| Anthrop. Anz. | Jg. 46 | 3 | 235–244 | Stuttgart, September 1988 |
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# Quantitative palmar dermatoglyphics and the assessment of population affinities: Data from marine fishermen of Puri, India

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With 2 figures and 7 tables in the text

**Summary:** Variation in quantitative dermatoglyphics among three endogamous groups of marine fishermen of Puri Coast, India, is greater for the palmar variables than for the fingers. This is the case in both the sexes. The pattern of population affinities, however, differs for the males and females. In order to evaluate the importance of palmar variables in population studies, the results in males are compared with those of finger variables and anthropometrics. There is no significant heterogeneity between the groups for finger variables. Although significant inter-group variability is observed in the palmar and anthropometric traits, the two sets of results are not in the same direction. Palmar dermatoglyphic relationships reflect the caste affiliations, while the anthropometric are in line with geographic proximity.

**Zusammenfassung:** An drei endogamen Fischerbevölkerungen von der Puri Coast (Indien) wurde die Variabilität von quantitativen Hautleistenmerkmalen untersucht. In beiden Geschlechtern ist diese bei der palmaren Variablen größer als bei denen der Finger. Dagegen zeigen Männer und Frauen unterschiedliche Ähnlichkeitsbeziehungen zwischen diesen Bevölkerungen. Um die Bedeutung der palmaren Variablen für Populationsstudien zu erfassen, wurden für die Männer die entsprechenden Ergebnisse mit denen für anthropometrische Variable und Hautleistenmerkmalen der Finger verglichen. Obwohl sowohl für die palmaren und anthropometrischen Merkmale signifikante Intergruppenvariabilität vorliegt, liegt diese nicht in der gleichen Richtung. Erstere reflektieren Kastenunterschiede, letztere gehen mit der geographischen Entfernung zwischen den Gruppen einher.

## Introduction

In an earlier paper (Reddy et al. 1986) we have examined biological affinities between the three endogamous groups of fishermen of Puri coast, India, using a set of anthropometric and dermatoglyphic variables each. The results based on the anthropometric measurements suggested closer similarity between sympatric populations rather than ethnically similar ones. The dermatoglyphic traits, however, did not provide a clear picture regarding ethnic or geographic affiliations. Disagreement in the pattern of population affinities, based on anthropometrics and dermatoglyphics, has been observed in many earlier studies (Chai 1972; Neel et al. 1974; Friedlaender 1975; Rudan 1978; Jantz & Chopra 1983). This is generally interpreted as a result of the different roles of evolutionary and/or environmental factors causing variation in the two sets of variables. But, even within dermatoglyphics, different methodologies may lead to different results (Jantz & Chopra 1983); it depends on whether the variables are qualitative or quantitative and whether fingers only or fingers and palms are both considered. Our earlier study using quantitative finger and some selected palmar variables showed greater intergroup heterogeneity of palmar variables than the fingers, as also observed earlier (Jantz & Chopra 1983). Further, palmar variables are found to have rather low correlations with those of fingers (Knussmann 1967; Loesch 1971, 1986; Froehlich 1976; Chopra 1979, 1982; Skrinjaric 1981; Malhotra et al. 1981) and, therefore, may provide additional information. Since only a limited number of palmar variables like number of triradii in palm, main line index, and a-b ridge count were used in our previous study, it was of interest to examine interpopulation variation, as shown by a large number of quantitative palmar variables only. Malhotra et al. (1982) suggested quantifying the palmar patterns, by analogy with fingers, by counting the ridges. Following their methodology, we have increased our set of quantitative palmar variables to study the intergroup variation in the Puri population.

## Materials and methods

During 1977 and 1978 rolled finger and dab palm prints from 676 individuals (394 males and 282 females), aged between 8 and 75 years, were collected by ink and roller method (Cummins & Midlo 1943). However, palm prints of only 560 individuals (292 males and 268 females) could be used in this study. Sex and population-wise sample sizes can be seen from Tables 2 and 3. While interdigital ridge counts, maximum atd-angle, palmar triradii and main line index were scored following Cummins & Midlo (1943) and Holt (1968), the ridge count of palmar patterns were determined following Malhotra et al. (1982).

Both univariate and multivariate analyses were employed to decipher the pattern of overall group heterogeneity. In addition to this, the importance of each variable in discriminating the groups has also been examined. The computations were done with the help of SAS packages (SAS, 1982).

In a recent paper, Kamali et al. (1986), while applying multivariate statistical tests to ridge counts of palmar patterns in different interdigital areas, excluded zero values to avoid bimodality caused by these cases. However, in our sample the frequency of zero values is high (range from 52 to 82 %, 96 to 100 %, 81 to 98 %, 24 to 74 %, and 26 to 64 %, in hypothenar, Th/I, II, III, and IV interdigital areas, respectively) making them unsuitable for quantitative treatment, at least in our populations. Therefore, only distal palmar pattern ridge counts (DPPRC) and total palmar pattern ridge counts (TPPRC) were used, which were derived by pooling ridge counts of patterns in distal palmar areas, and all palmar areas, respectively.

## Population backgrounds

Marine fishermen of Puri are migrants. They constitute three endogamous groups, namely *Vadabalija of Penticotta* (VP), *Vadabalija of Vadapeta* (VV), and *Jalari* (JL). While the VP migrated some 30 years ago, from 48 villages in East Godavari, West Godavari, and Visakapatnam districts of coastal Andhra Pradesh the VV and JL did so a century ago, from 42 to 17 villages, respectively, in Srikakulam district of Andhra Pradesh and the contiguous district of Ganjam in Orissa. The last two populations thus overlap geographically even in their ancestral places. The population sizes of the three groups at Puri are about 8000, 4000, and 800, respectively. Although the VP and VV belong to the same caste, *Vadabalija*, they are reproductively isolated both at Puri and in their places of origin. The exchange of mates between them is only about 1 %, and that of the JL with the two *Vadabalija* groups is non-existent. Gene flow from any other population could not be recognized. The scheme of interrelationships between the three fishing groups, based on ethnohistorical and demographic information, is summarized in Table 1. More detailed information about these groups is given in Reddy (1984); see also Schömbucher (1986).

Table 1. Scheme of interrelationships of the fishing groups.

| | VP and VV | VP and J | VV and J |
|---|---|---|---|
| Ethnically similar | * | – | – |
| Intermarry | – | – | – |
| Sympatric | – | – | * |
| Similar in occupational pattern | – | – | * |
| Similar migrational backgrounds | – | – | * |
| Similar demographic pattern | – | – | * |

## Results and discussion

Descriptive statistics together with univariate F-ratios for each of the studied variables are presented in Tables 2 and 3. The analysis of variance results shows significant population heterogeneity ($p \leqslant 0.05$) in most of the variables. But there is also a sex difference. For example, while females do not show heterogeneity in TPPRC(L), number of triaridii, and main line index, males show such a pattern. Further, the magnitude of intergroup heterogeneity is in general larger in males than in females in most of these characters.

Although to a lesser degree, compared to fingers, palmar variables are also intercorrelated (Knussmann 1967; Loesch 1971, 1974, 1983; Malhotra et al. 1981, 1982). Our analysis based on Spearman's rank correlation, computed for males and females separately, suggests a similar trend. For the sake of brevity, the intercorrelation results are not presented in this paper. In view of these intercorrelations, multiple discriminant analysis was thought appropriate to give an overall picture of palmar dermatoglyphic affinities among these fishermen populations. This method transforms original variables into a set of multivariate vectors which are a linear combination of independent variables. In this process of transformation, intercorrelation of variables is taken into account, and the ratio of among group variance to total variance is maximized (Tatsuoka 1971). It should be, however, mentioned that the multivariate approach in the present context is considered descriptive and heuristic, as some of the assumptions made in the analysis are not met, especially that most of these variables show non-normal distribution.

Table 2. Mean and SD of the quantitative palmar dermatoglyphic variables in males along with F-ratios for intergroup heterogeneity.

| Variables | | VP (n = 99) | | VV (n = 85) | | J (n = 108) | | F-ratio |
|---|---|---|---|---|---|---|---|---|
| | | Mean± | SD | Mean± | SD | Mean± | SD | |
| Distal palmar pattern ridge | R | 9.89 | 6.35 | 11.66 | 7.79 | 13.11 | 6.99 | 6.34** |
| count (DPPRC) | L | 8.28 | 6.33 | 9.31 | 6.39 | 12.00 | 7.06 | 9.53** |
| Total palmar pattern ridge | R | 13.58 | 11.20 | 16.54 | 12.13 | 17.93 | 10.33 | 4.33* |
| count (TPPRC) | L | 12.10 | 10.32 | 13.28 | 9.69 | 17.94 | 11.01 | 9.37** |
| a-b ridge count | R | 36.97 | 7.02 | 38.67 | 5.96 | 38.26 | 5.12 | 2.04 |
| a-b ridge count | L | 38.51 | 6.85 | 40.55 | 6.00 | 40.06 | 5.19 | 2.98* |
| b-c ridge count | R | 20.73 | 8.32 | 21.29 | 7.03 | 29.07 | 5.80 | 44.27** |
| b-c ridge count | L | 19.98 | 8.52 | 20.38 | 7.13 | 27.65 | 7.14 | 32.77** |
| c-d ridge count | R | 30.06 | 9.35 | 32.47 | 8.23 | 37.55 | 5.54 | 24.97** |
| c-d ridge count | L | 28.22 | 10.73 | 34.02 | 8.93 | 35.49 | 7.09 | 18.38** |
| atd-angle | R | 41.26 | 7.37 | 43.47 | 8.07 | 43.20 | 9.42 | 2.00 |
| atd-angle | L | 40.30 | 6.60 | 43.60 | 8.41 | 42.82 | 6.55 | 5.51** |
| Triradii on palms | R | 5.75 | 1.03 | 5.97 | 1.07 | 5.62 | 0.81 | 3.03* |
| Triradii on palms | L | 5.93 | 1.04 | 6.13 | 1.28 | 5.65 | 0.78 | 5.30** |
| Main Line Index | R | 9.17 | 1.96 | 9.25 | 1.86 | 8.69 | 1.98 | 2.39 |
| Main Line Index | L | 7.79 | 2.27 | 8.37 | 1.91 | 7.52 | 2.12 | 3.88* |

Table 3. Mean and SD of the quantitative palmar dermatoglyphic variables in females along with F-ratios for intergroup heterogeneity.

| Variables | | VP (n = 92) | | VV (n = 126) | | J (n = 50) | | F-ratio |
|---|---|---|---|---|---|---|---|---|
| | | Mean± | SD | Mean± | SD | Mean± | SD | |
| Distal palmar pattern ridge | R | 9.14 | 6.14 | 13.01 | 6.44 | 9.68 | 7.41 | 10.33** |
| count (DPPRC) | L | 7.54 | 5.85 | 11.30 | 6.65 | 9.62 | 6.57 | 8.09** |
| Total palmar pattern ridge | R | 14.53 | 11.61 | 18.91 | 11.53 | 19.36 | 11.77 | 4.58** |
| count (TPPRC) | L | 13.09 | 11.60 | 16.21 | 10.08 | 15.68 | 9.96 | 2.23 |
| a-b ridge count | R | 36.26 | 6.65 | 37.92 | 5.20 | 38.24 | 5.91 | 2.75 |
| a-b ridge count | L | 37.39 | 6.38 | 40.28 | 5.82 | 40.42 | 6.03 | 7.06** |
| b-c ridge count | R | 19.40 | 6.97 | 24.21 | 7.16 | 21.88 | 8.35 | 11.50** |
| b-c ridge count | L | 17.96 | 10.05 | 22.98 | 8.45 | 22.70 | 9.99 | 8.54** |
| c-d ridge count | R | 28.69 | 8.67 | 34.95 | 9.10 | 30.50 | 9.92 | 13.38** |
| c-d ridge count | L | 24.19 | 13.37 | 33.01 | 11.03 | 28.32 | 10.57 | 14.98** |
| atd-angle | R | 42.59 | 8.05 | 45.21 | 10.00 | 45.92 | 9.46 | 2.91* |
| atd-angle | L | 42.77 | 7.52 | 44.16 | 9.08 | 46.40 | 7.73 | 3.08* |
| Triradii on palms | R | 6.02 | 1.10 | 5.86 | 1.07 | 5.96 | 0.97 | 0.66 |
| Triradii on palms | L | 6.04 | 1.21 | 5.77 | 1.03 | 5.70 | 1.00 | 2.27 |
| Main Line Index | R | 9.13 | 2.00 | 8.85 | 1.84 | 8.72 | 2.24 | 0.86 |
| Main Line Index | L | 7.73 | 2.14 | 8.15 | 2.22 | 7.56 | 2.27 | 1.69 |

## Discriminant analysis

*Palms*

The multivariate test statistics, the Wilk's lambda, derived from the canonical discriminant analysis, and Rao's F-approximation suggest that the discrimination among the groups is significant both in males ($\lambda = 0.5786$; $F = 5.39$, $p < 0.0000$) and females ($\lambda = 6772$; $F = 3.36$, $p < 0.0001$). The group centroids are plotted in Figs. 1 and 2. The canonical correlations suggest that the discrimination on the two variates is highly significant in both males ($p < 0.0001$ and 0.01) and in females ($p < 0.0001$ and 0.05). The first canonical variate accounts for about 76.5 % and 74.5 % of the variation in males and females, respectively, and the rest is explained by the second variate. As there are only three groups, two variates will explain the total variation. From the centroids, it is interesting to find that the *Jalari* (males) separate out from the two *Vadabalija* groups, VP and VV, who are relatively closer to each other. The distance of *Jalari* from the two reproductive isolates of the same caste is approximately the same. This is what would be expected from the case affiliations. Strikingly, the pattern in females is not the same. Here, the VP and JL, who belong to different castes and as well to different geographical areas, are relatively close. However, the differences in distances between populations are rather small and the populations may be considered to be placed more or less at equidistance in the multivariate space (Figs. 1 and 2). These trends can be quantitatively deciphered from the $D^2$ values (Table 4).

To ascertain which of the variables make significant contributions to the discrimination, a step-wise discriminant analysis was performed, using eight and nine

Table 4. Matrix of Mahalanobis' $D^2$-values based on palmar variables between fishing groups, males and females.

| ♂ / ♀ | VP | VV | J |
|---|---|---|---|
| VP | – | 0.9938 | 2.1385 |
| VV | 1.627 | – | 2.5908 |
| J | 1.1685 | 1.1133 | – |

Table 5. Stepwise selection of palmar variables that make significant contribution for group discrimination.

| Sequence | Males | | Females | |
|---|---|---|---|---|
| 1 | b-c ridge count | (R) | c-d-ridge count | (L) |
| 2 | c-d ridge count | (L) | DPPRC | (R) |
| 3 | b-c ridge count | (L) | a-b ridge count | (L) |
| 4 | atd-angle | (L) | Main line index | (L) |
| 5 | c-d ridge count | (R) | Palmar triradii | (L) |
| 6 | Palmar triradii | (L) | TPPRC | (R) |
| 7 | TPPRC | (L) | DPPRC | (L) |
| 8 | a-b ridge count | (R) | b-c ridge count | (L) |
| 9 | – | | atd-angle | (L) |

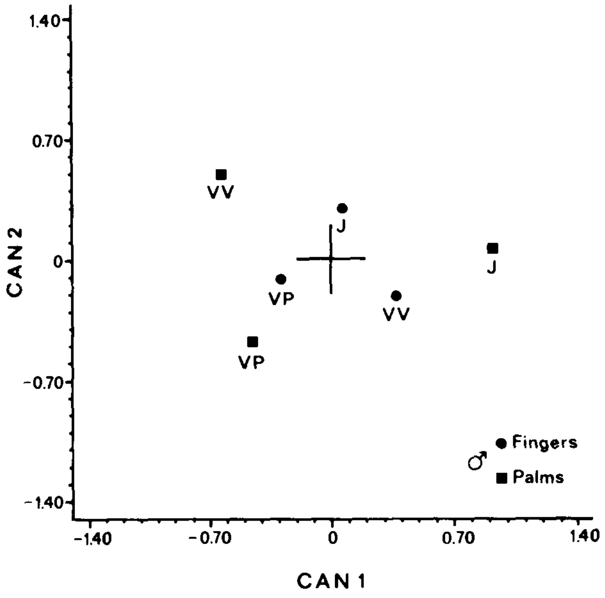


Fig. 1. Plots of centroids of the fishing groups derived from the canonical discriminant analysis of the finger and palmar variables in males.

variables, respectively, in males and females. The variables are arranged in the order of their contribution to group differentiation (Table 5). There is a clear sex difference in the variables selected and their order. Also, the greater importance of variables on left palm is apparent. Main line index and DPPRC are not represented in males, but are in females.

*Fingers*

In order to know the relative importance of palmar variables in tracing populations affinities it is necessary to compare the results with those from fingers. In total, sixteen finger variables (larger of the two ridge counts of the 10 fingers sum of radial ridge counts, ulnar ridge counts, and total number of finger triradii on right and left hands) were used in the analysis. The Wilk's lambda suggests that the discrimination between groups is not significant in males ($\lambda = 0.8881$; $F = 1.44$, $p > 0.05$), but highly significant in females ($\lambda = 0.7986$; $F = 1.96$, $p < 0.01$). The extent of discrimination is much smaller for fingers than for palms. This is clearly represented by the position of the centroids (Figs. 1 and 2) and the values of $D^2$ (Table 6). The first canonical variate accounts for about 62 and 61 % of the variance in males and females, respectively. In males, compared to females, the population distances are smaller and the samples are approximately equidistant from each other. The relative position of the female populations in the multivariate space conforms to the known ethnic history of the groups, as was the case in the males using the palmar variables. Hence, the results based on the two sets of variables are contradictory.

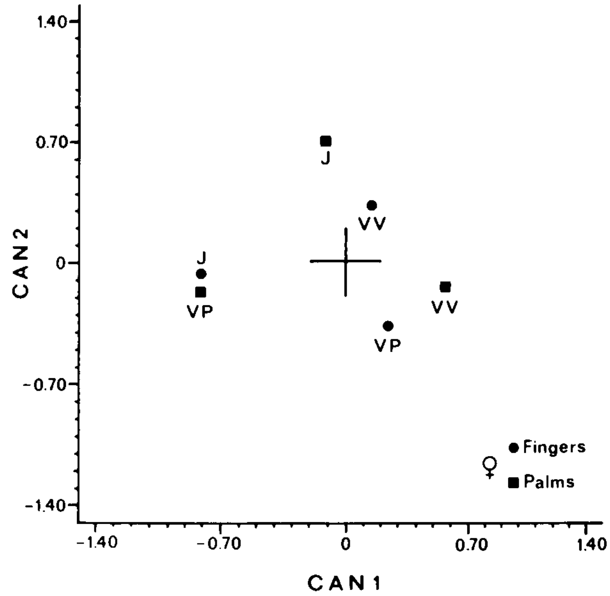


Fig. 2. Plots of centroids of the fishing groups derived from the canonical discriminant analysis of the finger and palmar variables in females.

Table 6. Matrix of $D^2$-values, based on finger variables, between fishing groups, males and females.

| ♂ / ♀ | VP | VV | J |
|---|---|---|---|
| VP | – | 0.4713 | 0.3008 |
| VV | 0.4599 | – | 0.3585 |
| J | 1.1522 | 1.0298 | – |

Table 7. Multivariate test statistics, Wilk's lambda, and F-ratios for different sets of variables.

| Variable set | Wilk's lambda | F-ratio | d.f. | p < |
|---|---|---|---|---|
| Dermatoglyphics (fingers) | 0.888 | 1.44 | 32 & 752 | 0.057 |
| Dermatoglyphics (palms) | 0.579 | 5.39 | 32 & 548 | 0.001 |
| Anthropometric measurements | 0.452 | 25.04 | 18 & 924 | 0.001 |

### *Comparison between different sets of variables*

The values of Wilk's lambda which is an inverse measure of discrimination together with the associated F-ratios are presented in Table 7, for the different sets of data. As has already been mentioned, the intergroup heterogeneity obtained from the palmar variables is larger than that from fingers. Thus the palmar variables emerge as better interpopulation discriminators than fingers. This is true for both the sexes. Similarly, Jantz & Chopra (1983) compared four endogamous groups treating the finger and palm variables separately and observed the same phenomenon.

Males and females, however, do not display the same pattern of interpopulation variation. While it conforms to the caste affiliations in males, no clear picture emerges in the females. They are more or less equidistant from each other in the multivariate space and the extent of variation, although significant, is less than that observed in the males. A sex difference in the pattern of interpopulation distances is also observed for finger variables. Inconsistency in the pattern of dermatoglyphic distances with respect to sexes is not, however, unique to this study. Earlier, for example, Rudan (1978) among the Istrian populations of Yugoslavia, and Lin et al. (1984) among the Black Caribs also observed different patterns of interpopulation variation for males and females and offered different migratory patterns as a probable explanation. In the present study, however, no explanation of the observed sex difference can be offered.

Further, it is of interest to know if the palmar dermatoglyphic pattern of affinities corresponds to that of other sets of variables including the ethnohistoric evidence. Since the anthropometric data were not available for females, we could only compare the patterns of variation for males based on palmar, finger and anthropometric variables. Wilk's lambda (Table 7) is non-significant ($p > 0.05$) for the finger variables and thus suggests poor discrimination between the groups. Palmar and anthropometric features show significant heterogeneity, but the patterns of variation are different in the two sets. Anthropometrics give smallest distance between the two sympatric groups, the VV and JL. In palmar dermatoglyphics VV is closer to VP which belongs to the same caste, conforming to the ethnohistorical relationships. Although the patterns of intergroup distance are different from the two sets of data, they are interpretable and demonstrate two different important aspects of interpopulation variation. In this context, the studies of Malhotra et al. (1985, 1986) and Kamali et al. (1986) may be mentioned. They used palmar pattern ridge counts to examine population affinities and found a similar agreement with known ethnohistorical relationships among a large number of populations of Western India and Iran. On the basis of these observations, it may be concluded that the palmar quantitative variables provide biologically relevant information additional to that from the finger variables and, therefore, should be included in studies of interpopulation variation.

## Acknowledgements

B.M. Reddy acknowledges with grateful thanks the Alexander-von-Humboldt-Foundation for awarding him a post-doctoral fellowship, during which this paper was prepared. The data were collected during 1977–1978, when he was a Research Fellow of the Anthropological Survey of India. We thank Mr. Hermann Müller for computational assistance and Miss Andrea Mathews for drawing the figures.

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Received May 8, 1987

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