many archaeologists favour a first settlement of Hawaii from the Marquesas, Hawaiian traditions relating to "Kahiki" are interpreted as evidence of possible secondary settlement from Tahiti. These, however, may actually record much more recent contacts of a kind which is apparently predictable from study of variables affecting inter-island voyaging frequency. By European contact, small and isolated Easter Island may already have experienced some decline in social complexity, while large and more recently settled New Zealand was perhaps still at a relatively early stage of elaboration. It is interesting, also, to consider whether social development in New Zealand was following a different path from that of its eastern Polynesian ancestry, partly because of greater isolation from it. Given that New Zealand was probably settled only 1,000 years ago, a curious absence in its archaeological record is some more conspicuous variant of the eastern Polynesian marae.

By contrast with eastern Polynesia, however, when history interrupted prehistory in the region centred on Tonga, Samoa, and Fiji, elements of political integration and social complexity were still (or once again) being expressed through the added dimension of overseas voyaging. A sphere of Tongan influence was expanding, and this marks a trend which, in one region, may have begun to reverse the contraction of Polynesian interaction that followed colonisation.

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Anthropometric Variation in India: A Statistical Appraisal[1]

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26 VI 89

India has a strong tradition of anthropometric studies. The major focus of most early work (Risley 1915, von Eickstedt 1934, Guha 1935) was the identification of racial types and the development of a racial classification of the people of India. The data collected in these early studies provided ample evidence of enormous anthropometric variation among the different Indian populations. Convinced that a broad racial classification of the people of India was possible, anthropologists turned their attention to specific regions, quantifying variability and studying relationships among populations with a view to such classification (see, e.g., Mahalanobis, Majumdar, and Rao [1949] for the United Provinces [Uttar Pradesh], Majumdar and Sen [1949] for Gujarat, Karve and Dandekar [1951] for Maharashtra, Majumdar and Rao [1960] for Bengal, and Malhotra, Balakrishnan, and Karve [1981] for Tamilnadu). The characters used and the methods of data collection and analysis were not uniform, however, and this led to a profusion of racial

gical

classifications. Furthermore, these classifications were based primarily on mean population values of anthropometric characters and indices, occasionally supported by somatoscopic observations, without taking into consideration within-population variability. In 1960, Majumdar and Rao wrote, "Out of about 40 Presidential addresses at the annual meetings of the Anthropology Section of the Indian Science Congress Association, at least 30 percent have been devoted to a study of ethnic elements in India on the basis of anthropometric measurements. But the situation with regard to the validity of the comparison of the methods and techniques adopted in the various anthropometric studies has remained practically fluid and time seems to have been wasted" (p. viii).

Although more sophisticated methods of statistical analysis of anthropometric data have since been adopted, there is still considerable lack of uniformity, and comparison of results from different studies still poses a problem. Many of the more recent studies have shown, however, that when data analysis is carefully performed, the validity of racial/ethnic classification, at least at the regional level, diminishes. Two of the major findings of the Bengal anthropometric survey (Majumdar and Rao 1960) were that there were significant regional differences within social groups and there was sometimes a closer resemblance between castes within a region than between individuals of the same caste from different geographical areas even within the same state. Thus Mahalanobis (1960:iv) emphasized that "a term like 'Brahmins of Bengal' has to be used with some caution" and questioned the validity of any ethnic classification: "If this finding [the second cited above] is corroborated by further investigations, it would present a serious problem of eliminating regional or geographical differences in comparing groups of individuals belonging to the same caste or group but living in different regions of the State." Some later studies (for example, Karve and Malhotra 1968) have shown, however, that within restricted geographical regions the patterning of anthropometric variation correlates fairly well with the social hierarchy. The purpose of this study is to apply a uniform set of multivariate statistical methods to the variation in a single set of anthropometric characters among populations differing in geographical location and in ethnic characteristics with a view to investigating how well the pattern of variation correlates with their ethnic backgrounds.

In order to understand the broad patterns of anthropometric variation in India, we aimed to analyze data on as many different populations as possible. One of the major impediments to the accomplishment of this objective was the absence in past surveys of a standard battery of anthropometric characters and standard landmarks for their measurement. It was imperative that comparisons be based on a large number of characters, but maximizing the number of characters restricted the number of populations that could be included in the analysis. Further, some populations had to be excluded because the published data contained only estimated population values of some parameters (e.g., means and standard deviations) and measurements on individual subjects were not readily available. We finally came up with 82 populations (see appendix) and seven anthropometric characters: stature, bizygomatic breadth, head length, head breadth, nasal length, nasal breadth, and total facial length. (We verified that the landmarks used for measuring these characters were the same in all studies.) Since many early anthropometric surveys excluded females, our study had to be restricted to males. Populations for which fewer than 50 individuals had been examined were excluded; where more than 100 individuals had been examined, a table of random numbers was used to select data on 100 individuals for analysis. (This was done both to avoid statistical problems resulting from grossly unequal samples and to cut down on computing time.) Data on a total of 7,762 males were thus compiled. The populations were classified by geographical zone and ethnic category. The geographical classification (table 1, fig. 1), based on ecological considerations, was that of Chatterjee (1973), the ethnic classification (table 2) that of Malhotra (1978; for further details, see Karve 1961). Although the terms used to subclassify tribal groups may sound "racial," "Australoid," "Mongoloid," and "Caucasoid" are to be viewed as morphological rather than "racial" types.

TABLE 1
Geographical Classification

Geographical Zone	Code
Western Himalaya	01
Central Himalaya	02
Eastern Himalaya	03
North-Eastern Range	04
Northern and Eastern Plains	05
Western Plains	06
North-Central and South-Central Highlands	07
Eastern Plateaus	08
North and South Deccan	09
Eastern Hills	10
Eastern Coastal Plains	11
Western Coastal Plains	12
Western Hills	13
Andaman and Nicobar Islands	14
Lakshadweep Islands	15

SOURCE: Chatterjee (1973).

The broad strategy adopted in this study is similar to that employed by Majumder and Roy (1982). Since sampled individuals differed in age, we age-adjusted the anthropometric characters to make the data on individuals comparable within and between populations. A multiple regression analysis was performed for each character using age, age^2 (i.e., age × age), and age^3 as independent variables. Age^2 and age^3 were included to account for possible non-linear trends with age. Tests of significance (Rao 1973) were performed to assess null hypotheses that the regression coefficients for the inde-

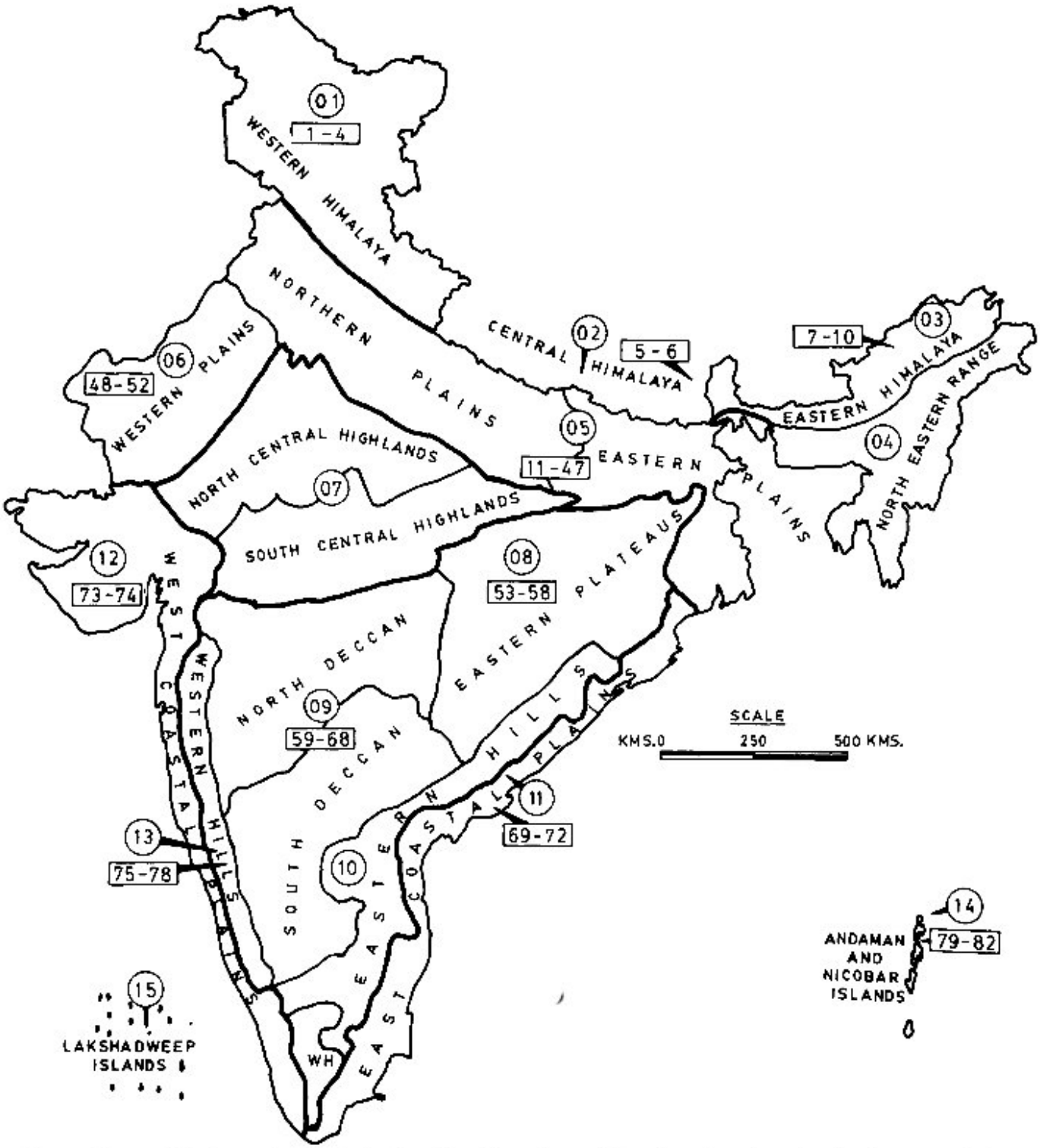

FIG. 1. *Geographical zones* (codes circled) *and locations of populations* (numbers in rectangles [see appendix]).

TABLE 2
Ethnic Classification

Ethnic Category	Code
Caste	
Upper	11
Middle	12
Lower	13
Tribe	
Australoid	21
Mongoloid	22
Caucasoid	23
Negrito	24
Religious group	
Christian	31
Buddhist	32
Muslim	33
Parsi	34
Sikh	35

pendent variables were equal to zero. For variables on which age effects were found to be significant at the 5% level, the estimated regression equations were used to eliminate the effect of age for each individual. The subsequent analyses were performed on age-adjusted values of anthropometric measurements.

Since geographical distance and ethnic difference were the other factors presumably contributing to anthropometric variation to be considered, we performed tests on the populations classified by geographical zone and ethnic category to find out whether the mean vectors of anthropometric characters (that is, the mean values of the seven anthropometric characters considered jointly) were equal for these zones and categories. The statistic used to test the null hypothesis of equality of mean vectors was Wilks's lambda, the significance of which is determined using an approximate F ratio (Rao 1973). The tests yielded significant results, indicative of significant differences in anthropometric profile, for both geographical zones and ethnic categories. Wilks's lambda for geographical zones was 0.9733, significant at the 5% level (F ratio = 2.813; d.f.$_1$ = 70, d.f.$_2$ = 42357.02). Just three of the seven anthropometric characters—head length, head breadth, and bizygomatic breadth—explained 92% of the observed anthropometric variation. Wilks's lambda for ethnic categories was also significant (0.9752; F ratio = 3.724; d.f.$_1$ = 49, d.f$_2$ = 36892.65). Again, just three characters—head length, bizygomatic breadth, and stature—explained some 93% of the variation. Thus head length, head breadth, bizygomatic breadth, and stature were the characters most useful for assigning an individual to the geographical zone and ethnic category to which he belonged.

The differences in anthropometric profile among populations occupying different habitats and among populations of differing ethnic backgrounds could not immediately be explained. They showed no consistent clinal patterns, and the design of the study did not permit discrimination among their various evolutionary causes (natural selection, admixture, drift, etc.). Because the differences in anthropometric profile among geographical zones might have arisen from the pooling of populations with different ethnic backgrounds and the differences among ethnic categories might have arisen from the pooling of populations occupying different zones, however, it was clear that further analysis needed to consider simultaneously geographical and ethnic differences. We therefore cross-classified the populations into geographical × ethnic subsets. Of the 31 subsets that were found to be non-empty, 14 comprised only a single population each. When the remaining 17 subsets were tested for equality of mean vectors, 10 proved heterogeneous (table 3). Thus it was clear that the observed variation in anthropometric profile among populations in India could not be fully explained by differences in geographical location and ethnic background.

Since no other classificatory information was available, we resorted to the statistical procedure of identifying clusters of populations that could be considered homogeneous with respect to anthropometric profile. Within each of the heterogeneous subsets, we performed a cluster analysis (using the single-linkage algorithm [Anderberg 1973]) and then sequentially computed Wilks's lambda at each node of the resulting dendrogram to break the subset down into what we have called *rational homogeneous clusters* (RHCs) (Majumder and Roy 1982). (Obviously, the subsets that had proved homogeneous at the previous step constituted independent RHCs.) For example, for the four populations included in the geographical × ethnic subset 13 × 21, the Australoid tribes of the western hills, the Wilks's lambda value corresponding to the null hypothesis of equality of mean vectors was 0.8240, significant at the 5% level (F ratio = 3.053; d.f.$_1$ = 21, d.f.$_2$ = 919.42). Thus the four populations included in this subset were heterogeneous. To break this subset down into RHCs, we computed the matrix of Mahalanobis's D^2 values between all pairs of these four populations and applied the single-linkage clustering procedure to construct a dendrogram (fig. 2). Wilks's lambda computed at Node 1 was, obviously, the significant value presented above. Wilks's lambda at Node 2, corresponding to the null hypothesis of equality of mean vectors of the populations Pulayan, Urali, and Katkari, was 0.9736, not significant at the 5% level (F ratio = 0.444; d.f.$_1$ = 14, d.f.$_2$ = 462). Thus the four populations in the subset 13 × 21 formed two RHCs: Pulayan, Urali, and Katkari and Jenu Kuruba. (Had Wilks's lambda at Node 2 turned out to be significant, we would have computed Wilks's lambda at Node 3.)

If anthropometric variation correlated strongly with ethnic background, then one would expect most populations in the same geographical × ethnic subset to form an RHC. (Since spatial effects are minimal within a zone, a strong correlation of anthropometric variation with ethnic background would be manifest in the clustering of most populations with the same background.) Absence of such a pattern would indicate either that ethnic background had no significant effect on an-

TABLE 3
Results of Tests of Equality of Mean Vectors of Populations Belonging to Various Geographical × Ethnic Subsets

Geographical Zone	Ethnic Category	Number of Populations	Wilks's lambda	*F* Ratio	$d.f._1$	$d.f._2$
01	12	2	0.9902	0.218	7	155.00
02	22	2	0.9123*	2.129*	7	155.00
03	22	4	0.8427*	2.731*	21	953.77
05	11	2	0.9874	0.324	7	178.00
05	12	15	0.4329*	11.623*	98	8047.43
05	13	5	0.8755*	2.265*	28	1688.82
05	21	12	0.4171*	14.294*	77	7006.59
05	33	2	0.7409*	9.542*	7	191.00
06	12	2	0.8705*	3.782*	7	178.00
08	12	3	0.8854*	2.197*	14	490.00
08	21	2	0.9846	0.429	7	192.00
09	11	3	0.9143	1.577	14	482.00
09	12	2	0.9610	0.997	7	172.00
09	21	2	0.9891	0.230	7	147.00
11	12	2	0.9870	0.338	7	180.00
13	21	4	0.8240*	3.053*	21	919.42
14	22	4	0.8182*	3.119*	21	905.06

*Significant at the 5% level.

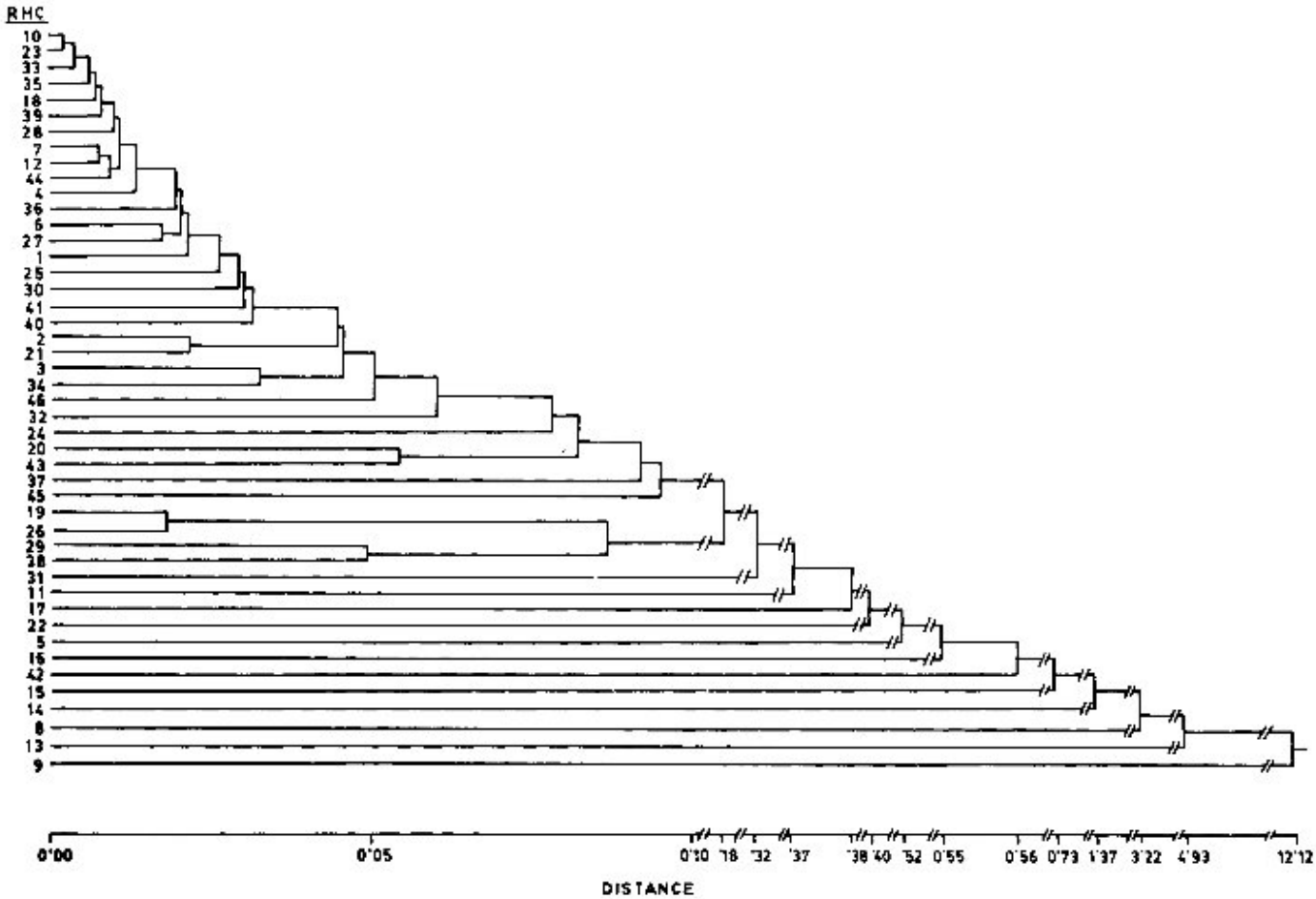

FIG. 2. *Relationships among the four Australoid tribal groups of the western hills.*

TABLE 4
Compositions of the 46 Rational Homogeneous Clusters

Number	Geographical Zone	Ethnic Category	Number of Populations	Populations
1	1	11	1	Brahmin (1)
2	1	12	2	Chowdhury (2), Gaddi Rajput (3)
3	1	33	1	Kashmiri Muslim (4)
4	2	22	1	Sherpa (5)
5	2	22	1	Tharu (6)
6	3	22	3	Christian Lepcha (7), Sherpa (8), Buddhist Lepcha (9)
7	3	22	1	Garo (10)
8	5	11	2	Basti Brahmin (11), Brahmin (12)
9	5	12	1	Ahir (13)
10	5	12	13	Kurmi (14), Agharia (16), Chhatri (17), Agarwal (18), Ahir (19), Gujjar (20), Jat (21), Rajput (22), Baisya (23), Kaibarta (24), Kayastha (25), Kshatriya (26), Sankhari (27)
11	5	12	1	Kahar (15)
12	5	13	1	Chamar (28)
13	5	13	4	Ramdasia (29), Chamar (30), Namasudra (31), Rishi (32)
14	5	21	8	Pahira (33), Bhil (34), Bhatu (35), Kharwar (36), Habru (39), Korwa (40), Rajwar (41), Santal (44)
15	5	21	1	Oraon (37)
16	5	21	1	Majhi (38)
17	5	21	1	Chero (42)
18	5	21	1	Panika (43)
19	5	33	1	Muslim (45)
20	5	33	1	Muslim (46)
21	5	35	1	Jat Sikh (47)
22	6	11	1	Palival (48)
23	6	12	1	Rajput (49)
24	6	12	1	Oswal (50)
25	6	13	1	Meghwal (51)
26	6	21	1	Bhil (52)
27	8	11	1	Vaidiki Brahmin (53)
28	8	12	1	Kamma (54)
29	8	12	2	Vokkaliga (55), Vysya (56)
30	8	21	2	Oraon (57), Oraon (58)
31	9	11	3	Havig Brahmin (59), Chitpavan Brahmin (60), Desasth Rgvedi Brahmin (61)
32	9	12	1	Lingayat (62), Chandrasenya Kayastha Prabhu (63)
33	9	13	1	Nav-Buddha (64)
34	9	21	2	Pawra (65), Bhil (66)
35	9	22	1	Tibetan (67)
36	9	34	1	Parsi (68)
37	11	11	1	Iyengar (69)
38	11	12	2	Chettiar (70), Kallan (71)
39	11	13	1	Pariah (72)
40	12	11	1	Namboodiri Brahmin (73)
41	12	13	1	Ezhava (74)
42	13	21	1	Jenu Kuruba (75)
43	13	21	3	Pulayan (76), Urali (77), Katkari (78)
44	14	22	2	Southern Nicobarese (79), Terressan (80)
45	14	22	1	Chowrite (81)
46	14	22	1	Car-Nicobarese (82)

thropometric variation or that there were other factors that had greater effect. The presence of a few populations within a subset that did not cluster with the majority could be attributed to chance, and we could conclude that ethnic background had a strong effect on anthropometric variation within a geographical zone. Further, a strong correlation between anthropometric variation and ethnic background would cause RHCs of the same ethnic background to cluster across geographical zones. Clustering of populations of the same ethnic background within but not across geographical zones would mean that an ethnic classification based on anthropometric data was feasible within limited regions but not at an all-India level.

The procedure just described produced 46 RHCs (table 4), of which 33 comprised a single population each. In several subsets, a single population was the source of the within-subset heterogeneity. The 37 populations from

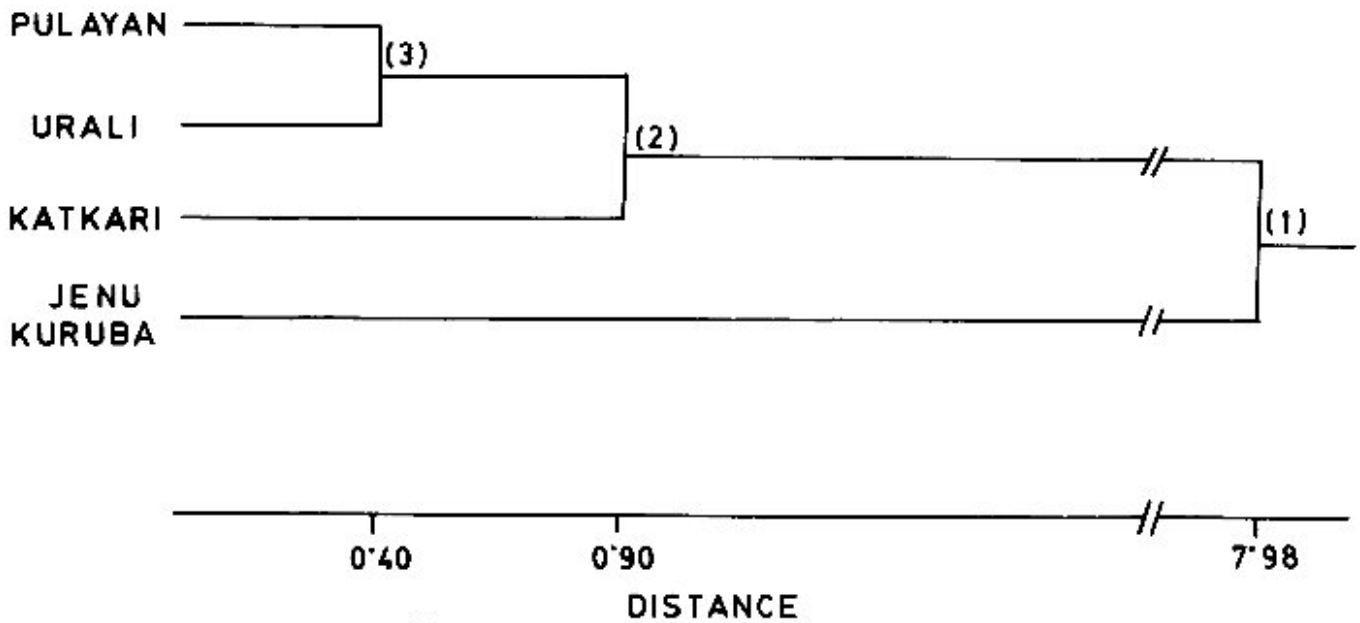

FIG. 3. *Relationships among the rational homogeneous clusters.*

the northern and eastern plains (Zone 5) formed 14 RHCs, of which 10 were single populations; thus, in effect, in this zone 27 populations formed 4 RHCs. There was considerable heterogeneity among the Australoid populations; Oraon, Majhi, Chero, and Panika did not group with any other. The two Muslim populations also formed separate clusters, which, however, is not surprising given the fact that the Muslims are largely religious converts of different ethnic backgrounds (Basu 1985). The pattern of clustering of populations of the Deccan (Zone 9) suggested that there was little heterogeneity once populations had been classified by ethnic background. These results showed that ethnic background is important in explaining heterogeneity among populations inhabiting a zone of more or less homogeneous ecology. This inference is in sharp contrast to the finding of Adhikari, Majumder, and Roy (1987), based on data from southern Indian populations, that geographical contiguity is the major factor in explaining anthropometric variation. The number of populations from southern India in the present analysis is too small to permit resolution of this conflict. It is certainly plausible, however, that ethnic background may not play a uniform role in all geographical regions. The cultural patterns, especially rules governing marriage, prevailing in northern and southern India are quite distinct (Karve 1953). The role of ethnic background in determining anthropometric variation within populations and similarities between populations is primarily mediated through mating practices, admixture, and founder effects, all of which are strongly influenced by cultural factors.

To investigate the similarities among RHCs of different subsets, we constructed a matrix of Mahalanobis's D^2 values between pairs of RHCs by using the combined (over populations comprising an RHC) mean vectors of the RHCs and the pooled dispersion matrix and then produced a single-linkage dendrogram for the RHCs (fig. 3). No clear clustering of RHCs by socio-religious background emerged. For example, the RHCs 10, 23, 33, 35, 18, 39, and 28, which formed a cluster, did not represent populations with same ethnic background, and the RHCs formed by the upper-caste groups of the different geographical zones (1, 8, 22, 27, 31, 37, and 40) did not cluster together. Again, the Australoid populations of RHCs 14–18, 26, 30, 34, 42, and 43 did not cluster together, nor did the Mongoloid tribes of RHCs 4–7, 35, and 44–46. Thus, although within geographical zones there seemed to be a fair correlation of the pattern of clustering of populations with their ethnic backgrounds, no such pattern was discernible across geographical zones. An ethnic classification of the people of India at an all-India level therefore does not seem justified.

That there are significant differences in anthropometric profile among populations inhabiting different geographical zones as well as among those having different ethnic backgrounds indicates that the effects of both these factors on anthropometric variation are important. The observed anthropometric variation at an all-India level cannot, however, be explained by these factors alone; other factors will need to be considered, and the possibility that the residual variation is largely due to chance cannot be ruled out. Further, just four anthropometric characters—head length, head breadth, bizygomatic breadth, and stature—explain an overwhelming proportion (>90%) of the anthropometric variation observed both among geographical zones and among ethnic categories. Many early anthropometric studies (for example, Sarkar 1954) used the cephalic index ([head breadth/head length] × 100) to classify populations into "races," and our finding that these characters are important discriminators of populations in India seems to provide some justification for that practice.

That populations/rational homogeneous clusters belonging to the same ethnic group or "race," for instance, Australoid or Mongoloid, do not cluster together suggests two possibilities: (1) While the early researchers adopted a priori the notion of racial groups and proceeded to classify populations in terms of them, in reality "races" did not exist. (2) "Racial" differences have been blurred by large-scale interbreeding over a long period in the region. The latter possibility is strengthened by ethnohistorical evidence that from time immemorial waves of migrants have been entering India and mixing with the local inhabitants (Kabir 1960, Majumdar 1958). Such interbreeding at the all-India level does not, however, preclude the possibility that migration and interbreeding were relatively limited in some parts of the country. The idea of the non-existence or eventual disappearance of "races" in the Indian context lends credence to the views of Livingstone (1962) and Littlefield, Lieberman, and Reynolds (1982), though it must be borne in mind that (1) our data set does not evenly cover all geographical zones, (2) the number of anthropometric characters is small and mostly confined to the head and face, and (3) the somatoscopic traits that may be better discriminators of "racial" variation are not included. Given these limitations, the present study unambiguously concludes that the people of India cannot be classified into a fixed set of ethnic categories based on anthropometric data. Efforts at typological/"racial" classification should be abandoned, and research should concentrate on the sources of anthropometric variation. We hope that this study will prompt others to verify the generality of its conclusions using a more extensive data set.

APPENDIX: POPULATIONS, THEIR GEOGRAPHICAL AND ETHNIC CLASSIFICATION, AND SAMPLE SIZES

No.	Population	Geographical Zone	Ethnic Category	n	Source[a]
1	Brahmin	1	11	93	1
2	Chowdhury	1	12	98	1
3	Gaddi Rajput	1	12	83	1
4	Kashmiri Muslim	1	33	73	1
5	Sherpa	2	22	67	6
6	Tharu	2	22	100	2
7	Christian Lepcha	3	22	100	6
8	Sherpa	3	22	100	6
9	Buddhist Lepcha	3	22	64	6
10	Garo	3	22	72	3
11	Basti Brahmin	5	11	86	2
12	Brahmin	5	11	100	2
13	Ahir	5	12	68	2
14	Kurmi	5	12	94	2
15	Kahar	5	12	56	2
16	Agharia	5	12	100	2
17	Chhatri	5	12	100	2
18	Agarwal	5	12	98	1
19	Ahir	5	12	99	1
20	Gujjar	5	12	76	1
21	Jat	5	12	100	1
22	Rajput	5	12	90	1
23	Baisya	5	12	73	3
24	Kaibarta	5	12	100	3
25	Kayastha	5	12	100	3
26	Kshatriya	5	12	100	3
27	Sankhari	5	12	100	3
28	Chamar	5	13	100	1
29	Ramdasia	5	13	100	1
30	Chamar	5	13	99	2
31	Namasudra	5	13	100	3
32	Rishi	5	13	100	3
33	Pahira	5	21	100	6
34	Bhil	5	21	100	1
35	Bhatu	5	21	100	2
36	Kharwar	5	21	100	2
37	Oraon	5	21	99	2
38	Majhi	5	21	100	2
39	Habru	5	21	100	2
40	Korwa	5	21	100	2
41	Rajwar	5	21	100	2
42	Chero	5	21	100	2
43	Panika	5	21	100	2
44	Santal	5	21	100	6

APPENDIX *(Continued)*

No.	Population	Geographical Zone	Ethnic Category	*n*	Source[a]
45	Muslim	5	33	100	2
46	Muslim	5	33	100	4
47	Jat Sikh	5	35	100	1
48	Palival	6	11	100	1
49	Rajput	6	12	100	1
50	Oswal	6	12	100	1
51	Meghwal	6	13	97	1
52	Bhil	6	21	100	1
53	Vaidiki Brahmin	8	11	100	1
54	Kamma	8	12	70	1
55	Vokkaliga	8	12	100	1
56	Vysya	8	12	100	1
57	Oraon	8	21	100	6
58	Oraon	8	21	100	6
59	Havig Brahmin	9	11	98	1
60	Chitpavan Brahmin	9	11	95	1
61	Desasth Rgvedi Brahmin	9	11	91	1
62	Lingayat	9	12	100	1
63	Chandrasenya Kayastha Prabhu	9	12	100	1
64	Nav-Buddha	9	13	91	1
65	Pawra	9	21	95	1
66	Bhil	9	21	100	1
67	Tibetan	9	22	100	1
68	Parsi	9	34	96	1
69	Iyengar	11	11	100	1
70	Chettiar	11	12	99	1
71	Kallan	11	12	100	1
72	Pariah	11	13	100	1
73	Namboodiri Brahmin	12	11	100	1
74	Ezhava	12	13	99	1
75	Jenu Kuruba	13	21	100	1
76	Pulayan	13	21	100	1
77	Urali	13	21	100	1
78	Katkari	13	21	100	1
79	Southern Nicobarese	14	22	66	5
80	Terressan	14	22	77	5
81	Chowrite	14	22	100	5
82	Car-Nicobarese	14	22	100	5
	Total			7,762	

[a]1, unpublished data, K. C. Malhotra, Indian Statistical Institute, Calcutta, and M. G. Abdushelishvili [U.S.S.R. Academy of Sciences, Thilisi]; 2, Mahalanobis, Majumdar, and Rao (1949); 3, Majumdar and Rao (1960); 4, Basu (1985); 5, Ganguly (1976); 6, unpublished data, A. Basu, R. Gupta, B. Mukhopadhyay, and S. K. Roy, Indian Statistical Institute, Calcutta.

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