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Size and shape components of anthropometric differences among the Yanadis

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Summary. Size and shape components of Mahalanobis D^2 were computed from a set of anthropometric characters among the Yanadis, a tribe in the south eastern part of Andhra Pradesh, India. These people are in a transitional stage of development and show differences in sociocultural variables between different geographical regions. From the study it appears that the pattern of differences due to size and shape is the same as that of general distance, irrespective of whether the distances were computed for male, female or pooled data, with some exceptions for females. The noteworthy finding is that the shape components for men and women dominate and are more similar than corresponding size components, thereby indicating that males and females are morphologically similar with respect to their relative measurements. The association of the morphological distances for the five breeding populations with the corresponding road, map and migrational distances were also investigated using simple and partial correlations. The results suggest that the migrational distance among the three is the strongest influencing factor for the morphological differences. The road distance also maintains a very high degree of association, especially with shape components.

1. Introduction

Morphological differences or similarities between individuals or populations may be due to size or shape, or both. The first statistical distance measures for estimating the size and shape components of morphological differences between populations were proposed by Penrose (1954). In a multivariate situation, according to Penrose, the square of the mean of the average differences constitutes the size function, while the shape function corresponds to the variance of the mean differences of characters between two populations. Naturally, when added the two functions yield the distance function, the coefficient of racial likeness (CRL), which is the average of the squares of mean differences. The basic difficulty of Penrose's size and shape partitioning of distance function is that it does not take the variabilities of measurements and the inter-correlations between measurements into consideration, and hence may lead to serious error (Mahalanobis, Majumdar and Rao 1949).

The Mahalanobis' D^2 distance measure takes care of the problem of inter-correlations between measurements as well as the variabilities of the measurements. The partitioning of Mahalanobis D^2 into size and shape components can be achieved by taking linear transformations, called principal components, and adjusting them by dividing with the corresponding standard deviations.

Spielman (1973) has developed a novel technique of partitioning the generalized distance into size and shape components, and applied it to the Yanomamo Indians. He could demonstrate using this measure that men and women from the same village are morphologically more similar in shape than those from different villages. His measure offers neat geometric interpretation, whereas the partitioning of Mahalanobis' distance measure into size and shape components offers good statistical interpretation. In this paper we have applied Mahalanobis' distance and its partitioning into size and shape components to a tribal population of Yanadi.

The Yanadis are an aboriginal tribe, living mainly in the south-eastern Andhra Pradesh, India. The population is widely distributed over different ecological zones—in coastal, island, plateau and hill forest regions. On the *islands*, the tribe is in a hunting-gathering-incipient agricultural stage; in the *plateau region*, it is mostly composed of casual and/or agricultural labourers (only a few are settled agriculturists); in the *hill forest region* they are gatherers and occasional agricultural labourers. The unique situation among the Yanadis provides a rare opportunity to investigate biological differentiation in relation to cultural diversity in a single tribal population. Details of the settlement pattern, breeding isolation (Vasulu 1988) and anthropometric differences (Vasulu and Pal 1988) have already been described. In the present study we have investigated the following aspects:

(1) Do the Yanadis living in diverse ecological conditions and subsistence patterns also show differences in their size and shape?

(2) Do the size and shape distances correspond with the total distances?

(3) Is it true that in a regional settlement the females are morphologically similar to males? In other words, are the shape differences in males and females more similar than the size differences in males and females?

(4) Is there an association between road, map and migrational distances and size, shape and total distances?

2. Materials and Methods

The thirteen Yanadi settlements selected for our study are located in four geographical regions: coastal, insular, plateau and hill forest. A settlement comprises a cluster of families located at one place; either an independent cluster near the forests or ponds, a tribal hamlet near a village or an independent tribal colony. The size of the settlement also varies from 20 huts to 100 households. The settlements within a region have more marital exchange and geneological ties than those between regions. A detailed analysis of marital migration, endogamy-exogamy and surname marriage matrix, suggests that the settlements within a region constitute a breeding population (Vasulu 1988). The breeding populations of the study area are Challa Yanadis (CY), insular Yanadis (IY), upper plateau Yanadis (P1), hill forest Yanadis (HF) and lower plateau Yanadis (P2). Settlements I and 2 constitute Challa Yanadis of coastal regions; the insular region consists of settlements 3, 4 and 5; hill forest Yanadis consists of settlement numbers 8, 9 and 10; P1 and P2 regions consist of settlement numbers 6, 7 and 11, 12, 13 respectively; P1 and P2 regions are separated by hill forests. These settlements are shown in figure 1.

A total of 19 anthropometric characters were measured from men aged 20–60 years, whereas only 14 metric measurements could be collected from women aged 18–60 years. Almost all the individuals in each of the 12 settlements were measured for anthropometric data. However, no metric data could be obtained from settlement 9 in the hill forest region and only three females could be measured for metric data from settlement 6 in upper plateau P1 region. The distance analysis and the partitioning into size and shape was made using 14 measurements which were precise, well defined and common to both sexes. The anthropometric differences between settlements and regional breeding populations were discussed in an earlier paper (Vasulu and Pal 1988). Here we attempt to analyse the size and shape partitioning of anthropometric distances—mainly Mahalanobis' D^2—at two different levels: (1) taking the settlements as the unit of study, and (2) taking the regional breeding populations as the unit of study. The results will be discussed for both the cases, but tabular presentations are given for breeding populations only. The D^2 values were computed separately for males, females, combined sex

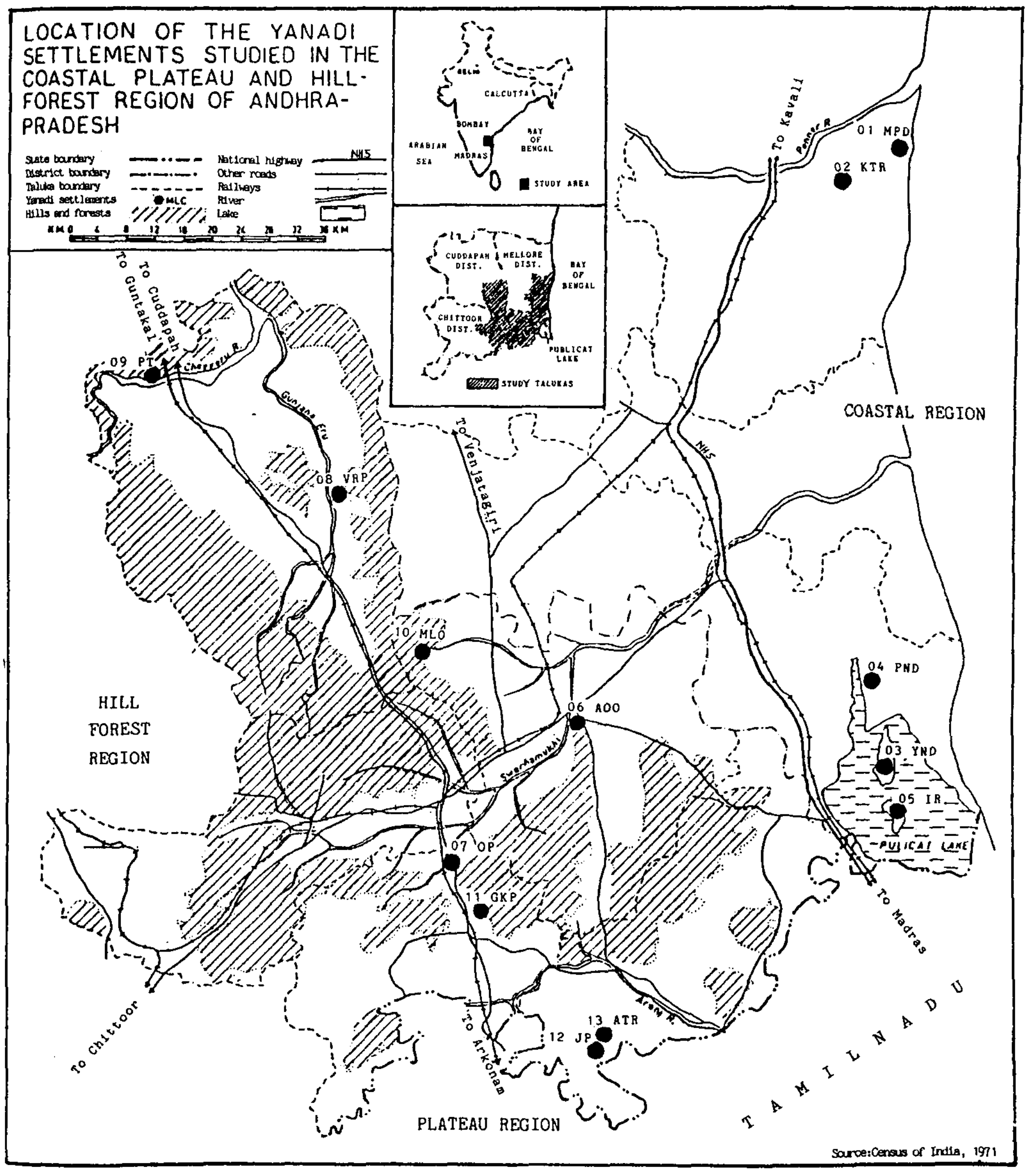

Figure 1. Map of the study area.

and combined sex after standardization. The metric data were standardized with respect to their overall mean and standard deviation separately for male, female and pooled data in order to account for sex differences. To see the relative closeness between settlements and regions dendrograms were drawn following a minimum distance clustering method.

In our analysis we have compared map, road and migration distances with morphological distances for breeding populations only. Map distances are the distances measured along straight lines connecting the centres of different breeding populations, whereas road distances are the actual distances one must travel from the centre of one population to the centre of another. Migrational distances were measured by means of number of surnames common to two populations. If d_{ij} is the migrational distance between the population i and j then:

$$d_{ij} = D_{ij} - \frac{D_{ii} + D_{jj}}{2} = \frac{J_{ii} + J_{jj}}{2} - J_{ij},$$

$$\text{where } D_{ii} = 1 - J_{ii},\ D_{ij} = 1 - J_{ij},$$

$$\text{and } j_{ii} = \sum_a x_{ai}^2 \text{ and } J_{ij} = \sum_a x_{ai}\, x_{aj}.$$

x_{ai} and x_{aj} are the relative frequencies of the ath surname in the ith and jth population respectively. J_{ii} and J_{ij} values are *kinship coefficients* (Katayama and Toyomasu 1979). To compare these distances with the morphological ones the square roots of the morphological distances were required to bring them to the same dimension.

We have calculated simple and partial correlations between these distance matrices. Since each matrix is symmetric the number of distinct values were $n(n-1)/2$, where n is the dimension of the matrix. In our case $n = 5$, hence correlations using 10 values of one matrix with the corresponding 10 values of another matrix were calculated for each pair, taking one from map, road or migrational distances and the other from one of the morphological distance matrices. It should be remembered that correlation is independent of the unit of measurement and the number of replications. Hence it will not matter whether the map and road distances are given in kilometers or in miles, or whether all the 20 off-diagonal elements for the calculation of correlation coefficient are used. We have followed the procedure as described in Dow, Cheverud and Friedlaender (1987). Computation of the significance levels of correlation coefficients, partial correlation coefficients and the corresponding levels of significance for the partial correlations, have also been performed as described in that paper. The only difference is in the calculation of significance levels. To establish significance Dow *et al.* took a number (m) of random permutations of the required matrix and counted how often the correlations for permutations exceeded the absolute value (the given value of the correlation) by a value l. They then found the ratio $(l+1)/(m+1)$ which is the probability value showing the level of significance. In our case, taking all 120 permutations (not a very large number) gave $(l+1)/120$ as the level of significance.

3. Results

Metric differences and size and shape distances between the Yanadi settlements

The D^2 values and the corresponding dendrograms (not presented here) suggest a strong anthropometric similarity between a few settlements and a marked difference between other settlements, regardless of whether the D^2 values are computed for men, women, or for the sex pooled data (Vasulu and Pal 1988). In particular, the two agricultural settlements (settlement 10 of the hill forest region and settlement 11 *in the* plateau region) always cluster together, and settlement 5 in the insular region forms a single separate cluster in both cases. The order and pattern of clustering are similar—i.e. the agricultural settlements of the interior plateau and hill forest regions and the hunter-gatherer settlement in the coastal and insular regions occupy the extreme positions, whereas the casual labourers (settlements 6 and 7) occupy the intermediate position. The two noteworthy exceptions are settlements 6 among females and settlements 10 and 11, as in the case of D^2, cluster together. In most cases, settlement 5 in the insular region has large distance values with other settlements. The reason for clustering of settlements is mainly due to their shape parameters. Since the shape paraclustering (figure 2a, 2b). In the case of the size component, the two agricultural settlements 10 and 11, as in the case of D^2, cluster together. In most cases for settlement 5, in the insular region, has large distance values with other settlements. The reason for clustering of settlements is mainly due to their shape parameters. Since the shape parameter dominates the size parameter, the D^2 values (not presented here) also show the same clustering.

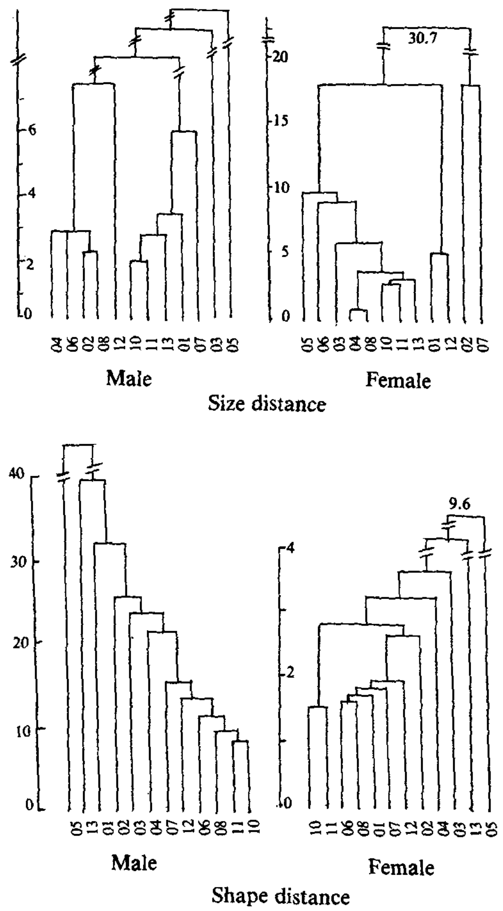

Figure 2a. Dendrograms showing size and shape distances in the Yanadi settlements separately for male and female samples.

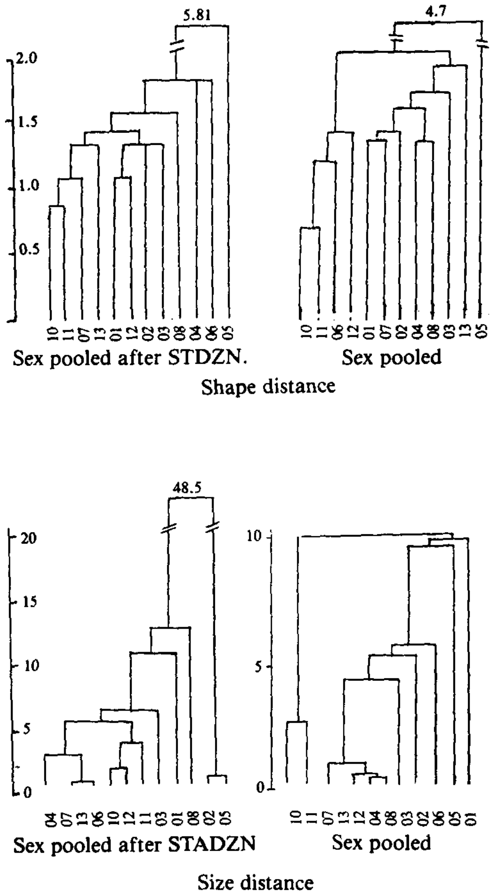

Figure 2b. Dendograms showing size and shape distances for the sex pooled data among the Yanadi settlements.

Male-female differences

Since the men and women within a settlement share the same environmental influences and more or less share common genetic endowment, the relationship among variables or the overall morphological configuration of men and women in that settlement are expected to be the same. In fact, from Spielman's study it appears that men and women are more similar in shape than size in the Yanomama Indian villages (Spielman 1973). This finding has led some authors to describe the morphological configuration of women as that of a 'harmoniously reduced male'. "If the differences between men and women of each village may realistically be regarded as primarily in scale, it will be possible to remove the mean differences in magnitude and pool measurements on the two sexes, thereby increasing sample size (often doubling it)...." (Spielman 1973).

To obtain metric distances for pooled data, the raw data were standardized with respect to their overall mean and standard deviation, separately for male and female. In order to test whether females are morphologically similar to males, we aimed to determine whether (1) shape differences in males and females are more similar than size differences, and (2) metric differences for standardized pooled data are more similar in size with that of females than that of males. The first criterion is easily verified as the extreme groups of settlements have pronounced shape differences for males as well as for females. The size differences for males and females do not show any similarity in clusters. The second criterion cannot be so easily verified. However, between the extreme group of settlements 2 and 5 in standardized distances and settlements 2 and 7 in female distances we have settlement 2 as common to both, so far as size distances are concerned. The pooled standardized metric distances between the Yanadi settlements show remarkable similarities with the pooled unstandardized metric distances, indicating size differences between sexes to be very small.

From the size and shape components of anthropometric distances between the Yanadi settlements, for males and females and for the pooled data, it would seem that when shape alone is considered the Yanadi males between settlements form a cluster with gradual differentiation from agricultural to coastal hunting-gathering settlements. However, the size clustering does not show any association with the geographical location or with the subsistence pattern. Comparison of D^2 and shape clustering suggests that it is the shape component that is reflected in the D^2 values.

Metric differences, size and shape distances between the regional breeding populations

The D^2 values and size and shape components and the corresponding dendrograms for the five breeding populations are shown in tables 1 and 2 and figure 3. The tables and diagrams show that shape dominates size component. Irrespective of size, shape, D^2 or sex, the breeding populations HF and P2 form a cluster and PI remains very close to HF and P2. CY and IY form separate clusters. The only exception is for shape and D^2 in females—D^2 because it is dominated by shape.

Table 1. Size and shape components of anthropometric distances (D^2) between the Yanadi breeding populations.

Females		Males				
		CY	IY	PI	HF	P2
CY	Size	—	0·31	0·30	0·004	0·08
	Shape	—	1·33	1·43	2·56	2·19
	D^2	—	1·64	1·73	2·57	2·27
IY	Size	1·02	—	0·20	1·00	0·11
	Shape	2·11	—	1·93	2·19	2·14
	D^2	3·14	—	2·13	3·19	2·26
PI	Size	0·18	0·10	—	0·04	0·001
	Shape	0·96	3·54	—	0·46	0·85
	D^2	1·14	3·64	—	0·50	0·85
HF	Size	1·18	0·04	0·03	—	0·004
	Shape	2·12	1·94	1·94	—	0·33
	D^2	3·30	1·97	1·97	—	0·34
P2	Size	0·11	0·06	0·10	0·003	—
	Shape	2·15	2·93	1·49	0·63	—
	D^2	2·27	3·00	1·59	0·63	—

Lower triangle female; upper triangle male.

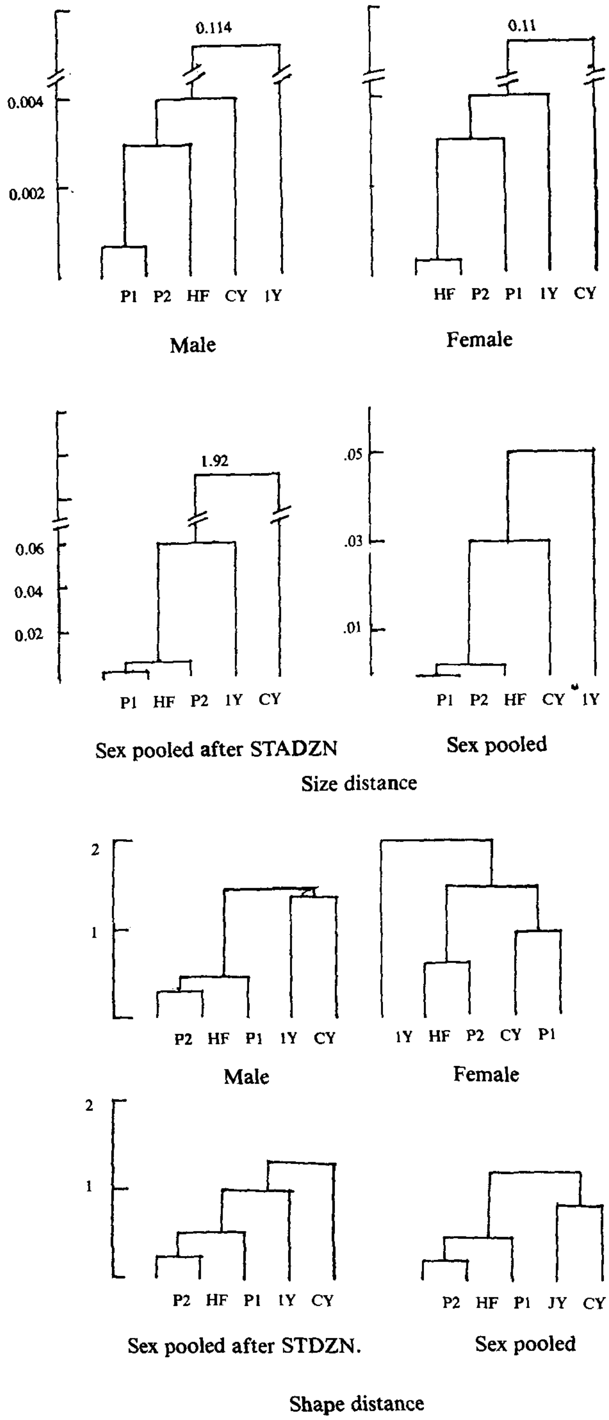

Figure 3. Dendrograms showing size and shape distances among the Yanadi regional populations.

Table 2. Size and shape components of anthropometric distances (D^2) between the Yanadi breeding population (sex pooled).

Sex pooled		Sex pooled after standardization CY	IY	P1	HF	P2
CY	Size	—	0·49	0·03	0·08	0·34
	Shape	—	0·85	1·28	2·08	1·28
	D^2	—	1·35	1·31	2·16	1·62
IY	Size	0·20	—	0·06	0·05	0·07
	Shape	1·33	—	1·96	2·30	1·84
	D^2	1·54	—	2·03	2·36	1·91
P1	Size	0·16	0·01	—	0·02	0·00
	Shape	1·00	1·92	—	0·50	0·67
	D^2	1·16	1·93	—	0·52	0·67
HF	Size	0·13	0·006	0·0001	—	0·002
	Shape	1·81	2·31	0·55	—	0·22
	D^2	1·95	2·32	0·55	—	0·222
P2	Size	0·50	0·21	0·0006	0·002	—
	Shape	1·36	1·84	0·70	0·26	—
	D^2	1·86	2·05	0·70	0·26	—

Lower triangle female; upper triangle male.

Male-female differences

As far as the sex differences are concerned (i.e. to examine whether females are morphologically similar to males), we see that shape clustering for males and females is more similar than size clustering. To be more precise, P1, HF and P2 form one cluster and CY and IY form separate clusters. But for size, P1, HF and P2 form a single cluster in males and HF, P2 form a single cluster and P1 forms a separate cluster in the case of females. The other criterion (in the pooled standardized data the metric differences are more similar in size to those of females than of males) is clear from the dendrograms, i.e. the breeding population of settlement 1 is extreme for females as well as pooled standardized data, whereas it is not so in the case of males.

4. Association between map, road, and migrational distances with size, shape and D^2 values

Simple correlations

Shape distance and total morphological distance have high correlations with road and migrational distances except for some cases in females. Moreover, migrational distances have significant relations with size distances, especially for male and pooled data. Map distances, however, do not show any significant relation with other variables except in the case of size for pooled data after standardization (table 3).

The values of the simple correlations are more or less similar to those of rank correlations (not pesented here), indicating that it is the linear relations which are acting. Correlations with road distances are higher than those with migrational distances for shape and total distances, whereas the reverse is observed for size components.

When standardized data are compared with the pooled data, the standardized data provide the better relation with road and migrational distances; the only exception is for the size component with migration. Because shape dominates size in most of the cases, the correlations with shape are very close to those of the total.

Table 3. Simple correlations of road, map and migrational distances with size, shape and total distances, separately for the data on male, female, male and female pooled, and male and female pooled after standardization

		Distances		
		Road	Map	Migration
Male	Size	0·60 (0·075)*	0·30 (0·433)	0·78 (0·008)***
	Shape	0·66 (0·067)*	0·46 (0·233)	0·54 (0·125)
	Total	0·71 (0·025)**	0·47 (0·208)	0·65 (0·025)**
Female	Size	−0·17 (0·700)	0·29 (0·425)	0·45 (0·305)
	Shape	0·45 (0·200)	−0·19 (0·567)	0·39 (0·275)
	Total	0·33 (0·383)	−0·06 (0·917)	0·50 (0.150)
Pooled	Size	0·28 (0·533)	0·56 (0·158)	0·78 (0·067)*
	Shape	0·68 (0·850)**	0·27 (0·433)	0·50 (0·050)**
	Total	0·68 (0·058)*	0·36 (0·317)	0·64 (0·033)**
Pooled after standardization	Size	0·31 (0·533)	0·71 (0·058)*	0·46 (0·367)
	Shape	0·72 (0·058)*	0·26 (0·558)	0·65 (0·025)**
	Total	0·72 (0·042)**	0·38 (0·308)	0·68 (0·025)**

Levels of significance are given in parentheses.
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

In conclusion, road and migrational distances play significant roles in explaining morphological differences between different breeding populations. Migrational indices explain size component better whereas road distances explain shape component (and total) better. The only instance where map distances show a significant relation is with size for standardized data. Though correlation with road distance is higher for shape, the significance level is slightly more with migration index. Hence we can conclude that migrational distance is the best variable to explain the morphological differences. The next best explanatory variable is road distance.

Partial correlations

Most values of partial correlations were smaller than those of simple correlations. This may be due to the fact that there is a common factor prevailing in size and shape components (table 4). When the effect of map distances are eliminated, partial correlations are not much reduced compared to the cases in which the effects of road or migrational distances are eliminated. This is as expected because correlations with map distances are not high. However some exceptions were found in the case of females: for example, partial correlations between migration differences with those for female size, when pooled and when pooled after standardized data, were better when the road effect was eliminated than when the effects of map distances were removed, i.e. with respect to size difference, map distance is not a bad indicator.

Simple as well as partial correlations were significant for the following cases:

(1) Road versus shape and total for male, standardized and simply pooled data when the effect of map distance was removed.

(2) Migration versus size for male data and migration versus total for pooled and standardized data when effects of map distance were removed.

(3) Migration versus size for male and simply pooled data after eliminating the effect of road distances.

Table 4. Values of partial correlations of morphological distances with map, road and migration distances.

		Map eliminated		Road eliminated		Migration eliminated	
		Road	Migration	Map	Migration	Map	Road
Male	Size	0·55 (0·18)	0.76 (0.03)**	0·12 (0·85)	0·68 (0·07)*	−0·11 (0·80)	0·35 (0·37)
	Shape	0·60 (0·10)*	0·42 (0·35)	0·33 (0·38)	0·31 (0·53)	0·27 (0·47)	0·52 (0·17)
	D^2	0·67 (0·03)**	0·55 (0·11)	0·34 (0·42)	0·46 (0·25)	0·25 (0·45)	0·58 (0·16)
Female	Size	−0·30 (0·50)	0·37 (0·47)	0·38 (0·42)	0·64 (0·13)	0·11 (0·82)	−0·53 (0·18)
	Shape	0·56 (0·14)	0·55 (0·16)	−0·41 (0·31)	0·21 (0·61)	−0·45 (0·23)	0·31 (0·47)
	D^2	0·37 (0·38)	0·60 (0·08)*	−0·19 (0·69)	0·41 (0·31)	−0·38 (0·33)	0·09 (0·85)
Pooled	Size	0·11 (0·83)	0·71 (0·12)	0·52 (0·33)	0·77 (0·08)*	0·37 (0·48)	−0·24 (0·57)
	Shape	0·65 (0·05)**	0·44 (0·18)	0·05 (0·87)	0·23 (0·56)	0·05 (0·89)	0·57 (0·14)
	D^2	0·64 (0·08)*	0·58 (0·10)*	0·18 (0·71)	0·46 (0·25)	0·09 (0·81)	0·53 (0·18)
Pooled after standardization	Size	0·10 (0·88)	0·21 (0·78)	0·68 (0·18)	0·37 (0·52)	0·64 (0·19)	0·09 (0·86)
	Shape	0·70 (0·05)**	0·63 (0·11)	0·01 (0·98)	0·47 (0·25)	−0·07 (0·85)	0·59 (0·16)
	D^2	0·68 (0·05)**	0·62 (0·08)*	0·20 (0·67)	0·52 (0·19)	0·09 (0·83)	0·58 (0·15)

Levels of significance are given in parentheses
* Significant at 5% level
** Significant at 10% level

The high correlations for the above mentioned cases explains why migration can be regarded as a superior index so far as morphological distances are concerned.

There are many cases where partial correlations are higher than the simple correlations; there are also some cases where partical correlations become negative which were initially positive on the simple correlations. The relevant explanation can be found in Dow *et al.* (1987).

Table 5. Values of partial correlations of size and shape distances with road, map and migration distances.

	M		F		M+F		Std	
	Size	Shape	Size	Shape	Size	Shape	Size	Shape
Road	0·48 (0·19)	0·56 (0·12)	−0·29 (0·27)	0·50 (0·18)	0·15 (0·75)	0·66 (0·12)	0·07 (0·87)	0·69 (0·07)*
Map	0·14 (0·78)	0·38 (0·33)	0·34 (0·38)	−0·26 (0·48)	0·53 (0·23)	0·16 (0·73)	0·69 (0·12)	−0·005 (1.00)
Mig.	0·73 (0·03)**	0·39 (0·30)	0·41 (0·38)	0·34 (0·27)	0·78 (0·06)*	0·50 (0·14)	0·32 (0·53)	0·59 (0·13)

Size correlations were partialled by shape and shape correlations were partialled by size. Levels of significance are given in parentheses.
* Significant at 5% level
** Significant at 10% level

We have also computed partial correlations of road, map and migration distances versus size (shape) when the effect of corresponding shape (size) component was removed (see table 5). The values we obtained were less than those of simple correlations because of the common factor as suggested earlier, prevailing in both size and shape. Only one case of partial correlation was significant at a 5% level. When the effect of shape was eliminated, size had a significant relation with migrational distances for male data. There are two more significant cases at the 10% level, all indicating superiority either of migrational distance in explaining size or of road distance in explaining shape (table 5).

5. Discussion

The anthropometric differences and the size and shape analysis indicate wide micro-differentiation at the regional level in conformation with the cultural differences. It is less pronounced among the plateau and hill forest sections of the Yanadis than from the Challa and insular Yanadis. It may be recalled here that the Challa Yanadis and the insular Yanadis are in a hunting-gathering incipient agricultural stage. The micro-differentiation has also been observed between settlements within the region of the same cultural and environmental situation, especially for insular Yanadis. The interplay of culture versus biology operates at different levels among the Yanadis.

Size and shape analysis indicates that the populations differ more by shape. The Yanomama Indians also show the same phenomenon. Shape differences in males and females have also been found to be more similar than size differences. These results, along with the results from pooled data after standardization, led us to the conclusion that females are morphologically more similar to males within a region than to females between regions.

In situations where the people live on plains, uniformly distributed with few geographical and artificial barriers, road distance and map distance may not differ much and analysis of these factors may lead to similar kinds of results. But in cases where the people are spread over wide geographical regions separated by natural barriers (such as hills and seas) and artificial barriers (such as lack of communication facilities), as among the Yanadis, road distance is an important special factor. Simple and partial correlation of road, map and migration distances with morphological distances support this. Migration distance can explain the morphological distances better than the other two factors since it takes into account the degree and mode of migration in the remote past. Ethnographic accounts confirm such migrations. Hence any micro-differentiation in biological characters is expected to show a high order of association with surname distributions. The road distances also maintain very high correlations with the morphological distances, especially for shape parameter.

Another dimension in the spatial analysis is the time factor. This could possibly explain the situation better than the road distance, but we were unable to incorporate this factor in our analysis. Particularly on the insular region, the island settlements are geographically isolated by backwaters from the mainland by about 10–11 kilometres. Depending on wind conditions, it can take 6–7 hours to cross this stretch by boat, which is the only possible route from the mainland; the same distance could be covered far more quickly if it were land. This is a possible explanation for the fact that the insular region takes an extreme position in the cluster analysis.

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Résumé. Les composants de forme et de format du D^2 de Mahalanohis ont été calculés à partir d'un ensemble de caractères anthropométriques, chez les Yanadis, une tribu du sud-est de l'Andhra Pradesh en Inde. Ceux-ci se trouvent actuellement dans une étape transitoire de développement et montrent des différences socio-culturelles d'une région à une autre. Il apparait que l'aspect des différences dues au format et à la forme est le même que celui de la distance générale, indépendamment du fait que les distances aient été calculées pour les hommes, les femmes ou les deux ensemble, à quelques exceptions féminines près. Le résultat le plus significatif est que les composants de forme pour homme et femme dominent et sont plus similaires, que les composants correspondants de format, indiquant ainsi que les hommes et les femmes sont morphologiquement similaires pour ce qui concerne leurs mensurations relatives. L'association des distances morphologiques des cinq populations génétiques avec les distances cartographique, routière et migratoire correspondantes, a également été étudiée au moyen de corrélations simples et partielles. Les résultats suggèrent que la distance migratoire est celle des trois qui est le facteur influençant le plus les différences morphologiques. La distance routière présente aussi un haut degré d'association, notamment avec les composants de forme.

Zusammenfassung. Die Komponenten Größe und Form von Mahalanobis D^2 wurden für einen Satz anthropometrischer Merkmale bei den Yanadis errechnet, einem Stamm der südöstlichen Teile von Andhra Pradesh in Indien. Sie sind in einem Obergangsstadium der Entwicklung und zeigen Unterschiede bei soziokulturellen Variablen zwischen verschiedenen geographischen Regionen. Nach der Untersuchung schient es, daß das Muster der Unterschiede von Größe und Form das gleiche ist wei beim allgemeinen Abstand, ohne Rücksicht, ob die Abstände für Männer, Frauen oder die zusammengeschlossenen Daten errechnet wurden, mit einigen Ausnahmen für Frauen. Ein bemerkenswerter Befund ist, daß die Formkomponenten bei Männern und Frauen dominieren und einander ähnlicher sind als entsprechende Größenkomponenten, was bedeutet, daß Männer und Frauen bezüglich ihrer relativen Maße morphologisch ähnlich sind.

Die Verknüpfung der morphologischen Abstände für die fünf reproduktiven Bevölkerungen mit entsprechenden Abständen nach Straßen, Karte und Wanderung wurde ebenfalls untersucht, wobei einfache und partielle Korrelationen verwendet wurden. Die Ergebnisse zeigen, daß die Wanderentfernung zwischen den drei Größen der einflußreichste Faktor für die morphologischen Unterschiede ist. Die Straßenabstände zeigen auch einen hohen Grad von Verknüpfung, besonders mit den Formkomponenten.