Climate and Head Form in India

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ABSTRACT The relationship between head form and climatic variation was investigated in different tribal and caste populations of India. The magnitude of the cephalic index varies significantly in different zones. In tropical zones, head form is longer (dolicocephalic), but in temperate zones, head form is more round (mesocephalic or brachycephalic), especially among Scheduled Tribes (ST) and Scheduled Castes (SC) than among other castes. These trends possibly support a climatic adaptation model in head form differences among ST and SC in India. Am. J. Hum. Biol. 13:626–634,

Environment is a major factor influencing biological and sociocultural adaptation in man. Several morphological features, such as stature, nose form, body build, head form, etc., are affected by variable climatic stresses (Weidenreich, 1945; Hulse, 1971). Abbie (1947) highlighted the work of Boas, who derived evidence that environmental changes can have effects on head form. Coon (1955) and Beals (1972) observed an inverse relationship between the cephalic index and climatic factors and showed that the longer head (dolichocephalic) is predominant in hot climatic regions and the broader head (mesocephalic or brachycephalic) is predominant in less hot regions.

Thus, cephalic index is apparently correlated with climatic stress and follows the ecological rules of Allen and Bergmann. It is generally expected that under cold stress, the most advantageous head shape would be of a round type (brachycephalic), since this most closely approximates the spherical ideal. Under hot climatic conditions, a long head would be more advantageous. In reality, there are numerous exceptions to these expectations.

While worldwide studies show significant associations of changes in head shape with respect to the climatic adaptation model, can this be validated at the regional level with similar climatic variations? Such studies have been rarely attempted possibly due to paucity of data and difficulties in controlling and separating confounding factors whose influences might mask real differences due to climatic adaptation. However, such an attempt may be worthwhile in a microevolutionary investigation in order to understand the influence of population structure variables and changes in head shape.

In this context, the Indian subcontinent represents global climatic conditions in different regions and bears evidence of human habitation since prehistoric times. This presupposes a situation of climatic adaptation and possible microevolutionary changes. Though several studies have shown the operation of microevolutionary phenomena among the diverse populations of India in different regions, both spatially and temporally, studies to investigate the overall biological changes using data of multiple populations are not many, especially with respect to climatic adaptation. The influence of population structure variables in investigations of head shape associated with climatic adaptation in India needs elaboration because it leads to several hypotheses. Due to historical reasons the population of India shows wide diversity in terms of biological, cultural, and linguistic aspects. It has several ethnic or tribal populations, who are the original settlers, with little migration and admixture. These also represent different racial groups. A majority are caste populations among which Scheduled Caste populations are the lowest in hierarchy and are maritally isolated from other populations. The other caste populations show many cultural and biological similarities, possibly due to migration and diffusion processes. Therefore, it is necessary that an investigation of head shape associated with climatic adaptation needs to consider popu-

lation structure. This situation prompts the suggestion that, if there is climatic adaptation of head shape, it should be more prominent among ethnic, tribal, and Scheduled Caste populations than among other Indian castes or among a similar racial stock in different regions. Therefore, the purpose of this study is to investigate the validity of the proposed climatic influence on head shape in the Indian subcontinent with respect to the ethnic and historical backgrounds of the populations.

MATERIALS AND METHODS

Climatic regions

The Indian subcontinent represents a variety of natural, geophysical, or topographical regions due to high mountains, a vast seacoast, rivers, jungles, deserts, etc., with their characteristic climates. They can be divided into typical climate zones according to whether they "generally possess a broad uniformity in climatic conditions produced by combined effects of climatic factors" (Bhasin et al., 1992, p 17). Based on monthly values of temperature and precipitation, as per Köppen's method, the country can be classified into eight climatic zones, in three natural regions: the Himalayan mountain complex, the Indus-Ganga-Brahmaputra plain, and the peninsular plateau. The eight zones are as follows: (1) tropical savannah, (2) monsoon with a short dry season, (3) monsoon with a dry season in the high sun period, (4) semi-arid and steppe climate, (5) hot desert, (6) monsoon with dry winters, (7) cold humid winter with a shorter summer, and (8) polar. The climatic regions along with state boundaries are shown in Figure 1.

Identification of populations

The data for the study has been obtained from "People of India," National Series, Vol. X (1994). This is a anthropological survey of physical and cultural identification of a wide diversity of populations in India, and it was conducted by the Anthropological Survey of India between October 1985 and March 1992. The total sample of 643 populations from different climatic regions (and States) with data on mean cephalic index (or head length and head breadth) were considered in the present study. From the name and place of the caste or community that was recorded, it was possible to link a particular population to its geographical location, especially *taluk* and district, and consequently to a specific climate region. Thus, the majority of the populations could be unambiguously assigned to a climatic region. However, in a few cases, the specific geographic location or the caste identity was not available, but its climatic region could be identified. These were some cases where the ethnic or caste identity was known, but the place and climatic region was not recorded; such cases were excluded. The detailed list of populations and their ethnic and climatic affiliations is available from the authors upon request.

Mean cephalic indices were broadly classified as per standard anthropological methods as, dolichocephal, mesocephal, and brachycephal, depending on the range of average index values: <75.0 , between 75.0 and 79.9, and ≥ 80.0, respectively. For each climatic zone, the number, mean, range, and standard deviations were calculated, and t-tests have been performed. The time period of the data set spans 1870 to 1990.

The population structure of India consists of tribal, caste, and religious or ethnic groups. The data for the study were divided into three categories: tribal population (ST) who are presumably the original stock and who are largely homogenous; Scheduled Castes (SC) who are also natives and ancient and who are lower ranked castes; and other castes (OC) which include various castes and subcastes of Hindu Society.

The different types of head shapes (especially meso, dolicho, and brachy) as per the average cephalic index of the three categories, ST, SC, and OC, were identified, and assigned to geographic locations and also to climatic regions. These are shown in Figures 2–4. Pairwise t-tests were performed to test the differences in mean values of cephalic index between two climate regions for each ethnic population. Further, ANOVA (one-way) was performed between climatic regions (seven and three separately) and for each population separately (all castes, SC, ST, and OC).

Any study based on published data has limitations that need to be addressed, and the results of the analysis should be interpreted accordingly. Limitations included sample sizes and the number of populations available in different regions. In some cases, sample size was not adequate. In others, the number of samples for a region was small or there were no data for some regions.

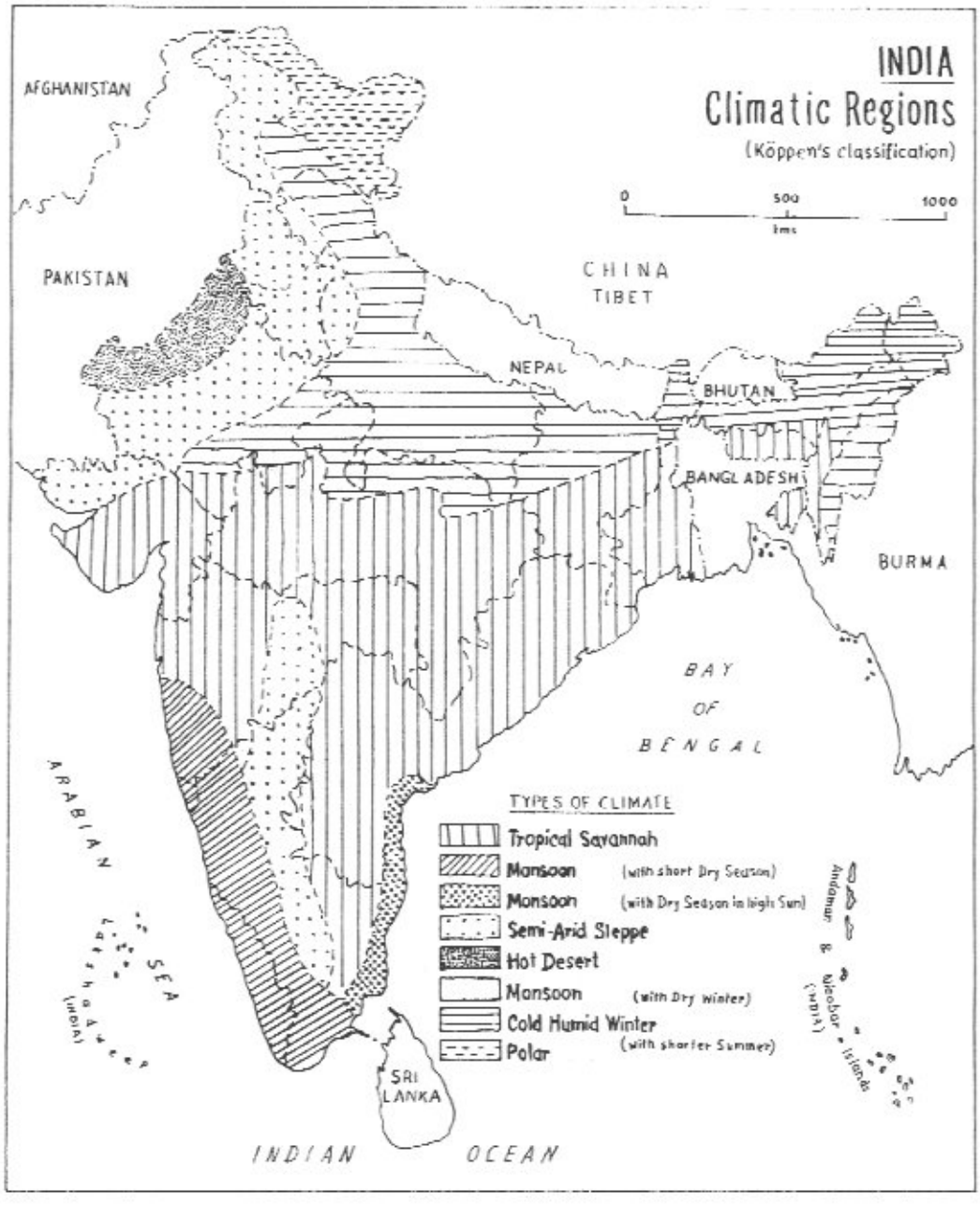

Fig. 1. Different climatic regions in India as per Köppen's classification.

RESULTS

Table 1 describes the average cephalic index values of the Indian populations based on the respective climate regions. Mean cephalic indices vary from about 75.0 to 80.0 in seven of the eight climate regions. The highest mean index (79.95) occurs in the monsoon with dry winter type and the lowest (75.16) occurs in the semi-arid–steppe-type regions. However, in both cases, sample sizes are small. In other regions where sample sizes are adequate, mean indices also vary, possibly suggesting associa-

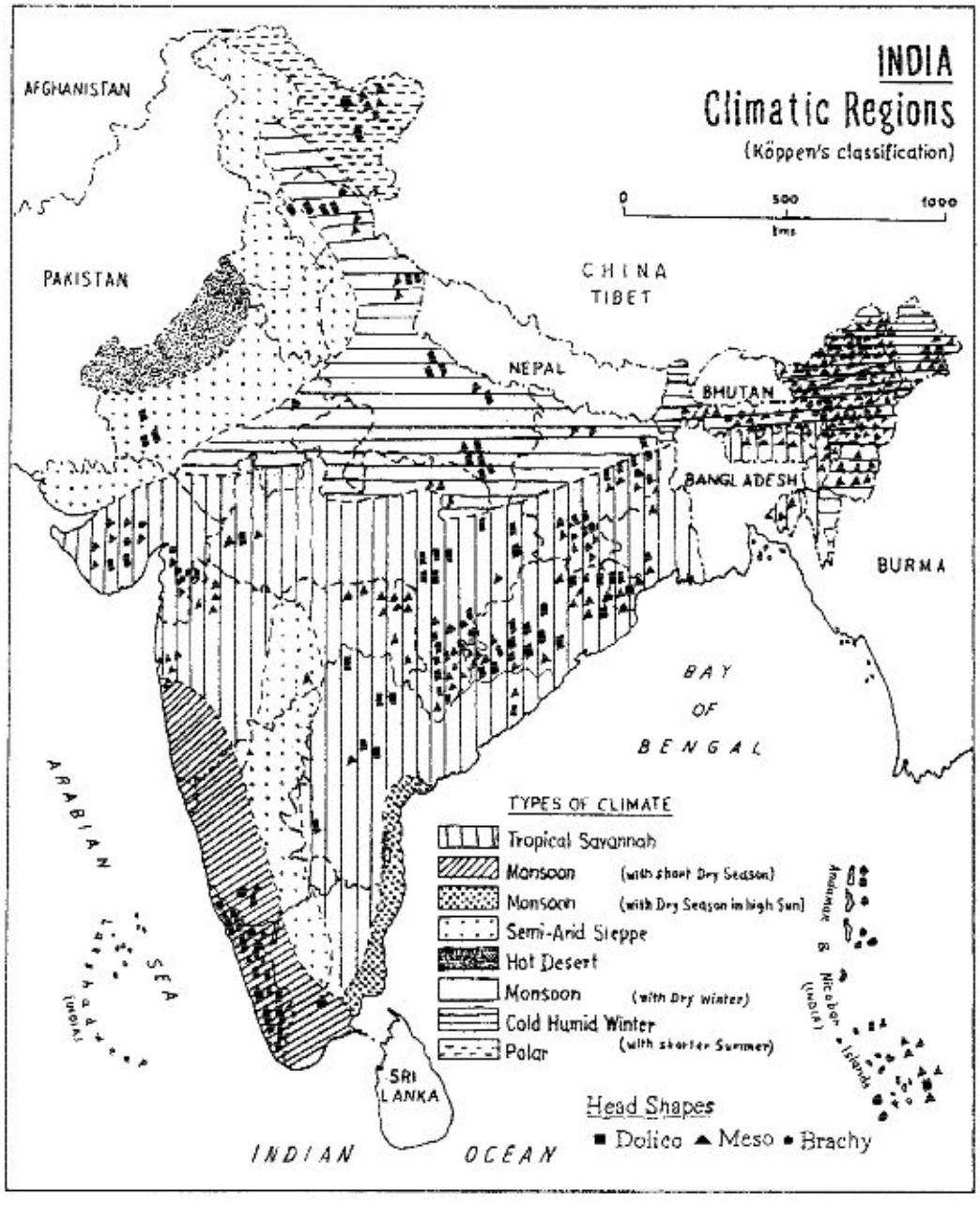

Fig. 2. Average cephalic index of Scheduled Tribes in different climatic regions.

tion in absence of other confounding variables. The variability of mean cephalic indices across regions is about the same, except where sample sizes are small. The high variance (3.36) in the case of the monsoon with dry winter region is due to the sample from the Andaman and Nicobar populations, which are racially distinct from other populations; this can be attributed to genetic differences.

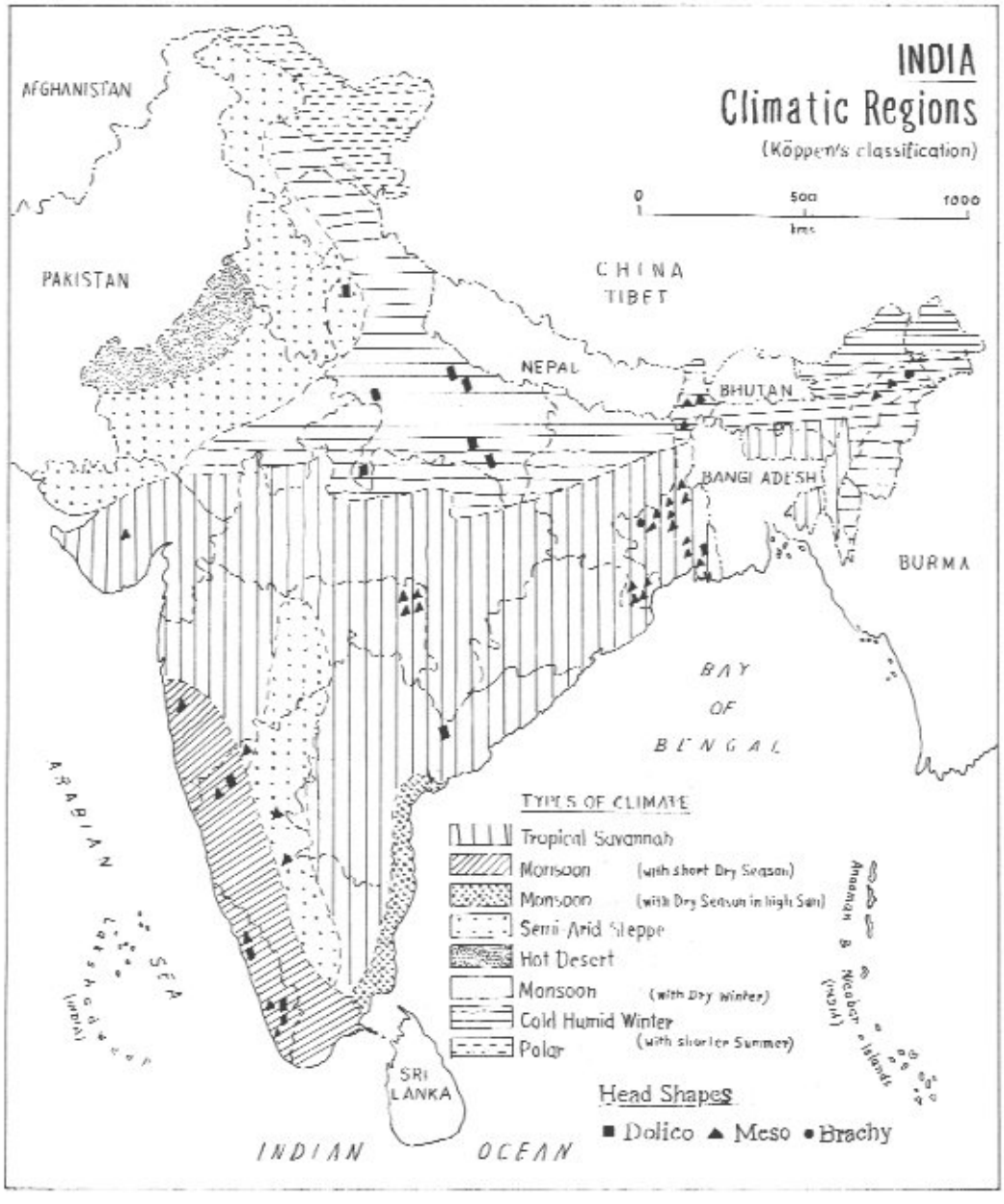

Fig. 3. Average cephalic index of Scheduled Castes in different climatic regions.

The seven climatic regions were coalesced into three broad categories (Table 2). The mean cephalic index is about the same between the tropical and monsoon regions, while a higher mean cephalic index (77.04) is observed in the cold and polar regions. When the data were further grouped into two regions, hot and cold, the mean cephalic index was significantly lower in the hot region (76.34) than in the cold climatic region (77.31).

A comparison of the results of paired *t*-tests between any two climatic regions showed that 12 of 21 were significant (the

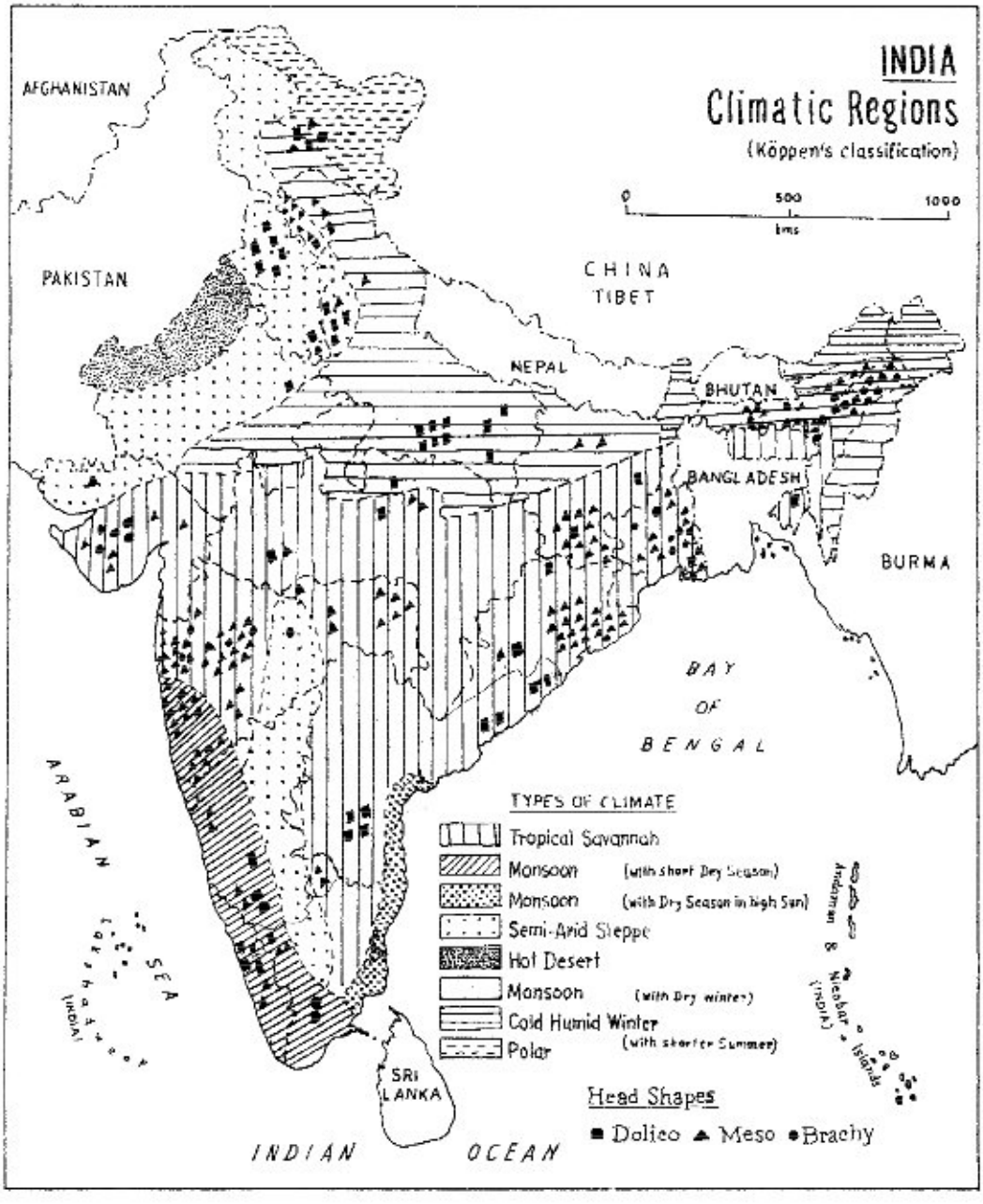

Fig. 4. Average cephalic index of other castes and others in different climatic regions.

table not included). Of the 12 significant values, those between the tropical savannah and monsoon with dry winter and with other regions were highly significant. Indices for cold humid winter with short summers showed significant differences with monsoon with dry season in high sun period and semi-arid and steppe climate only. These results suggest that mean cephalic indices do show some significant differences among climatic regions.

One-way analysis of variance (ANOVA)

TABLE 1. Cephalic index of all castes and communities in different climatic zones of India

Climatic zone	No. of samples	Range	Mean	SD
Tropical savannah	304	69.39–87.13	76.65	2.45
Monsoon (with short dry season)	80	67.10–82.09	75.68	2.54
Monsoon (with dry season in high sun)	6	72.28–77.24	75.30	1.51
Semi-arid steppe	30	71.12–80.19	75.16	2.52
Hot desert	—	—	—	—
Monsoon (with dry winter)	16	74.33–86.11	79.95	3.36
Cold humid winter (with short summer)	197	69.42–82.24	77.05	2.58
Polar	10	72.20–83.10	76.75	2.99

TABLE 2. Cephalic index of all castes and communities in the major climatic zones of India

Climatic zone	No. of samples	Range	Mean	SD
Tropical	334	69.39–87.13	76.51	2.49
Monsoon	102	67.10–86.11	76.36	3.15
Cold	207	69.42–83.10	77.04	2.60

TABLE 3. Cephalic index of all castes and communities in hot and cold regions of India

Climatic zone	No. of samples	Range	Mean	SD
Hot	420	69.39–87.13	76.34	2.52
Cold	223	69.42–86.11	77.31	4.22

was performed to test the difference in cephalic indices among the seven climatic regions separately for all castes, ST, and SC populations. The result showed significant differences in the cephalic index among the seven climatic zones in case of all castes ($F = 11.3$; df = 6, 637; $P = 4.68 \times 10^{-12}$) and Scheduled Tribes ($F = 19.1$; df = 6, 346; $P = 2.87 \times 10^{-19}$). Similarly, ANOVA (one way) was carried out in case of three broad climatic regions separately for all castes, ST, and SC populations. The result showed no significant differences in cephalic index between all castes ($F = 2.8$; df = 2, 641; $P = 0.061$) but a significant difference in SC populations ($F = 3.4$, df = 2, 46; $P = 0.043$) and in ST population ($F = 12.0$; df = 2, 350; $P = 8.95 \times 10^{-6}$).

Ethnicity and mean cephalic index

Because the populations in the different climatic regions are not homogeneous and belong to different castes and ethnic endogamous groups, some of the differences could be due to sample heterogeneity. The data have been, therefore, reanalyzed in four categories separately: Scheduled Tribes, Scheduled Castes, other castes, and non-caste groups. The Scheduled Tribes are the original inhabitants with distinct cultural, linguistic, and regional affiliation with little migration and are different from other populations.

Among different caste groups, Scheduled Castes are at the end of the caste hierarchy. They are mostly land laborers located in a particular region with little migration and admixture with other caste groups; they form a distinct group. The different caste groups (Brahmin, Kshatriya, Bania, and Sudra) although they follow a separate endogamy, show little physical and cultural differences, and are possibly nonlocalized and widely spread in different regions. The fourth category comprises the religious ethnic minorities, especially Muslim and Christian populations with possibly historical migration and spread in to different regions. A comparison of the mean cephalic index in different climatic regions for each of the four categories are shown separately in (Tables 4–6 and Figs. 2–4).

Among Scheduled Tribes (Tables 4a,b, Fig. 2), sample sizes for the monsoon type with dry season in high sun period, semiarid and steppe type and polar type were small. Even then , the polar type showed a high index (76.83) that is different from that for the monsoon type with dry season in high sun period and semiarid and steppe type. In the other four regions where the sample sizes were comparable, the results showed significant mean differences in the cephalic index among regions. Populations in the monsoon with dry winters and cold humid winter with a short summer showed higher indices (79.95 and 77.10) than populations in tropical (75.58) and monsoon with short dry season (74.45). The variability across regions is the same except for the monsoon with dry winters, which is due to the inclusion of Andaman and Nicobar populations. The data were regrouped into three distinct climatic regions. Both tropical and monsoon climates have the same mean cephalic index (75.52 and 75.99) which differs from the cold humid–polar region (77.09).

TABLE 4a. Cephalic index of Scheduled Tribes in different climatic zones of India

Climatic zone	No. of samples	Range	Mean	SD
Tropical savannah	144	69.39–87.13	75.58	2.56
Monsoon (with short dry season)	38	67.10–82.09	74.45	2.23
Monsoon (with dry season in high sun)	2	72.28–75.00	73.64	1.36
Semi-arid steppe	5	71.70–76.13	73.76	1.71
Hot desert	—	—	—	—
Monsoon (with dry winters)	16	74.33–86.11	79.95	3.36
Cold humid winter (with short summer)	140	70.50–82.24	77.10	2.26
Polar	7	74.90–83.10	76.83	2.77

TABLE 4b. Cephaic index of Scheduled Tribes in different climatic zones of India

Climatic zones	No. of samples	Range	Mean	SD
Tropical	149	69.39–87.13	75.52	2.27
Monsoon	56	67.10–86.11	75.99	3.73
Cold	147	70.50–83.10	77.09	2.29

Among Scheduled Castes (Table 5 and Fig. 3), the available data were limited to three climatic regions: tropical savannah, monsoon with short dry season, and cold humid winter. The mean cephalic index decreases from tropical to monsoon to cold humid). In case of other castes (Table 6 and Fig. 4), tropical savannah, monsoon with short dry season, semi-arid and steppe, and cold humid winter populations have comparable sample sizes, but the results do not indicate a clear trend. For example, population in the tropical monsoon and cold humid regions have mean cephalic index around 77.00. In case of other ethnic groups, the samples are too small.

DISCUSSION

The ecological rules of Allen and Bergman applied to climatic adaptation in head shape have been evaluated among world populations like for Africa by Hiernaux (1968), for Europe by Crognier (1981), and for the Mediterranean populations by Beals (1972). These studies do not negate the climatic adaptation model of head shape, though other factors may also play a role. If so, can this be investigated in a subcontinental situation where similar climatic regions exist? India presents such a situation. Possible confounding factors, especially related to the influence of population structure variables, marriage patterns, and migration, can be considered. The present study has thus tried to investigate the climatic adaptations in head shape in different ethnic groups in India. The results, with limited sample sizes in some cases, do support such a possibility. For example, the Scheduled Tribes who represent the original stock of India (suggesting adaptation to the region) and little migration show a higher average cephalic index in colder regions than in non-humid regions. This is consistent with the climatic adaptation model. In contrast, among different caste groups, such changes are least expected due to their heterogeneous nature and to admixture and migration in different regions. Thus, it is difficult to observe an association with climatic regions; potential associations may be masked or influenced by population structure variables related to migration and admixture.

The results suggest least association of head shape in different eco-regions among caste groups. In an early study investigating the brachycephalization among Indian populations, Guha (1935) observed a trend toward broader mesocephals in the Eastern and Himalayan regions, which extended to the northeastern parts of India such as Assam, Nagaland, Manipur, Tripura, and West Bengal, possibly due to Mongoloid elements in these parts. Mesocephalic head form is seen in Western and Southern regions of India except in Kerala, where it is predominantly dolichocephalic. The present results support the observations of Guha (1935). Similarly, Sarkar et al. (1955) showed that brachycephalics sweep across the peninsula to the south Madras, except along the Malabar coast. Because the data are taken from published materials and the time period spans from 1870 to 1990, the influences of cultural, nutritional, and/or economic changes are potentially confounding.

Various hypotheses have been suggested to explain the temporal trends in head shape. It may be due to natural selection (Henneberg et al., 1978). Bielicki and Welon (1964) showed that long-headed individuals have lower life expectancy than others, while Olivier (1979) suggested dolichoce-

TABLE 5. Cephalic index of Scheduled Castes in different climatic zones of India

Climatic zone	No. of samples	Range	Mean	SD
Tropical savannah	24	73.07–80.54	77.61	1.67
Monsoon (with short dry season)	9	73.10–79.60	76.04	2.06
Monsoon (with dry season in high sun)	—	—	—	—
Semi-arid steppe	1	—	78.86	—
Hot desert	—	—	—	—
Monsoon (with dry winter)	—	—	—	—
Cold humid winter (with short summer)	16	71.90–80.40	75.84	2.93
Polar	—	—	—	—

TABLE 6. Cephalic index of other castes in different climatic zones of India

Climatic zone	No. of samples	Range	Mean	SD
Tropical savannah	129	70.90–82.91	77.39	2.13
Monsoon (with short dry season)	33	72.00–81.60	77.00	2.30
Monsoon (with dry season in high sun)	4	75.50–77.24	76.12	0.67
Semi-arid steppe	24	71.12–80.19	75.30	2.52
Cold humid winter (with short summer)	34	69.42–81.49	79.96	3.36
Polar	3	72.20 ± 80.60	76.57	3.44

phalic is more susceptible to death from tuberculosis, plague, and small pox. In the Indian climatic context, the present data suggest that the dolichocephalic head form is restricted to the semi-arid zone and also that a broader head form is predominant in cold regions. The absence of brachycephalic (cephalic index > 80.0) in polar region in India may be explained by the fact that, compared to other regions, the polar region is a very small zone and it was largely uninhabited except in the Leh region of Kashmir by Tibetan ethnic populations. Further, the available data are limited to only a few samples. The majority of populations in the valleys of Kashmir have recently migrated into the area over a century or two, which is probably not sufficient in the context of the climatic adaptation model.

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LITERATURE CITED

Abbie AA. 1947. Head form and human evolution. J Anat 81:233–258.

Basu A, Majumder PP, Ghosh AK, Biswas SK. 1980. Human biological variations in Asia, with special reference to India. In: Hiernaux J, editor. La Diversitè biologique humaine: human biological diversity. Paris: Masson. pp 197–273.

Beals KL. 1972. Head form and climatic stress. Am J Phys Anthropol 37:85–92.

Bhasin MK, Walter H, Danker-Hopfe H. 1992. The distribution of genetical, morphological and behavioral traits among the peoples of Indian region (Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka). New Delhi: Kamla-Raj Enterprises.

Bielicki T, Welon Z. 1964. The operation of natural selection on human head form in an East European population. Homo 15:22–30.

Coon C. 1955. Some problems of human variability and natural selection in climate and culture. Am Nat 89: 257–279.

Crognier E. 1981. Climate and anthropometric variation in Europe and the Mediterranean area. Ann Hum Biol 8:99–107.

Guha BS. 1935. The racial affinities of the people of India, Census of India, 1931. New Delhi: Government of India Press.

Harrison GA, Tanner JM, Pilbeam DR, Baker PT. 1990. Human biology. London: Oxford University Press.

Henneberg M, Pionten J, Strzalko J. 1978. Natural selection and morphological variability. Curr Anthropol 19:67–82.

Hiernaux J. 1968. La Diversitè humaine en Afrique Sub-Saharienne. Bruxelles: Universitè Libre de Bruxelles.

Hulse F. 1971. The human species. New York: Random House.

Olivier G, de Castro e Almeida ME. 1979. One of the factors of brachycephalization over the centuries: the susceptibility of dolichocephals to tuberculosis. In: Stini WA, editor. Physiological and morphological adaptation and evolution. The Hague: Mouton. p 279–285.

Sarkar SS, Deka U, Agarwal KK. 1955. Brachycephaly in India. Man India 35:257–273.

Singh KS, Bhalla V, Kaul V. 1994. People of India, National Series, Vol X.

Anthropological Survey of India. New Delhi: Oxford University Press. p 140–204.

Weidenreich F. 1945. The brachycephalization of recent mankind. Southwest J Anthropol 1:1–54.