.3	26.5	27.4	10.8	39.6	2.57*
TE	82	35.7	5.5	15.3	38.1	5.4	14.1	2.86*	21.7	7.8	36.2	20.4	9.3	45.5	0.93	32.3	10.2	31.5	28.8	12.2	42.5	1.97*
TH	110	36.7	5.2	13.7	38.2	5.0	13.2	2.18*	22.2	7.2	32.5	20.3	8.3	41.1	1.85	32.5	8.4	25.9	29.6	10.7	36.3	2.21*
UN	61	36.7	5.7	15.7	37.7	5.8	15.5	0.88	24.3	5.7	23.6	22.5	7.8	34.7	1.44	33.9	6.4	18.9	31.6	9.9	31.3	1.51*
VA	75	35.7	6.5	18.2	37.9	4.4	11.6	2.43*	22.8	6.1	26.6	22.1	8.2	37.2	0.66	33.7	7.1	20.9	30.6	10.3	33.8	2.13*
ZE	106	35.1	5.2	14.8	37.5	4.7	12.6	3.45*	23.0	7.8	33.9	20.8	9.0	43.3	1.89	30.2	10.0	33.2	27.0	11.4	42.4	2.20*
ZA	70	32.7	5.1	15.6	34.6	4.2	12.1	2.36*	21.8	6.1	28.0	19.7	7.1	35.9	1.90	31.2	7.5	23.9	29.4	9.3	31.7	1.26
All Dhangar Castes	2927	34.6	5.5	15.9	36.5	5.5	15.1	13.29*	21.8	7.1	32.5	20.8	8.2	39.2	5.19*	31.5	8.7	27.7	28.7	19.3	35.8	11.15*

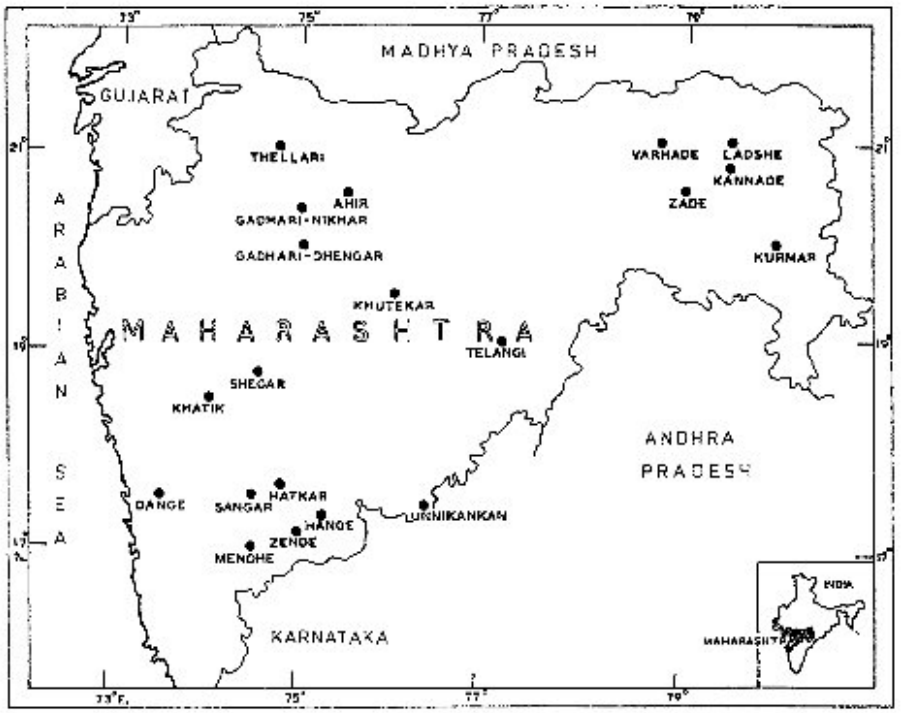

Fig. 1. Geographic location of 20 Dhangar castes in the state of Maharashtra, India (after Malhotra 1979).

among the Dhangar caste-cluster of Maharashtra, India; the population structure, genetic differentiation and other aspects have been thoroughly investigated in a series of papers published earlier (among others see Malhotra et al. 1977, Chakraborty et al. 1977, Malhotra et al. 1978, Malhotra 1979, Malhotra & Gadgil 1981). The specific objective of this paper is to investigate: 1. the nature of distribution of the three interdigital ridge-counts of a-b, b-c and c-d; 2. to study the affinities between the 20 Dhangar castes based on interdigital ridge-counts; and 3. to compare the results with other distance measures based on other palmar dermatoglyphic, anthropometric and serological characters among the Dhangar castes.

Materials and methods

Data

The palmar prints used for this paper have been collected during 1969–1974 as a part of a multidisciplinary project. The data consist of 2927 normal males belonging to 20 castes between the age from 18 to 60 years. The sample sizes vary from 61 to 537 with a series average of about 146 subjects. The Dhangar castes are spread over 82 Thesils among 177 villages of all the 26 districts of Maharashtra. The data were generated as per the random sampling design prepared by Drs. T.H. Hanurao and R. Chakraborty of the Indian Statistical Institute, Calcutta. The names and sample sizes of the 20 castes are given in Table 1 and their geographical locations in Maharashtra are shown in Fig. 1.

The Dhangar castes

The Dhangar caste-cluster, numbering over 3 million, comprises of 23 endogamous castes. Some of these are highly localized whereas others are found in several districts. Their population size varies from a few thousand to more than 100,000. They are in different stages of sedentariness: some are settled, others are semi nomads and a few continue to be true nomads. Although popularly the word Dhangar refers to shepherds, these castes are engaged in a variety of traditional occupations: sheep rearing, woolen blanket weaving, cattle breeding, agriculture, meat selling and cotton blanket weaving.

At least four different languages – Marathi, Hindi, Telugu, Kannada – are spoken by these people. Some of the castes have been living in their present habitat for several centuries, whereas a few are recent immigrants. Further details about their ethnographic accounts are given in Malhotra & Gadgil (1981).

Methods

The prints were collected from apparently normal healthy individuals by the standard ink method on specially designed printed glazed sheets. The interdigital palmar ridge-counts were obtained following Holt (1968). In the total sample of Dhangars, there were about 6.5 % of individuals with missing c triradius. Among the castes, it was less than 5 % in 9 castes, between 5 to 9 % in 8 castes and about 10 % in three castes (Ahir, Shegar and Varhade). Palms where triradius c was absent were not included in the study. Equality of means was tested by using F-statistics; equality of standard deviations by employing Hartley and Pearson's method (1946); and bilateral comparisons were tested by using t-statistics. The normality of distribution was tested by computing statistics g_1 (measure of skewness) and g_2 (measure of kurtosis). The analysis was performed by using the BMDP 2D package. The significance of g_1 and g_2 was examined by w statistics.

Results

Variation in average ridge-count

The mean, standard deviation (SD) and coefficient of variation (CV) of a-b, b-c and c-d interdigital ridge-counts for right and left palms and bilateral differences are shown in Table 1. The results show wide variations between the three ridge-counts and between the castes. The range of mean a-b ridge count varies from 31.6 among Shegar and 36.7 in three castes (Ladshe, Thellari and Unnikankan) on the right palm, while on left it ranges from 34.2 among Shekar to 39.2 in Ladshe. The SD ranges from 4.2 among Hande to 6.5 in Varhade, on the right palm, while on the left palm it ranges from 3.9 among Hande and 7.0 in Kannade.

There is a wide variation in b-c ridge-count on both right and left palms among the Dhangar castes. The mean on right palm ranges from 19.6 in Dange to a maximum of 24.9 in Ladshe and Unnikankan, while on left palm it ranges from 18.3 among Dange to 24.2 in Ladshe. The SD on right palm ranges from 4.5 in Kurmar to 7.9 in Khatik, and on left palm it ranges from 4.9 in Kurmar to 9.3 in Telangi. The CV ranges from 19.7 in Kurmar to 39.8 in Khatik on right palm, while on left palm it ranges from 22.2 in Kurmar to 47.7 in Ahirs.

The c-d ridge count ranges from 28.9 in Dange to 34.4 in Kannade on right palm, while on left palm it ranges from 25.3 among Mendhe to 31.8 in Gadhari-Dhengar. The SD ranges on right palm from 5.5 in Kurmar to 10.0 in Zende and on left palm the range is between 5.7 in Kurmar and 12.2 in Telangi. The CV ranges from 17.2 among Kurmar to 34.9 in Khatik on right plam, while on left palm it ranges from

Table 2. Mean, SD and CV of a-b, b-c and c-d ridge-counts among the Dhangar castes (both palms combined).

Dhangar Castes	N	a–b			b–c			c–d		
		Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Ahir	267	70.38	10.35	14.7	39.37	15.44	36.6	56.11	18.65	33.2
Dange	172	67.32	8.44	12.5	38.30	13.26	34.6	55.35	17.30	31.3
G. Dhengar	101	73.34	9.26	12.6	44.01	12.57	25.6	64.19	14.04	21.9
G. Nikhar	85	73.75	9.50	12.8	46.26	11.85	25.6	60.81	14.94	24.6
Hande	84	66.35	7.06	10.6	40.96	12.50	30.5	58.13	13.08	22.5
Hatkar	537	73.97	10.04	13.5	45.56	13.88	30.5	63.56	17.02	26.8
Kannade	83	70.34	8.38	11.9	45.61	12.73	27.9	66.76	13.86	20.7
Khatik	160	70.44	10.20	14.4	40.57	14.11	34.7	59.75	16.58	27.7
Khutekar	420	68.52	9.22	13.4	40.21	13.45	33.4	58.96	16.74	28.4
Kurmar	83	68.98	10.87	15.7	45.08	8.30	18.4	61.31	9.63	15.7
Ladshe	102	75.74	10.85	14.3	49.16	15.96	32.5	64.12	16.95	26.4
Mendhe	166	68.09	8.62	12.6	41.58	14.16	34.0	54.40	17.06	31.4
Sangar	81	72.81	10.72	14.7	42.96	10.96	25.5	60.38	13.55	22.4
Shegar	82	65.85	10.07	15.3	41.05	13.42	32.7	58.78	16.84	28.6
Telangi	82	73.83	10.02	13.6	42.13	15.27	36.2	61.16	19.14	31.3
Thellari	110	74.98	9.06	12.1	42.48	13.94	32.8	62.15	15.99	25.7
Umbikankan	61	74.48	10.6	14.3	46.82	12.44	26.6	65.56	14.70	22.4
Varhade	73	73.74	9.30	12.6	44.93	13.22	29.4	64.36	16.07	24.9
Zende	106	72.56	9.19	12.6	43.88	14.90	33.9	57.26	19.40	33.8
Zade	70	67.29	8.47	12.6	41.89	11.83	28.2	61.11	13.79	22.5
All Dhangar Castes	2925	71.08	10.03	14.1	42.76	13.92	32.6	60.28	16.85	27.98

19.7 among Kurmar to 45.1 in Ahir. Significant bilateral differences are found in 17 castes in case of a-b ridge-count and in 13 castes in case of c-d. But the Dhangar castes do not show bilateral differences in b-c ridge count, except in case of Hatkar ($t = 2.82$, d.f. 5, $p < 0.05$).

In the pooled sample, the left palms show higher a-b ridge-counts (36.5) than the right palms (34.6) but the corresponding variances are equal (5.5) on both palms. In case of b-c ridge-count the right palm shows higher (21.8) average than the left (20.8); however, the left palms show higher variability (8.2) than the right palms (7.1). The c-d ridge-count shows the same trend observed in case of b-c ridge-count, but the bilateral differences in mean and SD are higher; the right palm shows higher mean (31.5) than the left (28.7) but lower SD (8.7) compared to left (10.3).

The mean, SD and CV for the three interdigital ridge-counts for both palms combined are shown in Table 2. Shegar caste shows the least average (65.83) and Ladshe shows the maximum (75.74) average in a-b ridge-count. The variances range from 7.06 in Hande to 10.87 in Kurmar. The CV ranges from 10.6 in Hande to 15.7 in Kurmar.

The b-c ridge-count varies from 38.30 among Dange to 49.16 in Ladshe, whereas the SD ranges from 8.30 in Kurmar to 15.96 in Ladshe. The CV suggests wide differences within Kurmar (18.4) but least among Ahir (36.6).

The average c-d ridge-count varies from 54.4 in Mendhe to 66.76 in Kannade. The Kurmar show the least variability (9.63) and Zende (19.46) the maximum variability. The CV ranges from 15.7 among Kurmar to 33.8 in Zende.

Table 3. F-values with level of significance for testing the equality of means of a-b, b-c and c-d interdigital ridge-counts.

Interdigital ridge-counts	R	L	R+L
a-b	10.81*	12.54*	13.72*
b-c	6.43*	4.69*	6.18*
c-d	5.48*	5.13*	4.07*

* $p \leq 0.05$

Table 4. Values of M-Statistics and M'-Statistics for testing equality of Standard deviations of a-b, b-c and c-d interdigital ridge-counts.

Interdigital ridge-counts	M-Statistics			M'-Statistics		
	R	L	R+L	R	L	R+L
a-b	43.87*	87.50*	58.05*	44.01*	87.79*	59.99*
b-c	53.56*	81.71*	66.96*	53.74*	81.98*	67.18*
c-d	93.61*	99.59*	83.62*	93.92*	99.92*	83.90

1 = d.f. = 19 (in all cases);
* Significant at 5 % and below levels.

In the pooled sample the average a-b ridge-count shows the highest value (71.08) followed by c-d (60.28) and b-c (40.26). In case of variances, c-d shows maximum variability (16.85) compared to b-c (13.92) and a-b (10.03) ridge-counts. The coefficient of variation suggests that both b-c (32.6) and c-d (27.9) are quite heterogeneous from a-b (14.1) ridge-count.

Overall, the Dhangar castes show wide variations in all the three ridge-counts. Some castes tend to show higher or lower averages for all the ridge-counts especially in b-c and c-d. The estimates of CV suggest least differences within each of the Dhangar castes in case of a-b, but wide differences in b-c and c-d ridge-counts. The analysis of variance test (Table 3) and M and M' estimates (Table 4) show significant differences in mean and variance of all the three ridge-counts between the Dhangar castes, on right, on left and on both palms combined. Further, the pairwise t-test indicates significant differences in at least six castes (Ahir, Dange, Hande, Kannade, Khatik, Khutekar and Shegar) from others in a-b ridge-count. Similar significant differendes were also found in b-c ridge-count for Dange and Ladshe castes and in c-d ridge-count in case of Dange, Kannade and Mendhe when compared to other castes. Thus the univariate analysis shows wide differences in the three interdigital ridge-counts among the Dhangar castes.

Frequency distributions

The minimum and maximum values of the three ridge-counts differ widely between the 20 Dhangar castes: The minimum a-b ridge-count shows a range between 35 in Varhade to 57 in Unnikankan and the maximum ranges from 88 in Kannade to 114 in Hatkar (and in Khutekar). The minimum b-c ridge-count also shows wide

Table 5. Measures of skewness, kurtosis and test of normality of the interdigital ridge-count distributions of a-b, b-c and c-d.

Dhangar Castes	a-b			b-c			c-d		
	g_1	g_2	w-statistics	g_1	g_2	w-statistics	g_1	g_2	w-statistics
Right									
Ahir	−0.17	0.04	0.92	0.01	0.46	0.92	−0.62	1.11	0.91
Dange	0.10	0.48	0.91	0.04	0.05	0.89	0.18	0.21	0.91
Hatkar	0.42	0.99	0.91	0.13	0.23	0.92	−0.33	0.04	0.91
Khutekar	0.52	1.56	0.89	0.23	0.08	0.91	−0.17	0.78	0.93
All Dhangar Castes	0.32	0.68	*	0.17	0.04	*	−0.25	0.31	*
Left									
Ahir	0.50	0.77	0.91	−0.15	−0.35	0.89	0.19	0.16	0.90
Dange	0.03	0.06	0.89	−0.36	0.34	0.90	−0.25	0.78	0.90
Hatkar	0.49	1.01	0.91	0.02	0.39	0.90	−0.05	0.05	0.92
Khutekar	0.48	0.92	0.90	0.08	0.33	0.92	−0.25	0.39	0.91
All Dhangar Castes	0.44	0.82	*	0.02	−0.16	*	−0.11	0.28	*
Right + Left									
Ahir	0.40	0.61	0.90	−0.63	−0.11	0.88	−1.23	0.62	0.84
Dange	0.19	0.0	0.88	−0.62	0.16	0.89	−0.95	0.82	0.85
Hatkar	0.41	1.06	0.90	−0.50	0.37	0.91	−1.05	1.38	0.87
Khutekar	0.58	1.59	0.89	0.29	0.31	0.92	−0.89	1.23	0.89
All Dhangar Castes	0.42	0.78	*	−0.40	0.21	*	−0.93	1.17	*

The values w-statistics are not significant
* The values are not computed due to large sample size (> 2000)

variation from 2 in Khutekar to 22 in Kurmar and the maximum ranges from 65 in Telangi to 80 in Hatkar. In the c-d ridge count the minimum varies from 11 in Mendhe to 35 in Kurmar and the maximum ranges from 81 in Zende to 103 in Hatkar. Interestingly, the Hatkars consistently show the maximum range of variation in all three ridge-counts. Similar trends of equally higher range of minimum ridge-counts in b-c and c-d interdigitals are observed in Kurmar and in lower range of maximum ridge-count in case of a-b and c-d interdigitals in Hande caste. The results indicate a wide variation in the distribution pattern of the three interdigital ridge-counts in different subcastes of the Dhangar.

In case of right and left hands, the pattern of variation in the range of distribution of the three interdigital ridge-counts follows the same trend as observed in case of combined data, except for some small deviations.

Therefore to examine the nature of distributions of the three interdigital ridge-counts as a first step, we plotted the frequency of ridge-counts separately for each caste. Visual inspection of the histograms suggested normal distribution in all ridge-counts in all castes irrespective of size and right plus left totals. The frequency distributions of ridge-counts of only four Dhangar castes (Ahir, Dange, Hatkar and Khutekar), where the sample sizes are large (177 to 537), and the pooled samples of

Table 6. Penrose's C²H biological distances for palmar interdigital ridge counts in 20 Dhangar castes.

Populations		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Ahir	AH	–	0.503	1.511	1.261	3.095	0.443	2.270	0.349	0.274	6.519	0.291	0.454	1.288	0.173	0.129	1.054	1.199	0.974	0.443	1.413
2 Dange	DA		–	0.755	0.612	1.241	0.271	1.096	0.436	0.137	6.364	0.456	2.778	1.348	0.726	0.129	0.196	1.023	0.304	0.024	0.648
3 Gadhari Dhangar	GD			–	0.146	0.750	0.352	0.097	0.786	0.534	3.140	0.560	0.744	0.487	1.091	0.917	0.267	0.234	0.111	0.979	2.362
4 Gadhari-Nikhar	GN				–	1.069	0.219	0.353	0.670	0.416	3.294	0.458	0.577	0.364	0.849	0.744	0.344	0.190	0.096	0.730	0.098
5 Hande	HA					–	1.543	0.413	2.359	1.599	5.883	2.106	1.313	2.401	3.011	1.983	0.541	1.791	0.788	1.533	0.728
6 Hatkar	HT						–	0.733	0.132	0.045	4.196	0.064	0.733	4.893	0.265	0.188	0.302	0.271	0.134	0.335	0.295
7 Kande	KA							–	1.395	0.985	3.336	1.136	1.105	0.936	1.825	1.454	0.389	0.584	0.303	1.379	0.118
8 Khatik	KH								–	0.099	4.825	0.026	0.387	0.610	0.061	0.131	0.662	0.305	0.494	0.470	0.735
9 Khutekar	KT									–	5.077	0.093	0.110	0.716	0.268	0.266	0.283	0.523	0.216	0.181	0.464
10 Kumar	KU										–	4.291	6.243	2.044	4.646	6.380	5.184	2.343	4.371	6.747	3.290
11 Ladshe	LA											–	0.405	0.397	0.094	0.199	0.563	0.316	0.350	0.515	0.520
12 Mendhe	ME												–	1.266	0.652	0.304	0.214	0.963	0.610	0.019	0.639
13 Sangar	SA													–	0.057	1.089	1.095	0.046	0.589	1.477	0.490
14 Shegar	SH														–	0.289	1.058	0.596	0.771	0.714	1.031
15 Telangi	TE															–	0.462	0.889	0.460	0.124	0.824
16 Thetari	TH																	0.717	0.086	0.344	0.219
17 Umrikar-kar	UN																	–	0.325	1.177	0.237
18 Varhade	VA																		–	0.439	0.067
19 Zende	ZE																			–	0.849
20 Zade	ZA																				–

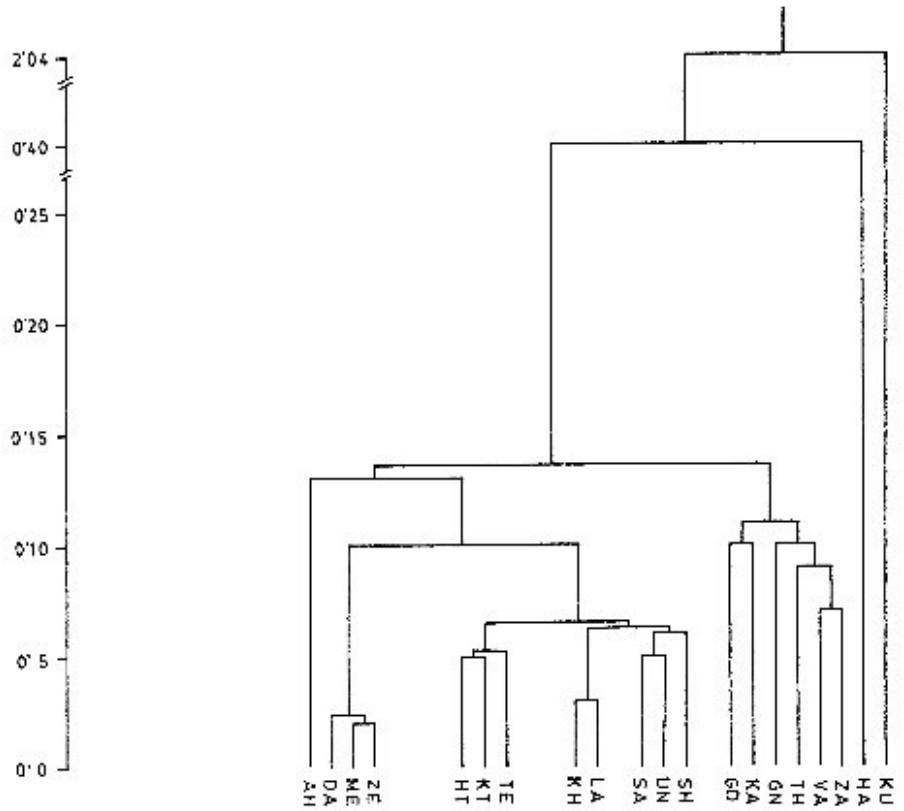

Fig. 2. Dendrogram of the 20 Dhangar castes based on Penrose's C^2H distances in respect of palmar interdigital ridge-counts; abbreviations see Table 6.

all the 20 Dhangar castes have been considered for statistical test of normality (Table 5). The results show the least deviation from normality for all the three ridge-counts. They show equal mode and median but they differ in mean ridge-counts. All the four castes and the pooled Dhangar data show a nearly normal distribution with slight tendency of negative skewness in b–c and c–d ridge-counts, whereas a–b depicts a weak trend to be positively skewed. Of the three ridge-counts, b–c depicts least platykurtosis and c–d shows the maximum. Hatkar, Khatekar and the pooled sample show platykurtosis, especially in c–d ridge-count. No such pattern is observed in case of skewness. The pattern of distribution in both right and left palms follows the same trend as above.

Cluster analysis

Based on the three interdigital ridge-counts, distances between the Dhangar castes were computed using Penrose's C^2H distance measure (Table 6) and a dendrogram was constructed based on the distance matrices following the single linkage method of clustering (Fig. 2). An examination of the dendrogram reveals the following:

The two castes Kurmar and Hande stand out separately from each other as well as from the rest of 18 Dhangar castes. The remaining 18 castes form basically three major clusters with varying degree of heterogeneity between them. The six castes, Zade, Varhade, Thellari, Kannade, Gadhari Dhengar and Gadhari Nikhar form a separate cluster. The second major cluster consists of 8 castes, which form three subclusters; Shegar, Unnikankan and Sangar form the first, Ladshe and Khatik form the second, and Thellari, Khutekar and Hatkar form the third. The third major cluster consists of three castes (Zende, Mendhe and Dange) with least differences between them and show close affinity with the second major cluster. The Ahir caste is the third most differentiated caste, after Kurmar and Hande, which cluster with the second and the third major clusters.

Discussion

Though the normal distribution with slight tendency of negative and positive skewness in the three interdigital ridge-counts is observed in case of four numerically large castes, it is highly probable that other Dhangar castes also show the same trend irrespective of sample size. A review of literature suggests paucity of data on the distributions, however a few studies that investigated these distributions suggest no definite trend. Some indicate a nearly normal distribution, as was observed among Telugu Brahmin castes (both male and female samples and in both the palms) of Andhra Pradesh (Mathew 1980) and among female sample of Rastogi caste of Lucknow (Rastogi & Shukla 1969), however male samples of the study did not show the same. In contrast, studies by Pons (1964) from Spain and by Vrydagh-Laoureux (1970) from Belgium showed positively skewed distributions. Dennis (1977) found the same among the North Pennine Dales and Kenya. The sample size in the zero class is one of the factors that may influence the distribution pattern. However, absence of a-b ridge counts occurs in rather low frequencies in different populations. In the pooled sample of Dhangars only 2 (0.07 %) instances were observed. Therefore, the observed skewed distribution for Spain, Belgium and among Dales and Kenya, is caused by other reasons than the sample size in the zero class.

The consistent normal distribution observed in the three interdigital ridge-counts, is in conformity with the results obtained in embryological studies that the ridge formation is likely to affect the entire palmar surface, which influences the size and shape of the distribution equally in all the configurational areas. The ridge formation is also influenced by the position of the volar pads, which are not equidistant for the four triradii, and hence the ridge counts are different: it is greater for a-b than for b-c and c-d. In fact, the results obtained from the correlation between the interdigital ridge-counts in pooled Dhangar castes show significant ($p < 0.05$) correlations (higher) between b-c and a-b (0.22) and between b-c and c-d (0.22), but it is negative and nonsigificant between a-b and c-d (−0.08). In general, the other castes show higher correlations for b-c and c-d than for b-c and a-b (Karmakar 1984). Possibly this explains the slight negative skewness obtained in the b-c and c-d and the platykurtosis in c-d ridge counts.

It can be tentatively inferred from the study that possibly the normal distribution is the general characteristic of b-c and c-d ridge-counts, irrespective of sample size, though it is difficult to verify these results due to the almost total absence of such data on other populations. The results imply that the polygenetic model proposed

for other quantitative genetic characters is suitable for the palmar interdigital ridge-counts. The results also imply that the parametric tests, without the statistical necessity of transformation for adjustment to normal distribution, can be used for population comparisons.

Similar to finger ridge-count, the palmar interdigital ridge-counts also show high heritability estimates which vary among human populations and depict considerable ethnic variation. The results obtained among the Dhangar castes confirm the earlier observations, especially that they also show wide differences between themselves in the three individual ridge counts. Overall, the three interdigital ridge-counts reflect similar pattern of relationship between the Dhangar castes, and it is more so for b-c and c-d than for a-b ridge-counts. The dendrogram suggests that the pattern is least influenced by the exclusion of individuals with missing c-triradius; the three castes (Ahir, Shegar, Varhade) where the frequency was about 10 %, do not show the same pattern, but cluster separately castes. For example, the rank correlations between a-b and b-c (0.758), b-c and c-d (0.776) and between a-b and c-d (0.612) show significant ($p < 0.05$) association. Several results of the present study, especially the decreasing order of magnitude of interdigital ridge-counts: a-b > c-d > b-c and the bilateral differences are in agreement with other investigators (e.g., Sunderland & Coope 1973, Mathew 1980, Karmakar & Malhotra 1981, Reddy et al. 1988).

One of the objectives of the study is to examine whether the palmar interdigital ridge-counts can reflect the known biological relationship among the Dhangar castes and whether the obtained pattern agrees with the ethno-historical information and the pattern of affinities obtained from anthropometric, serological and other palmar and finger dermatoglyphic characters. The Dhangar castes differ in their population size, some castes are small restricted to one or two districts, while some others are numerically large and are spread to many districts of Maharashtra. These castes also show differences in their occupation, language and population structure variables e.g., mating pattern. The castes in southern districts tend to show greater levels of inbreeding due to preferential consanguineous marriages compared to castes in northern Maharashtra, where such practices are less preferred (Malhotra 1984). These wide differences among the subdivided populations suggest a greater degree of homogeneity among smaller localized castes (e.g., Hande, Kannade and Telangi) and greater diversity among the numerically large and wide spread castes (e.g., Hatkar, Dange, Ahir). Based on the ethnological information, the following patterns of biological affinities of Dhangar castes are expected: 1. Dange, Hatkar, Zende and Thellari to cluster together. 2. The Kurmar to be more related to the southern castes like Shegar, Khatik, Mendhe, Zende etc. 3. The two Gadhari castes to be different from other castes. 4. Ahir caste to show close affinity to southern and eastern castes.

The clustering pattern based on the three interdigital ridge-counts is in agreement with the above expectations with some deviations. Three caste Hande and the two Gadhari castes do not confirm to the expected affinities. Let us now examine how far this pattern of affinities between the Dhangar castes agree with the pattern obtained from other palmar and dermatoglyphic variables. Recently Kamali et al. (1986) and Malhotra et al. (1993) examined population differentiation among Dhangar castes and the population of Iran on the basis of palmar pattern ridge-counts. The patterns of affinities obtained are in agreement with the known ethnic historical background of the populations. The other palmar dermatoglyphic char-

acters examined, i. e., palmar flexion creases (Karmakar & Malhotra 1986a), main-line terminations (Karmakar & Malhotra 1986b), hypothenar triradii (Karmakar & Malhotra 1981) among the Dhangar castes also reveal a high degree of differentiation. Compared to all other palmar elements examined so far, the axial triradii (Karmakar & Malhotra 1978) show least intercaste differentiation.

The clustering pattern based on 9 palmar quantitative variables including the three interdigital ridge counts also shows a more or less similar pattern of clustering (Karmakar et al. 1989) with some differences, especially the Kurmar show close affinities with Dange and Hatkar. Further, Ahir, Shegar, Ladshe and Kannade deviate from other castes, what was not expected. The clustering pattern based on qualitative dermatoglyphic variables also shows similar patterns observed in case of palmar quantitative characters. Of the three dermatoglyphic clustering patterns, the clustering pattern based on the interdigital ridge-counts is in better agreement with the ethno-historical information.

This illustrates the usefulness of the interdigital ridge-counts in studying ethnic affinities in subdivided populations. The anthropometric clustering of Dhangar castes based on 18 body measurements shows a pattern of clustering which follows the geographical propinquity of castes (Malhotra et al., nd), which is not observed in case of dermatoglyphic variables. Likewise, in case of serological data the Dhangar castes showed relationships which are not based on geographic proximity (Malhotra et al. 1978).

In general, the pattern of distribution based on genetic traits and dermatoglyphic variables show strong agreement (Karmakar et al. 1989, Karmakar 1990). Therefore, the observation that dermatoglyphic characters are in general fuzzy and do not show clear population affinities does not get support from this study. Furthermore, the study demonstrates that the interdigital ridge-counts like other biological characters are extremely useful in studying inter-population affinities.

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