ANTHROPOLOGY FOR ARCHAEOLOGY
Proceedings of the Professor Irawati Karve Birth Centenary Seminar

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2007

HUMAN BIOLOGICAL DIVERSITY IN ANCIENT INDIA: DR. IRAWATI KARVE AND CONTEMPORARY ISSUES IN BIOLOGICAL ANTHROPOLOGY

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Abstract

A renaissance woman, Dr. Irawati Karve made significant contributions to our understanding of the social and cultural dynamics of Indian society and presented original and provocative perspectives on the biological composition and origins of Hindu castes. Her research in biological anthropology was methodologically and theoretically original and set the stage for subsequent research on the biological adaptations of living and prehistoric people of India.

Anthropometric variation among the castes and tribes of India has a long history in India and Dr. Karve made substantive contributions to this research, in Maharashtra and in Orissa. More importantly, on the basis of anthropometric, anthroposcopic, and serologic variation she formulated a fusion theory of caste formation. Significantly, Dr. Karve was a pioneer in the use of multivariate measures of biological distance in biological anthropology, and used these sophisticated statistical methods to estimate the degree of biological affinity between sub-castes.

Dr. Karve's early research interests in biological anthropology are manifest in modern approaches to biological diversity among ancient Indian populations. Three examples, taken from my recent research will be highlighted: a) stature: from caste differences to evolutionary adaptation; b) dental morphology: reliable clues to biological relationships; and c) oral health: subsistence change and sex factors.

Descriptive comparisons of caste differences in stature comprised one among many measures of the biological attributes of Hindi castes. Today stature is viewed within a micro-evolutionary adaptive context, with nutritional variation, activity patterns, and climatic factors constituting significant influences on variation in stature, in ancient and in living populations. Numerous and highly heritable morphological variants of the dentition provide more accurate estimates of population affinity than do environmentally malleable measures of affinity such as craniometric variables. Cultural changes in subsistence, including greater reliance on, and intensification of, farming, has resulted in worse dental health generally, and a significantly greater decline in the oral heath of women than of men. This widespread sex difference becomes more divergent through time and is best measured in archaeological samples by sex differences in dental caries prevalence. The aetiology of caries may be more complex and multi-factorial than many dentists or anthropologists believe, and in addition to diet may include complicating effects of hormonal fluctuation and reproductive history.

Introduction

This contribution has two main objectives: a) to consider Dr. Irawati Karve's research contributions to the field of anthropology, especially her impact on biological anthropology in India, and b) to present data and new perspectives on adaptive diversity in stature that are intellectually and conceptually linked to Dr. Karve's pioneering research in the field.

Dr. Karve's Impact on Biological Anthropology in India[1]

A renaissance woman, Dr. Karve made significant contributions to multiple sub-disciplines in the field of anthropology. In archaeology she was involved in the early phases of research at the important site of Langhnaj, Gujarat (Karve 1945; Sankalia and Karve 1949). In her widely read and influential book, entitled *Kinship Organization in India*, Karve (1953) dealt with complex issues of Indian social organization. In this work she recognised five major kinship and language groups, which were based on comprehensive descriptions of:

a) kinship terminology and behaviour,
b) rules of descent,
c) marriage and family organisation, as well as
d) ownership, succession and inheritance.

In today's parlance, Dr. Karve's research in biological anthropology would be referred to as bio-cultural in nature because it examined the interplay between social systems and human biological diversity. The effects of caste endogamy on the genetic and anthropometric characteristics of castes and tribal peoples of India were a prime focus of her research in biological anthropology. Dr. Karve's research agenda was motivated by such questions as: How similar or distinctive are castes and tribes from one another in terms of morphology and genetic structure? Are there consistent and significant differences between Hindu castes, and between castes and tribal populations, in traditional phenotypic components of human biological variation, such as stature, skin colour, cranial shape and form, limb length and proportions? Much of this research was conducted within her home state of Maharashtra, where she initially focused on the Marathas (Karve 1948) and subsequently analysed the anthropometric features of the people of Maharashtra (Karve and Dandekar 1951).

The close association of several distinctive social groups in the confined space of a traditional village relied upon segregation by ritual, occupational and economic factors. The co-existence and functional integration of caste groups fascinated Dr. Karve and motivated her research agenda. In another influential and widely read book, entitled *Hindu Society: An Interpretation*, Dr. Karve (1961) provided a diagram depicting the complex structure of Social Groups in Maharashtra (Fig. 1). Karve's view of Maharashtrian social organization and the questions she asked about the ancestry and biological identity of endogamous groups formed the basis for a recent analysis of biological relationships among Mahars, Marathas and the indigenous early farmers of Inamgaon (Hemphill *et al.* 2000).

Going beyond data collection and descriptive research on the physical attributes of individual castes and tribes, Dr. Karve was concerned with larger and more difficult research questions. For example, what processes and mechanisms were responsible for the origin of castes and of the caste system itself? Can biological variation among castes inform us about the origin and early history of castes? She formulated opposing models of caste origins often termed fission and fusion models of caste formation. The research hypothesis

1. Biographical essays on Dr. Karve's scholarly writings and contributions to anthropology provide additional valuable perspectives (Berreman 1991; Gulati 1973; Singh 1997)

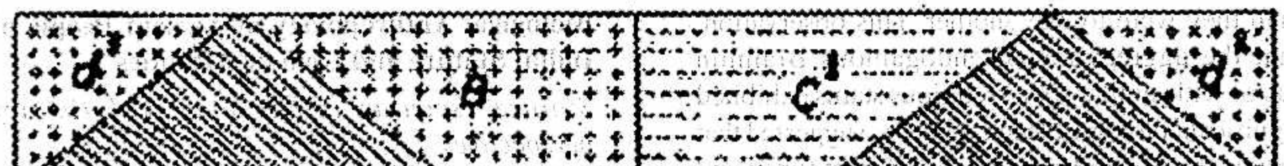

Fig. 1 Diagram of Maharashtrian Village Social Organization according to Karve (1961, p. 67). Letters and numbers represent distinct social groups. Roman numberals I, II, III and IV designate Brahmin castes; the diamond at center is the dominant Maratha caste of Maharashtra; B and B1 signify eastern and western Mahars; while C and C1 are Chambhar (shoe-maker) castes; d, d1, d2 and d3 are Kumbhar (potter) castes, each of different origin (Gujarat, Ganga Plain, Andhra Pradesh and local). The presence of distinct endogamous groups living in close proximity to one another and linked by socioeconomic and ritual bonds is characteristic of traditional Indian society.

was that if sub-castes displayed a high degree of biological similarity, then fission from a common ancestral group would be a reasonable explanation of caste formation. Alternatively, if sub-castes are biologically dissimilar and display numerous and significant differences in their genetic and anthropometric traits, then they likely represent heterogeneous amalgamations formed by the fusion of distinctive groups with divergent past cultural and biological histories. In a seminal article published in 1968, the anthropometric and genetic attributes of eight endogamous Brahmin casts of western Maharashtra were presented to an international audience (Karve and Malhotra 1968). While comprising only 9% of the Maharashtrian population, the eight endogamous Brahmin castes studied by Karve and Malhotra displayed significantly higher levels of inter-group biological heterogeneity than more numerous groups comprising the Maratha-Kunbi caste. Some Brahmin castes, such as Deshastha Rigvedi or Saraswat Brahmins, were found to be more similar in anthropometric and genetic trait frequencies to non-Brahmin castes, such as Marathas or Prabhus, than they were to one another. This observation, that the aggregation of endogamous Brahmin castes with similar socio-religious status exhibited significant biological heterogeneity, suggested that they attained similar status at different times and through unique historical pathways. The new term 'caste-cluster' was coined to reflect biological diversity in anthropometric and genetic attributes among Brahmin endogamous groups. Karve and Malhotra (1968) concluded that the fusion model of caste origins played a more critical role in the formation of Brahmin caste-cluster of western India than previously believed and had greater general relevance than the fission model.

My research career has been devoted to describing and interpreting biological variation among prehistoric peoples of ancient India. The objective of research is to more fully understand the mechanisms by which prehistoric populations adapt to changing environmental settings and cultural behaviours. In preparing for this conference I considered Dr. Karve's research accomplishments in bio-cultural anthropology and how she and her students have influenced the structure and focus of my own research. This reflective exercise resulted in the selection of a current research topic that I feel demonstrates continuity in research with Dr. Karve, yet illustrates important new evidence and comparative examples from other geographic regions.

In the following sections I review long- and short-term variation in stature among prehistoric and living people of India from an adaptive and comparative perspective and interpret the pattern as evidence for a negative secular trend in stature. This analysis of stature variation in India reflects influence from and continuity with past research by Dr. Karve and her students, includes data from recently completed research, and points to new directions and questions about biological adaptation and diversity among the peoples of India past and present.

Biological Anthropology of Ancient People of India: Stature and Genetic Affinities

Stature: secular trends and evolutionary perspectives

Changing perspectives on variation and trends in human stature are discussed in this section. Early anthropologists working within a typological or racial analytic paradigm were motivated to gather abundant anthropometric data on castes and tribes to ascertain their racial identity or composition (Eickstedt 1923, 1926, 1934, 1935; Guha 1935; Risley 1908). Extensive data on the stature of different caste groups was included in Karve's anthropometric work in Maharashtra (Karve 1948; Karve and Dandekar 1953), yet her objective was not racial classification. Her research goal was to use anthropometric data, including data on stature, to answer questions regarding the fission or fusion models for the origin and formation of castes. In this section we place stature in adaptive and chronological contexts by: a) documenting the tall stature of early Holocene hunters and foragers of north India, b) discussing factors influencing short- and long-term change in stature, and c) reviewing data for a negative secular trend among living populations. We are well acquainted with fact that nature or genetic heritage, and nurture, quality of the environment, have a direct influence on variation in stature (Bogin 1988; Sinclair 1969; Tanner 1978). Though we have little control over the inherited and complex genetic contributions to variation in stature, most readers are keenly aware of the impact variation in diet has on growth in height. Climate, behaviour, and activity levels comprise additional environmental components that have indirect and complex consequences for the attainment of adult stature (Larsen 1997; Katzmarzyk and Leonard 1998, Pearson 2000).

In the following analysis, trends in stature are approached from several different yet complementary perspectives. First, long-term trends in stature are documented using evidence derived from prehistoric human skeletal remains. Individual estimates of stature derived from measurement of limb bones are converted to mean stature estimates for each available skeletal series. Second, short-term trends in stature among living peoples of India over several generations are presented and evaluated. Maximum standing height of living people were statistically summarised by group for caste and tribal populations. Average stature values in both prehistoric and living study groups are for males only. Finally, negative secular trends in stature are briefly discussed and potential causal mechanisms underlying short- and long-term decline in stature are considered.

Long-term trends in stature - the prehistoric evidence

Recent evidence from bioarchaeological research in northern India confirms the tall stature of early hunters and foragers of the Ganga Plains (Lukacs and Pal 2003). This distinctive phenotypic attribute is found in skeletal samples from Sarai Nahar Rai (Kennedy et. al. 1986), Mahadaha (Kennedy *et al.* 1992), and Damdama (Lukacs and Pal 1993), and was initially recognised by (Sharma 1973). For example, estimates of mean stature for early Holocene inhabitants of Damdama reveal tall males (179.1 cm. ± 8.1; n= 18) and tall females (173.0 cm. ±10.1; n= 11). These stature estimates compare favourably with values for nearby sites of Sarai Nahar Rai and Mahadaha, and collectively indicate that early hunters and foragers of the Ganga Plain were unusually tall (Lukacs and Pal 2003). This adaptation may have conferred an adaptive advantage with regard to physiological stress in hot dry climatic conditions and to enhance locomotor efficiency facilitating logistical and transhumant mobility (Lukacs *et al.* 1997; Lukacs 2002). Figure 2 provides a Graphic Comparison of Stature Estimates for Ganga Plain samples (males only) with early farmers and nomads of northwest India and with living castes and tribes of India. (Abbreviations in Fig. 2: DDM = Damdama, MDH = Mahadaha, SNR = Sarai Nahar Rai; HAR: R37 = Harappa, cemetery R37; HAR: H = Harappa, cemetery H; TMG = Timargarha; BZH = Burzahom; MR 2 = Mehrgarh, Chalcolithic; Castes 1 and 2 and Tribes 1 and 2 are from Ganguly 1979). Three groups of sites were chosen for comparison on the basis of criteria such as subsistence pattern, geographic location or chronological context. The left three data points comprise group 1 and represent early Holocene hunting and foraging peoples of the Ganga Plain, including data for the samples from Damdama, Mahadaha, and Sarai Nahar Rai (from left to right). This group is chronologically the earliest and phenotypically the tallest in the comparative sample, with an overall average stature of 179.9 cm. (± 6.5). Group 2 consists of seven early farming and nomadic skeletal samples from northwest India. This group includes Harappan agricul-turalists from Harappa (cemeteries R 37 and H), Lothal and Mohenjodaro, whose overall average stature is 172.2 cm. (± 7.5), as well as series from Timagarha (TMG), Burzahom (BZH) and Chalcolithic Mehrgarh (MR 2; Lukacs and Hemphill 1991). The third group consists of living castes and tribes of India. The means for these groups were computed from data reported by Ganguly (1979). Symbols in Fig. 2 for mean stature of Caste - 1 (164.2 cm) and Caste - 2 (163.3 cm) represent the first (earlier) and second (later) values for all castes listed in Ganguly's (1979) Tables 1 and 2. Likewise, Tribe - 1 (161.5 cm) and Tribe - 2 (160.7 cm) represent mean values for first and second measurements of stature among all tribes listed in Ganguly's Table 1 and 2. The 'error bars' in Fig. 2 indicate one standard deviation above and below the mean, while the diagonal line running through the data points indicates the overall trend in stature. The groups with greatest antiquity are the early Holocene hunters and foragers on the left of the chart, while living castes and tribes on the right side represent a range of subsistence and activity patterns. While mostly agricultural, some of the living groups in the analysis practice mixed subsistence strategies that include varying amounts of foraging, fishing, and limited agriculture. The long-term decrease

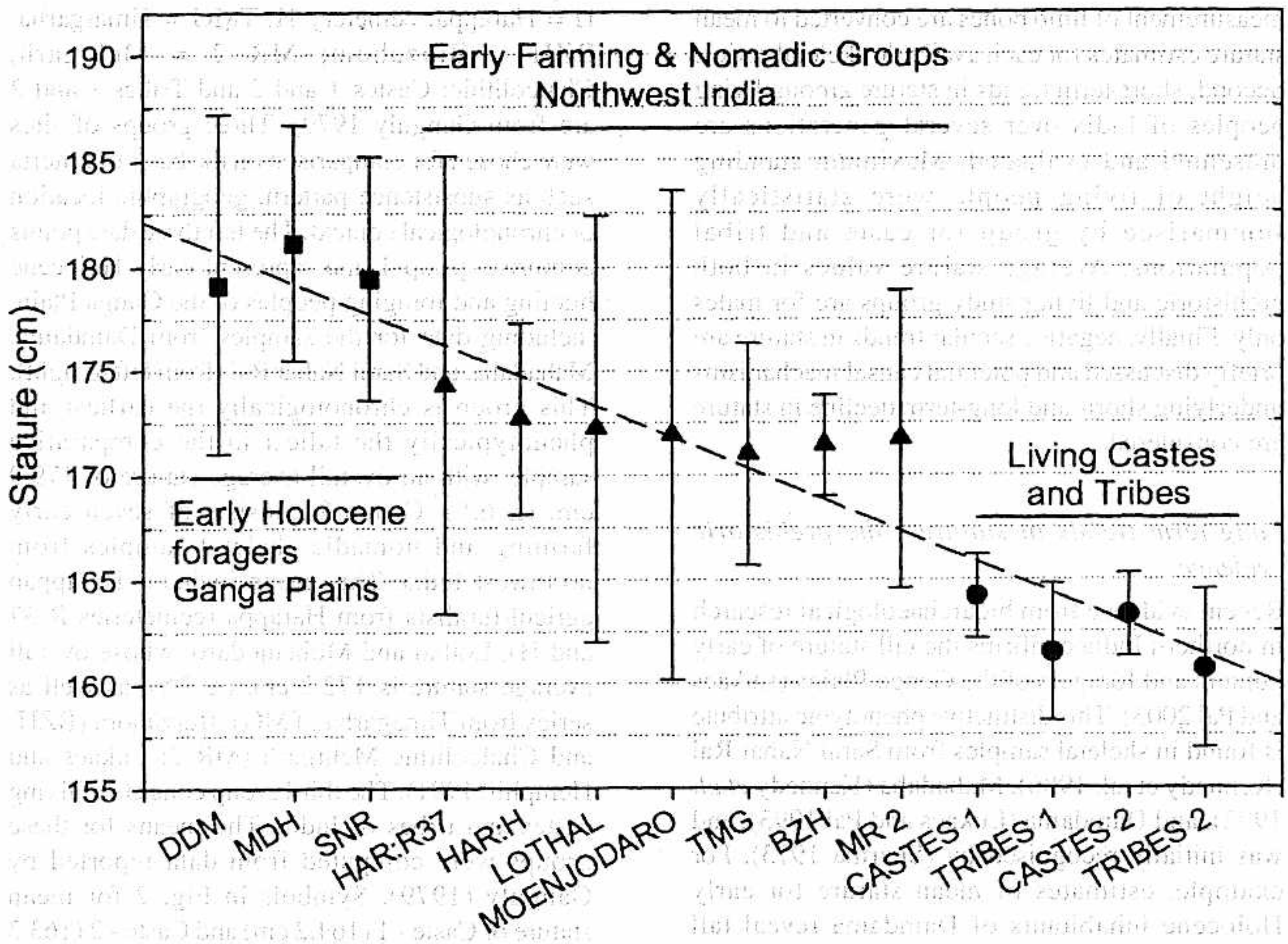

Fig. 2 Stature and Subsistence in India: Prehistoric and Living Samples

in stature documented here on the analysis of prehistoric skeletal remains has inter-generational, short-term parallels among living castes and tribes of India. At the inception of this study, the South Asian evidence for stature reduction was regarded with skepticism as a unique and anomalous finding, since in most developing and developed economies the trend is characterised by stature increasing over time.

Short-term trends in stature - evidence from living castes and tribes

Short term trends in stature are often discussed under the rubric "secular trend ", a term that has been defined in different ways by human biologists specialising in human growth and development. An early and descriptive definition was offered by Tanner:

> *"During approximately the last hundred years in industrialized countries, and recently in some developing ones, children have been getting larger and growing to maturity more rapidly. This is known as the 'secular trend' in growth." (Tanner 1978)*

More recently, according to Bogin (1999), "The process that results in a change in the mean size or shape of a population from one generation to the next is known as the secular trend in growth." Secular trend in stature is an active area of research in South Asia today although many studies are population specific, cross-sectional in design, and lack comparative perspectives (Khanna and Kapoor 2004; Singh and Harrison 1997; Torretta *et al.* 1994; Virani 2005).

An early two-phase meta-analysis of variation in stature among India's castes and tribes by Ganguly (1979, Ganguly and Pal, 1974) is notable for its thoroughness, rigorous research protocol and insightful analysis of causality. These analyses provided extensive evidence on variation in stature and documented a short-term negative secular trend in stature (Ganguly 1979; Ganguly and Pal 1974). In the first of these analyses, Ganguly and Pal (1974) report stature for ten tribal and ten caste groups that have been studied on two different occasions. Three criteria were used in selecting groups for inclusion in the analysis:

1) time interval between first and second study at least 25 years;
2) sample size not less than 50; and
3) first and second study conducted in the same geographical area (district).

The mean stature reported in the first and second study and the number of years separating the first and second studies are presented. The mean interval between the first and second study is 47 years, and the mean change in stature for all 20 groups is - 9.64 mm. When castes and tribes are evaluated separately, castes show a decrease of 12.0 mm while tribals show only a 7.3 mm decrease. While the authors find this discrepancy 'curious', it may well be consistent with current understanding of differences in subsistence between caste and tribal populations in India and adaptive advantages - or absence of disadvantages - that accrue to individuals off small stature.

In the second analysis, Ganguly (1979) expands his review of secular trend, increases the number of study groups to sixty (17 tribes and 43 castes), and considers a wider range of causal factors responsible for the observed negative secular trend. While this analysis utilises two data sets, one containing 36 groups with specific geographic descriptions (Gamguly 1979; Table 1, p. 323) and another containing 24 groups with geographic reference to state only (Ganguly, 1979; Table 2, p. 324), the overall results confirm the 1974 study. Both data sets yield evidence of a secular decline in stature; -8.6 mm over 48 years for all castes and tribes in Table 1 (from 1631.3 to 1622.7 mm) and -9.9 mm over 54 years for all groups in Table 2 (from 1639.2 to 1629.3 mm). For ease of reference data from Ganguly's (1979) Table 1 are plotted in Fig 3. Circles represent the first or earlier measurement on each group, while triangles signify the second measurement that was obtained an average of 48 years later (range 29 - 69 years). The direction and magnitude of changes in stature evident in Ganguly's data sets (Tables 1 and 2) are similar and statistically significant. An important difference in the 1979 study is the

Table 1: Negative secular trend: Ganguly's meta-analysis Data (in mm)

	Ganguly and Pal (1974)		Ganguly (1979)
		From Table 1	from Table 2
Years between 1st and 2nd study	47 years	48 years	54 years
Sample size (number and type of groups studied)	n = 20 (10 castes, 10 tribes)	n = 36 (19 castes, 15 tribes, 2 comm-unities)	n = 24 (20 castes, 2 tribes, 2 comm-unities)
Pooled (castes and tribes)	$\bar{x}$ 9.6	$\bar{x}$ 8.6	$\bar{x}$ 9.9
All Tribes	$\bar{x}$ 7.3	$\bar{x}$ 8.6 (Table 1-2)	
All Castes	$\bar{x}$ 12.0	$\bar{x}$ 9.3 (Table 1- 2)	

absence of a contrast in amount of stature reduction between tribal groups and caste groups. When Ganguly's (1979) data for Tables 1 and 2 were combined and re-analysed, the decline in stature between first and second observations was not significantly different between tribals ($\bar{x}$ = 8.61 mm, sd = 15.69), representing a decline in mean stature from 1615.8 to 1607.2 mm, and caste groups ($\bar{x}$ = 9.32 mm, sd = 15.94) with a mean reduction in stature from 1641.9 to 1632.5 mm (t= 0.1565, df=58, p= 0.8762).

The long- and short-term trends toward reduced stature that have been described here for prehistoric and living people of South Asia were initially regarded as a unique and anomalous finding. Evidence from South Africa provided a parallel example, where processes of growth and development under the socio-economic disadvantages of apartheid resulted in a negative secular trend (Tobias 1985, 1990). At the outset, I believed the South Asian and South African evidence would prove to be distinctive in global comparative context. However, recently published analyses of stature over the short- and long-term provide evidence for a sustained negative secular trend in stature from three continents: Europe, Latin America, and Southeast Asia. Each of these areas display negative trends in stature similar to that described above for South Asia.

Trends in Stature: Comparative Perspectives

Three studies of long-term trends in stature provide a valuable comparative framework for interpreting the South Asian evidence. These studies include well-documented samples with significant temporal depth and employ rigorous analytical methods. One analysis is based on 21 western European samples over two millennia (Maat 2005), another is founded on 322 samples from Latin America and spans eight millennia (Bogin and Keep 1998), while the third focuses on Malaysian samples from the mid-Holocene to the Twentieth Century (Bulbeck 2004; Bulbeck and Lauer 2006). Although questions regarding the size and representativeness of samples can be raised in each study, the overall similarity between these studies and the South Asian data is striking. A strong association between stature and the quality of the biologic and socio-economic conditions of life is revealed in different geographic settings and chronological samples.

The analysis of stature, health and wealth in the Low Countries of Western Europe reveals a long period in which stature decreased, from 176 cm to 166 cm, from the Roman Period to the end of the first half of the 19th Century (Maat 2005). This persistent negative secular trend is attributed to the poor quality and irregular availability of food and is consistent with the increased prevalence of infectious and nutritional diseases. In the second half of the 19th Century the trend reverses and the ensuing sharp increase in stature to 184 cm is still ongoing. This positive secular trend is more commonly observed in developing nations where improvements in quality of life, including good nutrition and adequate health care spur the persistent inter-generational increase in stature.

The analysis of stature in Latin American also exhibits a long-term decline from 8250 B.P. to A.D. 1750 (Bogin and Keep 1998). In this study, data for males and females are presented separately and the curves fitted to the mean stature data points are congruent, with the female curve approximately 10 cm below the male curve. In agreement with the data for South Asia, the earliest samples are foraging populations of Ecuador that were taller than average and subsisted on a diverse array of wild plants, fish and shellfish. The negative trend in stature continues until the mid-18th Century when stature begins to increase. Because data on stature for living samples is more abundant, and gathered at regular intervals, finer-grained analysis is possible. When living stature in Latin America is analysed on a condensed time scale, statistically significant oscillations become evident, for example a decline from 1898 to 1939 (- 4.5 cm for men; - 3.0 cm for women), was followed by an increase from 1940 to 1980 (+ 5.0

cm for men; +4.0 cm for women; Bogin 1999). Oscillating trends in stature are influenced directly by local socio-economic conditions and indirectly by global economic shifts such as the depression and the recovery following World War II.

Similar long-term trends in stature reduction have recently been described for Southeast Asian populations by Bulbeck (2004; Bulbeck and Lauer 2006). For example, mid-Holocene Hoabinhian sites in peninsular Malaysia, including Gua Cha, Gua Peraling, Gua Kerbau, and Gua Kajang, display the tallest stature (male: 160-175 cm; female: 153-160 cm). Subsequent samples from Neolithic and metal phase sites and from living Senoi and Semang reveal a 5 - 15 cm reduction in stature over a period of five millennia (Bulbeck 2004; Bulbeck and Lauer 2006). While differences in the amount of stature reduction are evident in samples from the hinterland (10-15 cm reduction) and from coastal populations (5-10 cm reduction) the directionality of the change in stature is consistently reduction.

An earlier, comprehensive analysis of stature among South Asian populations included prehistoric and living study samples, adopted a bio-cultural approach, and came to similar conclusions (Baerstein and Kennedy 1990). This study selected 21 prehistoric and 314 modern groups from the literature. The prehistoric groups were categorised into four classes based upon cultural association, geographic location, and subsistence pattern - I. Mesolithic hunter-gatherer communities; II. Farming and nomadic populations of the Northwest; III. Early farming and herding communities of Central and Southern India; IV. Megalith builders and their Iron Age collaterals). Variation in stature among prehistoric and modern groups was then categorised, separately by sex, into five class-intervals and plotted geographically on a map of South Asia. In addition, stature for prehistoric and modern populations was plotted along a single x-axis for males, and on a separate x-axis for females. From these geographic plots of stature and from the distribution of stature values for modern and prehistoric study samples, Baerstein and Kennedy (1990) present the following generalisations and interpretations in the conclusions of their study:

1) Ancient populations of the Indian subcontinent had somewhat greater body heights than modern populations.
2) The trend towards decreasing stature was initiated in Neolithic communities because selection for greater body height no longer played the important role it once had in earlier hunter-gatherer populations.
3) Taller stature appears in northwest India, the area where agriculture and pastoralism were first practised.
4) Decreased stature in contemporary urban and village people may be an adaptive response to the chronic threat of protein deficiency and under-nutrition.

This study represents a landmark in the analysis of stature variation in South Asia for several reasons:

a) it compiled an extensive inventory on stature variation from a diverse array of sources,
b) it provided valuable insights into the ecological and evolutionary forces selecting for variation in stature and
c) offered succinct generalisations on the spatial and temporal patterns of stature variation in the Subcontinent.

Two controversial issues in anthropology were being actively debated and researched when Baerstein and Kennedy's analysis of stature appeared. These debates centred on changes in health at the origins of agriculture (Cohen and Armelagos 1984) and the assertion that small body size is adaptive under conditions of limited resources (Seckler 1980, 1982). The latter became know by the label, "the small but healthy hypothesis" and was treated to detailed anthropological scrutiny in 1989 in the pages of *Human Organization* (48, no. 1: 11-52). Both debates utilise data on variation in stature as a phenotypic variable from which adaptedness can potentially be inferred. The absence of these issues from Baerstein and Kennedy's (1990) otherwise thorough analysis of stature prompts a brief review of their relevance here.

At issue in the small but healthy debate was whether small body size resulting from nutritional stress in the form of mild to moderate malnutrition is adaptive, functional and healthy, or not? An array of arguments were presented in *Human Organization* against the concept and the ethical implications of linking small body size (and stature), due to mild to moderate protein-energy malnutrition (PEM), with a healthy existence, and viewing this combination as adaptive. Recent research countering the small but healthy hypothesis shows that malnourished children, who often exhibit stunting, may suffer increased caries prevalence due to the combined predisposing effects of higher rates of enamel hypoplasia and lower flow rates, buffering capacity and protein composition of saliva (Psoter *et al.* 2005). This perspective is reinforced by the inverse association of stature and caries prevalence among Brazilian adolescents (Nicolau *et al.* 2005) and infants (Peres et al. 2005). Taller adolescents were found to have a significantly lower risk factor for caries than shorter individuals (Nicolau *et al.* 2005) and a deficit in height for age at 12 months presented higher risk for dental caries developing later in childhood (Peres *et al.* 2005). These findings illustrate yet another way in which short stature due to PEM is unhealthy and is clearly associated with elevated risk for poor health and diminished quality of life.

The wide-ranging consequences of the rise of agriculture have caused this mode of subsistence to be characterised as, "the worst mistake in the history of the human race" (Diamond 1987). Social and political inequalities, increased levels of infectious and nutritional deficiency diseases, and increased mortality are some of the less well appreciated features associated with the origin and intensification of agriculture (Cohen, 1989; Diamond, 1987).

Does stature increase or decrease with the transition from foraging to farming? In the mid-1980s the answer was not clearly evident and contributors to *Paleopathology at the Origins of Agriculture* present varied results that - depending on the region studied - reveal either no clear trends, an increase, or a decrease in stature across the transition to agriculture (Cohen and Armelagos 1984: 588). If the rise and fall of adult stature is closely linked with the quality of life as manifest in the quantity and quality of available dietary resources as data argued by Bogin (1999; Bogin and Keep1998) based on Latin American data, and by Maat (2005) based on data from western Europe, then changes in stature across major subsistence transitions will varied and dependent on how the local ecological and cultural context influences diet and disease. The long-term trends of declining stature presented here for South Asia, Latin America, Western Europe, and Southeast Asia suggest a general pattern of stature reduction that began significantly before the inception of agriculture. In fact, reduction in stature from Upper Palaeolithic to Mesolithic cultures of Europe has been documented and attributed to improvements in hunting technology (Frayer 1981). Although subsistence change may have conferred adaptive advantage on different body sizes and statures, and local ecological and cultural factors undoubtedly enhanced or retarded the general pattern of stature reduction, it was not until much later - in the 18th or 19th Century that positive secular trends appear. As a skeletal record becomes available for protohistoric and early historic cities of South Asia the history of trends in stature will become better documented. Discovering the approximate timing and location in South Asia of the shift from a negative secular trend to a positive trend of increasing stature is a goal for future research.

Conclusions

The analysis of variation in stature has shifted from a typological approach grounded in racial classification, to one in which inter-caste differences in stature provided evidence for testing hypotheses on the biological meaning and origins of endogamous 'caste clusters'. Biological diversity stature is now interpreted in an adaptive evolutionary framework in which short- and long-term trends reflect the multi-factorial influences of diet, climate, subsistence and activity pattern. In the long-term history of stature in India, the tall stature of early Holocene hunters and foragers of north central India, is followed by medium statured early farming and nomadic herders, who are succeeded by living castes and tribes with medium to short stature. This negative long-term trend in stature is not unique to South Asia and South Africa, but represents a general pattern in stature reduction described for Southeast Asia, Latin America and Western Europe. Future studies of stature in South Asia might examine timing and regional variation in the shift from a negative to a positive secular trend, or link historical, inter-generational changes in stature to changes in social and economic conditions, or document differences in how urban and rural populations are affected by global and local shifts in economic and health conditions.

Acknowledgements

I'd like to express my deep appreciation to D.K. Bhattacharya and to Kailash C. Malhotra whose advice and mentorship was indispensable to the successful planning and completion of my first research visit to India in 1974. My gratitude goes to past and present directors of two centres for prehistoric research in India: at Deccan College thanks to H.D. Sankalia, S.B. Deo, M.K. Dhavalikar, V.N. Misra, and K. Paddayya, and at University of Allahabad to thanks U.N. Roy, S.C. Bhattacharya, and V.D. Misra for providing a long-term research association. The companionship and collegiality of research collaborators at both institutions has been productive and collaborative, I extend special thanks to G.L. Badam and S.R. Walimbe (Deccan College) and to J.N. Pal (University of Allahabad). Support for research comes from: Alexander von Humboldt Foundation, American Institute of Indian Studies (with logistical local support from M.D. and Bagyashree Bhandare), American Philosophical Society, National Geographic Society, Wenner-Gren Foundation for Anthropological Research.

I thank the organisers, Dr. K. Paddayya and Dr. S. R. Walimbe for inviting me to participate and for their hospitality during the conference, for the opportunity to learn in greater depth the wide ranging nature of Dr. Karve's intellectual interests, and for facilitating collegiality and comradery among conference delegates.

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