Dental Morphology and Odontometrics of Early Agriculturalists from Neolithic Mehrgarh, Pakistan

J. R. LUKACS

ABSTRACT

Human burials were discovered by the French Archaeological Mission to Pakistan during the excavation of Neolithic levels at Mehrgarh in Baluchistan Province. Human skeletal remains from this important pre-Harappan site provide our first glimpse of the dental morphology and tooth size of early agriculturalists on the western fringe of the Indus Valley. Morphological variations of both permanent and deciduous teeth were observed and graded according to standardized trait classifications. Mesiodistal and buccolingual crown diameters of permanent and deciduous teeth were recorded and statistically analyzed.

Permanent and deciduous teeth at Mehrgarh are complex in morphology and large in size when compared with other human skeletal series from southern Asia. The Neolithic inhabitants of Mehrgarh exhibit a dental pattern that is similar and possibly ancestral to Chalcolithic populations of west-central India, but which is clearly distinct from living inhabitants of north India and Epipaleolithic skeletal series from the Near East. Tooth size variation between Neolithic populations of the Near East, Pakistan, and Southeast Asia is small and may reflect similar subsistence techniques and varying ecological settings.

RÉSUMÉ

Des sépultures humaines ont été découvertes par la Mission Archéologique Française au Pakistan au cours de fouilles dans les niveaux néolithiques de Mehrgarh, dans la province du Baluchistan. Les restes squelettiques humains provenant de cet important site pré-Harrapéen nous fournissent une première image de la morphologie dentaire et de la taille des dents des premiers agriculteurs installés sur la rive occidentale de la vallée de l'Indus. Des variations morphologiques des dents permanentes et lactéales ont été observées et ordonnées selon les classifications standardisées des caractères. Les diamètres mésio-distal et bucco-lingual de la couronne des dents permanentes et lactéales ont été mesurés et analysés statistiquement.

Les dents permanentes et lactéales de Mehrgarh sont de morphologie complexe et de grande taille par comparaison avec d'autres séries squelettiques humaines d'Asie méridionale. Les habitants néolithiques de Mehrgarh présentaient un dessin dentaire semblable, et peut-être ancestral, à celui des populations chalcolithiques de l'Inde occidentale et centrale, mais nettement distinct de celui des habitants actuels de l'Inde septentrionale et des séries squelettiques épipaléolithiques du Proche-Orient. La variation de taille des dents entre les populations néolithiques du Proche-Orient, du Pakistan et de l'Asie du Sud-Est est faible et peut refléter des techniques voisines de subsistance et un environnement écologique variable.

In: Teeth Revisited: Proceedings of the VII[th] International Symposium on Dental Morphology, Paris 1986, Russell D. E., Santoro J.-P. & Sigogneau-Russell D., Eds, *Mém. Mus. natn. Hist. nat., Paris,* (série C) **53** : 285-303.

Paris, ISBN 2-85653-148-2

INTRODUCTION

Dental morphology and tooth-size variations for Neolithic populations of southern Asia are poorly documented. This situation is paradoxical given the importance of this geographic region during the course of human biological and cultural evolution, and the potential contribution dental anthropology can make toward the solution of crucial anthropological problems.

The pattern of dental variation for people of the Indus Valley Civilization is poorly known despite the recovery of abundant human skeletons from Harappa (Gupta *et al.*, 1962) and Mohenjo-Daro (Sewell & Guha, 1931; Guha & Basu; 1938). Until recently, skeletal and dental evidence from sites antecedent to the Indus Civilization was virtually non-existent. Since the mid-1970s the French Archaeological Mission to Pakistan has been excavating Neolithic human skeletons with well preserved dentition at Mehrgarh, in the north Kachi Plain of Baluchistan Province. This material provides, for the first time in South Asia, sufficient evidence for the study of dental anthropology among early agriculturalists of this region. The objective of this paper is to provide a thorough description and comparative analysis of dental morphology and tooth-size of the pre-Harappan Neolithic skeletal sample from Mehrgarh.

A research landmark in the dental anthropology literature on prehistoric Asian skeletal remains was Dahlberg's (1960) description of the dentition of early agriculturalists from Neolithic Jarmo (Iraq) in 1960. Subsequent investigations of the dental morphology and pathology of Natufian skeletal series were conducted by Smith (1970; Smith *et al.*, 1984). The dental anthropology of a small sample of Neolithic human skeletons from Abou Gosh was reported on by Arensburg *et al.* (1978), and a study of tooth-size and crown morphology of 49 specimens from the Neolithic site of Ganj Dareh Tepe in Western Iran is currently in progress (Lambert, 1980; Meiklelohn, pers. comm.; Smith, 1974). The rate of dental research in southwest Asia has been slow but steady and prehistoric patterns of dental variation are becoming clearer.

In contrast, the dearth of dental data for Neolithic inhabitants of the Indian subcontinent (South Asia) and southeast Asia precludes effective inter- and intra-regional comparisons for southern Asia as a whole (Lukacs, 1984). Human remains from late Neolithic sites of peninsular India are common (Brahmagiri, Wheeler, 1947; Maski, Thapar, 1957; Piklihal, Allchin, 1961; Tekkalakota, Nagaraja Rao, 1965), but their young age (3000-2000 B.C.), small sample size and undescribed dentition precludes direct comparison with samples from Neolithic horizons in the northwest (Possehl & Rissman, in press). Descriptive and comparative reports on these skeletal remains were published but are woefully incomplete (Brahmagiri & Maski, Sarkar, 1960, 1972; Piklihal, Ayer, 1961; Malhotra, 1967; Tekkalakota, Malhotra, 1965).

Dental morphology and odontometrics were reported for Neolithic Burzahom in Kashmir (Basu & Pal, 1980), and for Mesolithic Sarai Nahar Rai and Mahadaha in the Gangetic Basin (Kennedy, 1984; Kennedy *et al.*, 1986). These latter sites are perhaps more suitable as a comparative framework against which the Neolithic Mehrgarh dental variation can be analyzed, but thorough dental documentation is unavailable, and sample sizes are small. Southeast Asian Neolithic burials are few, though Brace & Vitzthum (1984) recently reported on tooth-size at Mesolithic, Neolithic and modern levels at Niah, Cave, Sarawak and Pietrusewsky (n.d.) has described the dental remains from Ban Chiang.

Previous reports on the human remains from Mehrgarh include descriptions of funerary practices (Samzun & Sellier, in press), demography (Samzun & Sellier, 1983; Sellier, in press), dental pathology and tooth-size (Lukacs, 1985b; Lukacs, 1983a; Lukacs *et al.*, 1985).

The dental data reported here for Neolithic occupants of the northwest borderlands of the Indian subcontinent fills a crucial lacuna in our record of prehistoric dental variation in southern Asia, and should contribute to the solution of anthropologically important questions such as:

1. Is there genetic continuity between Neolithic and early Chalcolithic people at Mehrgarh?
2. Could the people of Mehrgarh be ancestral to the builders of the Indus Valley Civilization?
3. What is the genetic relationship between the Neolithic people of Mehrgarh and contemporaneous people of Iran-Afghan highlands?

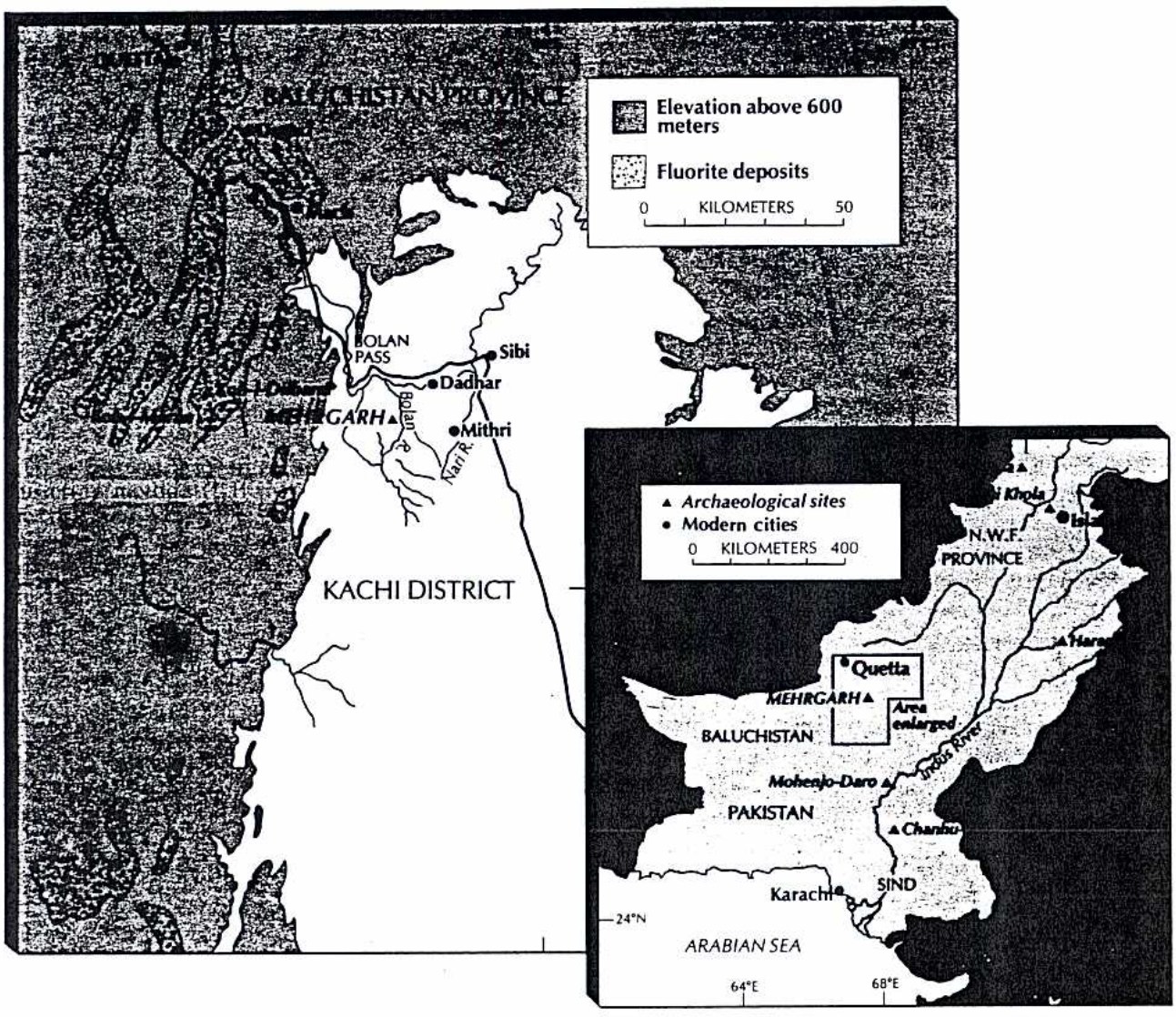
4. Which prehistoric people of the Indian subcontinent are most closely related to the Neolithic occupants of Mehrgarh?
5. To which living people of the Indian subcontinent are the people of Mehrgarh most closely related?

The study of dental morphology at Mehrgarh was begun with these questions in mind.

Material and Method

The site of Mehrgarh, encompassing about 500 acres, is located at the foot of the Bolan Pass, on the west bank of the Bolan River, and has been under excavation by the French Archaeological Mission for 11 seasons (Fig. 1). Three main areas of the site have been intensively excavated (from north to south): MR3—Early Neolithic; Period I; MR2—Chalcolithic, Period III; and MR1-late Chalcolithic, Periods V through VII (Jarrige, 1984; Jarrige & Lechevallier, 1979; Jarrige & Meadow, 1980).

The antiquity of early Neolithic levels at Mehrgarh is based on radiocarbon dates and cross-dating, which place the beginning of Period I prior to 6000 B.C. (Jarrige, 1984; Jarrige & Lechevallier, 1980). Geomorphologically MR3 is complex, consisting of two overlapping buried mounds (11 m in depth); the apices were subsequently eroded by sheetwash to the level of the surrounding plain. The transition from aceramic,



predominantly huntergatherer folk to pottery-using agriculturalists with domesticated cattle, sheep, and goat is well documented in Periods I and II (Lechevallier & Quivron, 1981; Meadow, 1981, 1983, 1984). Plant remains from MR3 were identified by Costantini (1984) who found two types of barley and three of wheat.

Human burials, containing bones varying in the quality of preservation, are moderately abundant in all excavated areas at Mehrgarh. Grave goods are often in the burials and include blade tools, ground stone axes, baskets lined with bitumen, ornaments of turquoise and lapis lazuli, and, in a few cases, the apparently sacrificial remains of several young goats (Lechevallier *et al.*, 1982; Lechevallier & Quivron, 1981). Neolithic burials are normally interred on the left side with knees and arms tightly flexed. The body is oriented toward the south, often facing a wall of handmade, unbaked mud brick.

The human skeletons on which this study is based are from the " upper graveyard " in the MR3 excavation area (n = 41 individuals) and from roughly contemporaneous burials (n = 22) adjacent to it. In order to maximize the dental sample an additional 27 individuals from MR3 were included in the analysis (MR3F, MR3T, MR3S). These specimens are derived from horizons adjacent to and below the " upper graveyard ", and consequently are not *strictly* contemporary with the graveyard sample.

Morphological variations of permanent dental crowns were assessed by reference to standards depicted in plaster models and/or published photographs. The morphological traits included in this description of the Mehrgarh dentition are listed below along with the primary sources describing or depicting categories of trait variation:

MAXILLARY INCISOR TEETH

1. Shovel-shape (Hrdlička, 1920; Dahlberg, 1963; Scott, 1980).
2. Double-shovel (Turner, 1967).
3. *Tuberculum dentale* (Turner, 1967).
4. Marginal interruption grooves (Turner, 1967).
5. Lingual tubercles (Turner & Scott, 1977).

MAXILLARY MOLAR TEETH

6. Hypocone development (Dahlberg, 1951).
7. Carabelli's trait (Dahlberg, 1963; Scott, 1980).
8. Metaconule variation (Harris & Bailit, 1980).
9. Protoconule variation (Turner, 1967).
10. Parastyle (Turner, 1967).

MANDIBULAR MOLAR TEETH

11. Groove pattern (Hellman, 1928; Jorgensen, 1955).
12. Cusp number (Hellman, 1928).
13. Entoconulid variation, C-6 (Turner, 1970).
14. Metaconulid variation, C-7 (Turner, 1970).
15. Protostylid (Scott & Dahlberg, 1982).
16. Deflecting wrinkle (Scott & Dahlberg, 1982).
17. Three rooted first molar (Turner, 1971).

The scoring of deciduous dental traits follows the standards outlined by Hanihara (1963, 1965; Hanihara & Minamidate, 1965) in the analysis of deciduous teeth of Japanese-American hybrids. Included in this study are many of the traits recognized by Hanihara (1966, 1968) as comprising the Mongoloid Dental Complex of the deciduous dentition. Deciduous dental traits observed include: 1) shovel-shape of central and lateral incisor teeth, 2) *tuberculum dentale* of dc, 3) cusp number of dm^1 and dm^2, 4) Carabelli's trait of dm^2, 5) labial (facial) deflection of di^1 root apex, 6) cusp number of dm_1 and dm_2, and accessory cusps of dm_2, including, 7) the entoconulid (cusp 6), 8) the metaconulid (cusp 7), and 9) the protostylid. Three variables were excluded from analysis due to inconsistent grading, rapid obliteration of the trait with attrition, or the frequent occurrence of intermediate categories. These traits include the distal trigonid crest, deflecting wrinkle and groove pattern of dm_2.

In tabulating dental trait frequencies, the individual count method of Scott (1977, 1980) was used. This technique counts the fullest expression of a given trait on either the right or left side of the jaw; if one side is missing the degree of expression on the side present is scored. Each individual is counted only once for each variable. This technique maximizes sample size in fragmentary skeletal samples derived from archaeological contexts and is well suited for the Mehrgarh dental sample.

Dental trait frequencies were calculated for each degree of expression of a trait. Prior to comparative statistical analysis (chi-square) of trait frequencies, an investigation of the correspondence of trait categories (used in this study and by others) was undertaken to ensure equivalence of trait classes being compared.

Two measures of crown size were made for each tooth: maximum mesiodistal diameter (MD) and maximum buccolingual diameter (BL), fol-

lowing the method described by Moorrees (1957). All measurements were made by Lukacs with a Helios needle-point dial caliper calibrated to 0.05 mm. Replicate measurements made more than two days apart on permanent Mehrgarh teeth yielded a mean measurement error of 0.10 mm. (SD = 0.126, n = 70) for MD diameter and 0.07 mm. (SD = 0.084, n = 74) for BL diameter. These values fall well within the acceptable range of measurement error reported by Wolpoff (1971). Linear crown dimensions were employed in calculating the dental index Crown Area (MD times BL), which serves as a measure of the cross-sectional area of the crown (Wolpoff, 1971).

RESULTS

A. *Dental Morphology*

Dental trait frequencies for permanent teeth are presented in Tables 1-3. Morphological variation in maxillary anterior teeth is presented in Table 1. Shovel-shaped incisor and canine teeth are common at Mehrgarh. The frequency of shovelling decreases distally, from central incisor to lateral incisor to canine, and intermediate grades of expression are more prevalent than full expression of the trait. Cingular tubercles are nearly three times more frequent in maxillary canine teeth than in lateral incisors. While rare in lateral incisors, the *tuberculum dentale* (= median lingual ridge) is present in fifty-eight percent of central incisor teeth. Marginal interruptions are absent from central incisors, but fifty-one percent of maxillary lateral incisors display the trait. Interruptions occur with equal frequency on the mesial and distal margins of the tooth crown.

Table 2 provides frequency data for morphological variations of maxillary molar teeth. Carabelli's trait is present in twenty-six percent of first molar teeth, but weak expressions (pit and groove forms) of the trait are twice as common as full-cusp expressions. Carabelli's trait is conspicuous by its absence from seventy-four percent of first molar teeth. Hypocone variation follows a typical pattern of size gradation from M1 (83.3 %, grade 4) to M2 (73.1 %, grade 4—) to M3 (79.4 %, grade 3+), with M1 the least variable and M3 the most variable tooth. Complete absence of the hypocone was not detected in first or second molars and was observed in only 5.9 % of third molar teeth. The metaconule is more frequent than the protoconule in M1 and this difference in frequency becomes greater in M2 and M3. The parastyle is present in low frequency in M2 and M3, but absent in M1.

Morphological variations in mandibular molar teeth are presented in Table 3. Due to occlusal attrition, groove pattern was discernable less often than cusp number, a factor that explains the difference in sample size for these variables. The most prevalent groove configuration varied by tooth, with 92 % Y in M1, 48.6 % + in M2 and 63 % X in M3. Variation in lower molar cusp number was greatest in M3 and least in M2. The most frequent cusp number sequence was M1 — 5; M2 — 4, M3 — 5, with 74.4 % of M1s exhibiting five cusps, 93.9 % of M2s four-cusped and 63 % of M3s five-cusped. Accessory lower molar cusps occur with moderate to low frequency. The entoconulid (C-6) was present in 8.1 % and the metaconulid (C-7) was found in 10 % of first molars.

Strong expressions of the protostylid were detected in the Mehrgarh sample but in low frequency (5 %) and three-rooted lower first molar teeth also occur rarely (5.6 %). Problems of recognizing weak expressions of the former under field lighting conditions and diagnosis of the latter, macroscopically and without the aid of radiographic plates results in small sample size for these traits. The frequencies reported for these traits should, therefore, be considered as tentative estimates rather than firm data points.

Variation in deciduous dental morphology is presented in Table 4. Though sample sizes are small for all traits considered, some idea of trait expression can be derived from these data. Shovel-shape is more common, especially weak expressions, in central than in lateral deciduous teeth. *Tuberculum dentale* is very frequent (83.3 %) in maxillary deciduous canine teeth, but is absent from maxillary incisors. The circular enamel defect (hypoplasia), a trait of uncertain etiology, is more common in lower deciduous canines (42 %, n = 19) than in maxillary canines (17 %, n = 24), a finding in agreement with Skinner (1986). The overall prevalence of this anomalous localized form of hypoplasia is 27.9 % (n = 43) in deciduous canines at Mehrgarh (MR3).

Weak expressions of Carabelli's trait (grades 1-3; pit and groove forms) are common (74.7 %, n = 11) in dm^2, and this tooth typically exhibits a full-sized hypocone (grade 4). Lower deciduous molar cusp number is more variable in dm_1 than in dm_2 where 72.7 % (n= 11) are five-cusped. Accessory cusps of dm_2 exhibit high frequencies, with the protostylid (37.5 %, n = 8) and entoconulid (27.3 %, n = 11) occurring more often than the metaconulid (9.1 %, n = 11).

Results of this morphological analysis of the Neolithic teeth from Mehrgarh can be succinctly summarized for permanent and deciduous teeth separately.

PERMANENT TEETH:

- — maxillary anterior teeth are highly sculpted, i.e., exhibit high frequencies of shovelling, lingual tubercles, lingual ridges and pits and marginal grooves;
- — maxillary molar teeth have a low incidence of Carabelli's trait and the hypocone exhibits little reduction and is rarely absent;
- — mandibular molar teeth are conservative morphologically and accessory cusps occur in moderate to low frequencies.

DECIDUOUS TEETH:

- — maxillary anterior teeth are frequently but weakly shovelled, and canines often display *tuberculum dentale*;
- — maxillary molar teeth exhibit fully developed hypocones and Carabelli's trait, though common, is weakly expressed.
- — mandibular molar teeth are morphologically complex and accessory cusps are common.

In comparing trait frequencies in permanent and deciduous dentitions at Mehrgarh, several noteworthy observations can be made. Particular dental traits display higher frequencies in the deciduous teeth than in their permanent successors (Carabelli's trait, *tuberculum dentale* of the canine, accessory cusps of the lower molar, including C-6, protostylid); while others are less common in deciduous teeth (shovel-shape, C-7) than in permanent teeth.

B. *Odontometrics*

Mean mesiodistal (MD) and buccolingual (BL) crown diameters for permanent and deciduous dental samples from Neolithic Mehrgarh are presented in Tables 5 and 6, together with relevant descriptive statistics (in mm., left side only).

The analysis of permanent tooth crown dimensions initially divided the dental sample into three groups for comparative analysis: Period IA, Period IB, Period I-level uncertain. While crown dimensions of teeth from IA were consistantly larger in MD and BL diameters than teeth from IB, these differences rarely attained statistical significance at the .05 level. The tendency toward reduced dental crown dimensions within the Mehrgarh Neolithic from earlier Period IA to later Period IB is suggested by the fact that : 1) all five significant differences are toward smaller teeth in IB, and 2) 78 % of MD and BL comparisons on the left and 84 % of the comparisons on the right show smaller crown diameters for IB teeth compared to the IA sample. Table 7 presents comparative data by Period for the analysis of diachronic change in dental dimensions at Mehrgarh.

The deciduous dental sample is too small to permit an analysis of diachronic change within Neolithic levels at Mehrgarh. The standard deviation for BL diameters of deciduous teeth is uniformly less (by .05 to .23) than the standard deviation for MD diameters. This may be due to the combined effects of greater genetic control over MD tooth size (selected for by jaw space constraints) and the greater accuracy and repeatability of measuring BL diameters.

The overall similarity in dimension of permanent teeth from Periods IA and IB justified using the entire Neolithic sample in computing cross-sectional tooth crown areas (MD × BL). This product was computed for each tooth individually then descriptive statistics were generated for each new variable. Table 8 presents mean tooth crown area figures and appropriate statistics for the left side of the dental arcade. When tooth crown areas are summed across all teeth the resulting total crown area is 1257.82 mm^2. The maxillary teeth as a unit make a larger (658.71 mm^2) contribution to total crown area (52.37 %) than the mandibular teeth (599.11 mm^2; 47.63 %). These figures are remarkably similar to

preliminary results obtained on smaller samples in 1985 (Lukacs *et al.*, 1985).

Mean cross-sectional crown areas for deciduous teeth are presented in Table 6, which reveals a total deciduous crown area of 533.59 mm^2. As in the permanent teeth, the maxillary dentition contributes more to total crown area (286.80 mm^2; 53.75 %) than does the mandibular dentition (246.79 mm^2; 46.25 %).

This descriptive analysis of the deciduous teeth from Neolithic Mehrgarh serves as a tentative and preliminary account. The possibility of bias in these small samples of deciduous teeth demands that the results be regarded with caution.

Discussion

Comparative assessment of dental morphology at Neolithic Mehrgarh is hampered by several factors: 1) paucity of skeletal remains from appropriate temporal and geographical contexts, 2) varying trait classification standards employed by different researchers, and 3) small sample size of most prehistoric skeletal series (Lukacs, 1984).

Comparative dental trait frequencies for twelve often studied variables are presented in Table 9 for prehistoric south Asian skeletal series. All samples were studied by Lukacs (1983b; Lukacs *et al.*, 1983) personally thereby reducing a prime source of uncertainty in comparative analyses — inter-observed variance.

The grades of expression employed in calculating the frequency of each trait are outlined below (many follow Scott & Dahlberg, 1982):

1. Shovel-shape (I^1): Only the full-shovel expression (Hrdlička, 1920), equivalent to the pronounced grades of Scott & Dahlberg (1982), was counted in calculating the frequency of this trait.
2. Median Lingual Ridge (I^1): Also known as *Tuberculum dentale*, any development of ridging on the lingual surface between the mesial marginal and distal marginal ridges was scored as present.
3. Marginal Interruption (I^1, I^2): Any groove extending from the lingual fossa across the mesial, distal or medial (cingular) marginal ridge. All expressions of the trait are graded as present in calculating trait frequency.
4. Cingulum Variation (I^1): One or more lingual grooves on the cingulum of maxillary central incisors. Any expression graded as present and used in calculating trait frequency.
5. Hypocone Size (M^1): The frequency reported for this trait includes only the fully developed expression (grade 4, Dahlberg, 1951). Grades 3, 3+, and 4— are considered as underdeveloped expressions of the trait and were not counted in computing this trait's frequency.
6. Carabelli's trait (M^1): All morphological variants occurring on the mesio-buccal aspect of the mesio-buccal cusp (groove, pit, pit and groove, or cusp of varying size) were counted in computing the frequency of this trait.
7. Metaconule, C-5 (M^1): Located between the metacone and the hypocone of maxillary molar teeth, any expression of this supernumerary cusp was counted in calculating its trait frequency.
8. Cusp Number (M_2): The presence of a hypoconulid (C-5) of any size, resulting in a five-cusped lower second molar, was counted in calculating the frequency of this trait.
9. Deflecting wrinkle (M_1): A conspicuous bend or deflection of the metaconid ridge was graded as present. A straight or slightly diverted ridge was graded as absent in computing the frequency of this trait.
10. Entoconulid, C-6 (M_1): Also termed the *tuberculum sextum* (Hellman, 1928), C-6 is located between C-4 and C-5 on the lower molar crown and varies continuously in size when present. All size variants were counted in computing the frequency of this trait.
11. Metaconulid, C-7 (M_1): This supernumerary cusp, also called the *tuberculum intermedium* (Hellman, 1928), is located on the lingual margin of the lower molar crown between C-2 and C-4. All cusp variants of this trait were counted in calculating the frequency of this trait.

12. Protostylid (M_1): Expressions of this trait graded as present include a groove, fissure or cusp of varying size on the mesiobuccal cusp of lower molar teeth (Dahlberg, 1950). Variations of the buccal pit were not included as part of this trait complex.

The chi-square test of intergroup differences was applied to the twelve traits in Table 9. In none of the comparisons was Inamgaon or Timargarha significantly different from the Neolithic Mehrgarh sample at the level of 0.05. The Sarai Khola series exhibited significant differences from Mehrgarh for three variables: median lingual ridge (I^1), marginal interruption (I^2) and deflecting wrinkle (M_1). These results suggest that the Neolithic occupants of Mehrgarh are more similar in dental morphology to the people of Inamgaon and Timargarha than they are to the sample from Sarai Khola. The consequences of small sample size on statistical analysis of this kind renders these conclusions tentative and subject to confirmation based on more complete evidence.

Further scrutiny of dental trait frequencies in Table 9 shows that the Mehrgarh teeth are different (though not significantly) from other prehistoric south Asian skeletal samples in having:

— a higher frequency of morphological variations present in maxillary incisor teeth, (not shown in Table 9 is the higher frequency of shovelling and cingular tubercles in maxillary canines which also distinguishes the Mehrgarh sample from other south Asian prehistoric groups);
— a lower incidence of Carabelli's trait, and
— a higher frequency of traits that contribute to molar crown complexity (accessory cusps, large hypocone (-id), and deflecting wrinkle).

From this analysis the Neolithic occupants of Mehrgarh display a morphologically complex dentition which could have been ancestral to the dental patterns at Inamgaon and Timargarha, but which seems less closely related to the more simplified dental pattern at Sarai Khola. Dental morphology at Neolithic Mehrgarh is much more complex than trait frequencies for modern Hindus of north India (Zubov, 1980) and Indian immigrants in South Africa (Scott, pers. comm.). Recent north Indian caste groups appear to have less incisor shovelling and cingular tubercles, higher incidence of Carabelli's trait and fewer accessory cusps of lower molars. Their dental pattern compares favorably with the simplified dental morphology reported for Sarai Khola, and contrasts strongly with the complexly structured dentition from Mehrgarh.

Except for the work of Kaul & Prakash (1981) on Jats, and Lukacs & Walimbe (1984) on prehistoric Inamgaon, few anthropologically valid studies of deciduous crown morphology are available for the Indian subcontinent. In comparison with these samples (see Table 10) the Neolithic deciduous teeth from Mehrgarh exhibit similarities to Inamgaon and modern Jats in maxillary central incisor shovelling (grade 2-3), Carabelli's trait (grade 4-6), and cusp number (2 cusped dm^1). The Mehrgarh sample is distinguished from Jats and/or occupants of Inamgaon by the prevalence of *tuberculum dentale* in maxillary canines, the higher frequency of grade 4 hypocone (dm^2) and accessory cusps (C-6, C-7 and protostylid). The chi-square test of inter-group differences between Mehrgarh and Inamgaon reveals only one significant difference (protostylid, = 0.01) in nine comparisons while the Mehrgarh-Jat contrast indicated differences in five traits (*tuberculum dentale*, dc; cusp number, dm^2 and dm_2; accessory cusps C-6, C-7 in dm_2) of seven comparisons. These results suggest a closer relationship between the Mehrgarh sample and the people of Inamgaon than between Mehrgarh and the modern Jats of north India.

Inter-observer variance and disparate sample sizes undoubtedly have some influence on results of the Mehrgarh-Jat comparison, but this degree of difference was not unexpected. Permanent dental morphology also points to significant divergence of modern north Indians from Neolithic occupants of Mehrgarh.

Comparative evaluation of tooth size at Neolithic Mehrgarh is facilitated by using the summed cross-sectional crown area. This figure is favored by some investigators because it represents the unit on which natural selection operates, and because direct comparisons can easily be made (Brace, 1980). Table 11 presents summed crown areas (mm^2) for permanent teeth of selected prehistoric skeletal series from southern Asia. The figure for Mehrgarh (1257 mm^2) falls squarely within the range of values reported by others for Neolithic dental samples from southwest Asia.

The mean summed crown area for four Neolithic groups (Jericho, Natufian, Jarmo and Abou Gosh) coincides with the figure of 1257 mm^2 reported here for Mehrgarh.

It is noteworthy that in dental morphology the Natufians are distinct from Neolithic inhabitants of Mehrgarh, but that the close correspondence of tooth size figures may represent evolutionary convergence (Lukacs, in press). From different gene pools both Natufian and Mehrgarh samples arrived at a similar optimal tooth size. Similar selective pressures related to shared patterns of subsistence, diet and food preparation methods are the most likely causes for this convergence in tooth crown area.

Mean crown areas for deciduous teeth of prehistoric and living south Asians are provided in Table 12 for comparison with the Mehrgarh data. The prehistoric samples were studied by Lukacs (Lukacs *et al.*, 1983), the living Gujaratis by Makhija (1981). The Mehrgarh deciduous teeth are uniformly larger in crown area than all other south Asian deciduous dental samples. The percentage by which tooth crown area of living and prehistoric samples are smaller than Mehrgarh teeth (in maxillary, mandibular and total crown area) is given in brackets after the summary tooth crown size figure. The size difference is least in the mandibular crown area at Inamgaon (6.51 %) and greatest in the mandibular teeth at Timargarha (12.26 %). Kaul & Prakash (1984) recently reported on crown dimensions of north Indian Jats in Harayana State. Teeth for which crown area can be computed (maxillary and mandibular deciduous molar teeth) are smaller than the Gujarat sample and much smaller than deciduous molars from Mehrgarh.

The direction of deciduous tooth-size variation reported here for prehistoric south Asians coincides with predictions based on Brace's hypothesis that populations with a longer dependence on agriculture and more sophisticated food preparation methods will have smaller teeth (Brace, 1962, 1978, 1984). This prediction was tested extensively by Brace with permanent tooth-size data, but has not been widely tested with deciduous tooth-size data.

Conclusion

This study of dental morphology and tooth size at Neolithic Mehrgarh provides our first impression of the dental pattern of early (pre-Harappan) agriculturalists in South Asia. The permanent and deciduous teeth at Mehrgarh are morphologically complex and crown dimensions are large (megadont).

Anterior permanent maxillary teeth (I, C) exhibit a distinctive trait complex including shovelling, *tuberculum dentale*, marginal interruption grooves and median lingual ridges. Molar tooth morphology combines a low incidence of Carabelli's trait with moderate to high frequencies of accessory cusps.

Comparative samples from the subcontinent are rare but dental morphology of permanent teeth suggests a closer biological relationship between Mehrgarh and skeletal series from Inamgaon (India) and Timargarha (Pakistan), than between Mehrgarh and Sarai Khola (Pakistan).

The morphological complexity of deciduous teeth is discernable in the high frequency of *tuberculum dentale* (dc), retention of a large hypocone (dm^2), and prevalence of accessory cusps (dm_2). The clear contrast in deciduous dental trait frequencies between Mehrgarh and modern Jats of north India indicate little if any biological relationship between them. The similarities in deciduous tooth morphology between Inamgaon and Mehrgarh strongly suggests a biological relationship between them. People with a dental pattern like that found at Mehrgarh could well have been ancestral to later Chalcolithic inhabitants of western and central India.

Acknowledgements

I thank Jean-François Jarrige for the invitation to examine human remains from Mehrgarh and for his continued cooperation and support of this research. Research on the skeletal biology of prehistoric Pakistanis is conducted in collaboration with the Government of Pakistan, Department of Archaeology. The

Acting Director General, Mr. Khurshid Hasan, has been especially helpful in facilitating the fieldwork phase of research. Palaeoanthropology fieldwork at Mehrgarh (Pakistan) began in 1983 with a research grant from the National Geographic Society; their continued support of this research is deeply appreciated.

REFERENCES

ALLCHIN B. & ALLCHIN F. R., 1982. — *The Rise of Civilization in India and Pakistan*, Cambridge: Cambridge University Press.

ALLCHIN F. R., 1961. — *Piklihal Excavations*. Hyderabad.

ARENSBURG B., SMITH P. & YAKAR R., 1978. — The human remains from Abou Gosh. *In:* Abou Gosh et Beisamoun: deux gisements du VII[e] millénaire avant l'ère chrétienne en Israël, Lechevallier M., Ed., *Mémoires et Travaux du Centre de Recherches Préhistoriques Français de Jérusalem*, **2** : 95-104.

AYER A. A., 1960. — Report on the human skeletal remains excavated at Piklihal near Mudgal. *In:* Piklihal Excavations, Allchin F. R., Ed., Hyderabad: *Andhra Pradesh Gov. Arch. Ser.*, **1**.

BASU A. & PAL A., 1980. — Human Remains from Burzahom. *Anthrop. Surv. India*, **56**.

BRACE C. L., 1962. — Cultural factors in the evolution of the human dentition. *In: Culture and the Evolution of Man*, Montagu M. F. A., Ed., New York, Oxford University Press: 343-354.

BRACE C. L., 1978. — Tooth reduction in the Orient. *Asian Perspectives*, **19**: 203-219.

BRACE C. L., 1980. — Australian tooth-size clines and the death of a stereotype. *Current Anthrop.*, **21** (2): 141-164.

BRACE C. L. & NAGAI M., 1982. — Japanese tooth size: past and present. *Amer. Jour. Phys. Anthrop.*, **59** (4): 399-412.

BRACE C. L. & VITZTHUM V. J., 1984. — Human tooth size at Mesolithic, Neolithic and modern levels at Niah Cave, Sarawak: comparisons with Asian populations. *Sarawak Mus. Jour.*, **33**: 75-82.

BRACE C. L., SHAO XIANG-GING & ZHANG ZHEN-BIAO, 1984. — Prehistoric and modern tooth size in China. *In: The Origins of Modern Humans*, Spencer F., Ed., New York, Alan R. Liss Publisher: 485-516.

COSTANTINI L., 1984. — The beginning of agriculture in the Kachi Plain: the evidence from Mehrgarh. *In: South Asian Archaeology 1981*. Allchin B., Ed., Cambridge, Cambridge University Press: 29-33.

DAHLBERG A. A., 1951. — The dentition of the American Indian. *In: Papers on the Physical Anthropology of the American Indian*, Laughlin W. S., Ed. Fourth Viking Fund Summer Seminar in Physical Anthropology (1949). New York, Viking Fund: 138-176.

DAHLBERG A. A., 1960. — The dentition of the first agriculturalists (Jarmo, Iraq). *Amer. Jour. Phys. Anthrop.*, **18**: 243-256.

DAHLBERG A. A., 1963. — Analysis of the American Indian dentition. *In: Dental Anthropology*, Brothwell D. R., Ed., New York, Pergamon Press: 149-177.

DUTTA P. C., 1983. — An odontometric study of the Bronze Age Harappans. *Anthrop. Anzeiger*, **41** (1): 1-19.

GUHA B. S. & BASU P. C., 1938. — Report on the human remains excavated at Mohenjo-Daro in 1928-1929. *In: Further Excavations at Mohenjo-Daro*, Mackey E. J. H., Ed., New Delhi, Government Press: 613-638.

GUPTA P., DUTTA P. C. & BASU A., 1962. — Human Skeletal Remains from Harappa. *Anthrop. Surv. India*, **49**: 3-186.

HANIHARA K., 1963. — Crown characters of the deciduous dentition of the Japanese-American hybrids. *In: Dental Anthropology*, Brothwell D., Ed., Oxford, Pergamon Press: 105-124.

HANIHARA K., 1966. — Mongoloid dental complex in the deciduous dentition. *Jour. Anthrop. Soc. Nippon*, **47**: 61-72.

HANIHARA K., 1968. — Morphological pattern of the deciduous dentition in the Japanese-American hybrids. *Jour. Anthrop. Soc. Japan*, **76** (3): 114-121.

HANIHARA K. & MINAMIDATE T., 1965. — *Tuberculum Accessorium Mediale Internum* in human deciduous lower second molars. *Jour. Anthrop. Soc. Nippon*, **73**: 9-19.

HARRIS E. F. & BAILIT H., 1980. — The metaconule: a morphologic and familial analysis of a molar cusp in humans. *Amer. Jour. Phys. Anthrop.*, **53**: 349-358.

HELLMAN M., 1928. — Racial characters in the human dentition. *Amer. Philos. Soc., Proc.*, **67**: 157-174.

HRDLIČKA A., 1920. — Shovel shaped teeth. *Amer. Jour. Phys. Anthrop.*, **3**: 429-465.

JARRIGE J. F., 1981. — Economy and society in the early Chalcolithic/Bronze Age of Baluchistan: new perspectives from recent excavations at Mehrgarh. *In: South Asian Archaeology 1979*. Hartel H., Ed., Berlin, Dietrich Reimer Verlag: 93-114.

JARRIGE J. F., 1985. — Continuity and changes in the Kachi Plain (Baluchistan, Pakistan) at the beginning of the second millenium B.C. *In: South Asian Archaeology 1983*, Schotsmans J. & Taddei M., Eds., Naple, Inst. Univ. Orientale: 35-68.

JARRIGE J. F. & LECHEVALLIER M., 1979. — Excavations at Mehrgarh, Baluchistan: their significance in the prehistorical context of the Indo-Pakistani borderlands. *In: South Asian Archaeology 1978*, Papers from the Fourth International Conference of South Asian Archaeologists in Western Europe, Naples 1979: 463-535.

JARRIGE J. F. & LECHEVALLIER M., 1980. — Les fouilles de Mehrgarh, Pakistan : problèmes chronologiques. *Paleorient.*, **6** : 253-258.

JARRIGE J. F. & MEADOW R. H., 1980. — Antecedents of civilization in the Indus Valley. *Scientific American*, **243**: 122-133.

JORGENSEN K. D., 1955. — The *Dryopithecus* pattern in recent Danes and Dutchmen. *Jour. Dent. Res.*, **34**: 195-208.

KAUL V. & PRAKASH S., 1981. — Morphological features of Jat dentition. *Amer. Jour. Phys. Anthrop.*, **54**: 123-127.

KAUL V., 1984. — Crown dimensions of deciduous and permanent teeth of Jats from Harayana (India). *Ann. Human Biol.*, **11** (4): 351-354.

KENNEDY K. A. R., 1965. — Human skeletal material from Ceylon, with an analysis of the island's prehistoric and contemporary populations. *Brit. Mus Nat. Hist., Bull.*, (Geology) **11**: 137-213.

KENNEDY K. A. R., 1984. — Biological adaptations and affinities of Mesolithic South Asians. *In: People of South Asia*, Lukacs J. R., Ed., New York, Plenum Press: 29-57.

KENNEDY K. A. R., BURROW C. B. & LOVELL N. C., 1986. — Mesolithic human remains from the Gangetic Plain: Part I, Sarai Nahar Rai. New Delhi: *Arch. Surv. India.*

LECHEVALLIER M. & QUIVRON G., 1981. — The Neolithic in Baluchistan: new evidences from Mehrgarh. *In: South Asian Archaeology 1979*, Hartel H., Ed., Berlin, Dietrich Reimer Verlag: 71-92.

LECHEVALLIER M., MEADOW R. H. & QUIVRON G., 1982. — Dépôts d'animaux dans les sépultures Néolithiques de Mehrgarh, Pakistan. *Paleorient.*, **8** (1): 99-106.

LUKACS J. R., In press. — Dental anthropology of human skeletal remains from Iron Age Mahurjhari. *In: Excavations of Mahurjhari*, Deo S. B., Ed., Pune, Deccan College Press.

LUKACS J. R., 1983a. — Human dental remains from early Neolithic levels at Mehrgarh, Baluchistan. *Current Anthrop.*, **24** (3): 390-392.

LUKACS J. R., 1983b. — Dental anthropology and the origins of two Iron Age populations from northern Pakistan. *Homo*, **34** (1): 1-15.

LUKACS J. R., 1984. — Dental anthropology of South Asian populations: a review. *In: People of South Asia*, Lukacs J. R., Ed., New York, Plenum Press: 133-157.

LUKACS J. R., 1985a. — Tooth size variation in prehistoric India. *Amer. Anthrop.*, **87** (4): 811-825.

LUKACS J. R., 1985b. — Dental pathology and tooth size at early Neolithic Mehrgarh: an anthropological assessment. *In: South Asian Archaeology 1983*, Schotsmans J. & Taddei M., Eds., Naples, Intituto Universitario Orientale: 121-150.

LUKACS J. R., In Press. — Biological relationships from dental morphology: the evidence from Neolithic Mehrgarh. Presented at the 15th Annual Wisconsin Conference on South Asia, Kenoyer J. M. & Narain A. K., Eds., Madison, Wisconsin. *Wisconsin Jour. Arch.*, **2**.

LUKACS J. R. & WALIMBE S. R., 1984. — Deciduous dental morphology and the biological affinities of a late Chalcolithic skeletal series from western India. *Amer. Jour. Phys. Anthrop.*, **65** (1): 23-30.

LUKACS J. R., JOSHI M. R. & MAKHIJA P. G., 1983. — Deciduous tooth crown dimensions in living and prehistoric populations of western India. *Amer. Jour. Phys. Anthrop.* **61** (3): 383-387.

LUKACS J. R., RETIEF H. & JARRIGE J. F., 1985. — Dental disease in prehistoric Baluchistan. *Nat. Geogr. Res.*, **1** (2): 184-197.

MAKHIJA P. G., 1981. — *A Cross Sectional Study of the Dimensions of Normal Deciduous Dentition and the Dental Arches of 100 Children from Gujarat.* Dissertation, Masters of Dental Surgery. Ahmedabad: Gujarat University: 97 p.

MALHOTRA K. C., 1965. — Human skeletal remains from Neolithic Tekkalakota. *In:* Stone Age Hill Dwellers of Tekkalakota. Nagarajarao M. S., Ed., *Deccan College Building and Centenary and Silver Jubilee Series*, **31**: 109-162.

MALHOTRA K. C., 1967. — Further observations on the human skeletal remains from Neolithic Piklihal. *The Anthropologist*, **14**: 99-111.

MEADOW R. H., 1981. — Early animal domestication in South Asia: a first report of the faunal remains from Mehrgarh, Pakistan. *In: South Asian Archaeology 1979.* Hartel H., Ed., Berlin, Dietrich Reimer Verlag: 143-179.

MEADOW R. H., 1983. — Animal domestication in the Middle East: A view from the eastern margins. *In: Animals and Archaeology* (Proceedings 4th International Conference on Archaeozoology). Clutton-Brock J. & Grigson C., Eds., Oxford, British Archaeological Reports: 1-24.

MEADOW R. H., 1984. — Notes on the faunal remains from Mehrgarh, with focus on cattle (*Bos*). *In: South Asian Archaeology 1981*, Allchin B., Ed., Cambridge, Cambridge University Press: 34-40.

MEIKLEJOHN C., LAMBERT P. & BYRNE C., 1980. — *Demography and pathology of the Ganj Dareh population: early Neolithic of Iran.* Read at 49th annual meeting American Association of Physical Anthropologists (Niagara Falls, April 17-19, 1980): 12 p.

MOORREES C. F. A., 1957. — *The Aleut Dentition.* Cambridge, Harvard University Press.

NAGARAJARAO M. S., 1965. — The Stone Age Hill Dwellers of Tekkalakota. *Deccan College Building Centenary* and *Silver Jubilee Series*, **31**.

PIETRUSEWSKY M. (n.d.). — *The human remains from Ban Chiang.* Philadelphia, University of Pennsylvania Press.

POSSEHL G. L. & RISSMAN P. C., In Press. — The chronology of prehistoric India: from earliest times to the Iron Age. *In: Chronologies in Old World Archaeology.* Ehrich R., Ed., Chicago, University of Chicago Press.

SAMZUN A. & SELLIER P., 1983. — Découverte d'une nécropole chalcolithique à Mehrgarh, Pakistan. *Paleorient*, **9** (2): 69-79.

SAMZUN A. & SELLIER P., 1985. — First anthropological and cultural evidence for the funerary practices of the Chalcolithic population of Mehrgarh. *In: South Asian Archaeology 1983.* Schotsmans J. & Taddei M., Eds., Naples, Inst. Universitario Orientale: 91-119.

SARKAR S. S., 1960. — Human skeletal remains from Brahmagiri. *Anthrop. Surv. India, Bull.*, **9** (1): 2-25.

SARKAR S. S., 1964. — *Ancient Races of Baluchistan, Panjab and Sind.* Calcutta, Bookland Private Ltd: 105 p.

SARKAR S. S., 1972. — *Ancient Races of the Deccan.* New Delhi, Munshiram Manoharlal: 212 p.

SCOTT G. R., 1977. — Classification, sex dimorphism, association, and population variation of the canine distal accessory ridge. *Human Biol.*, **49**: 453-469.

SCOTT G. R., 1980. — Population variation of Carabelli's trait. *Human Biol.*, **52** (1): 63-78.

SCOTT G. R. & DAHLBERG A. A., 1982. — Microdifferentiation in tooth crown morphology among Indians of the American southwest. *In: Teeth: Form, Function and Evolution.* Kurtén B., Ed., New York, Columbia University Press: 259-291.

SELLIER P., in press. — Hypothèses et estimateurs pour l'interprétation démographique de la population chalcolithique de Mehrgarh, Pakistan. *In: Archeologia protohistorica dell'Asia Media: due esperienze a confronto.* Gwoli G., Ed., Rome, Inst. Italiano per il Medio ed Estromo Oriente.

SEWELL R. B. S. & GUHA B. S., 1983. — Human remains. *In: Mohenjo-Daro and the Indus Civilizations.* Marshall J., Ed., London, Arthur Probsthan, **2**: 599-648.

SKINNER M. F., 1986. — An enigmatic hypoplastic defect of the deciduous canine. *Amer. Jour. Phys. Anthrop.*, **69** (1): 59-69.

SMITH P., 1970. — *Dental morphology and pathology in the Natufians: the dental evidence for dietary specializations*. Unpublished Ph. D. dissertation. University of Chicago.

SMITH P., BAR-YOSEF O. & SILLEN A., 1984. — Archaeological and skeletal evidence for dietary change during the late Pleistocene/early Holocene in the Levant. *In: Paleopathology at the Origins of Agriculture*. Cohen M. N. & Armelagos G. J., Eds., New York, Academic Press: 101-136.

SMITH P. E. .L., 1978. — An interim report on Ganj Dareh Tepe. *Amer. Jour. Arch.*, **82**: 538-540.

THAPAR B. K., 1957. — Maski 1954: a chalcolithic site of the southern Deccan. *Ancient India*, **13**: 4-143.

TURNER II C. G., 1967. — *The Dentition of Arctic Peoples*. Ph. D. Dissertation, University of Wiscontin (Madison): 284 p.

TURNER II C. G., 1970. — New classification of non-metric dental variation. *Amer. Jour. Phys. Anthrop.*, **33**: 144-145.

TURNER II C. G., 1976. — Dental evidence on the origins of the Ainu and Japanese. *Science*, **193**: 911-913.

TURNER II C. G., 1979. — Sinodonty and sunadonty: a dental anthropological view of Mongoloid microevolution, origin and dispersal into the Pacific Basin, Siberia and the Americas. Paper presented at the XIV Pacific Science Congress, Khabarovsk USSR, 1979. Ackerman R. & Vasilievsky R. S., conveners.

TURNER II C. G. & SCOTT G. R., 1977. — Dentition of Easter Islanders. *In: Orofacial Growth and Development*, Dahlberg A. A. & Graber T. M., Eds., Morton, The Hague: 229-249.

WHEELER R. E. M., 1947-48. — Brahmagiri and Chandravalli 1947: Megalithic and other cultures in Mysore State. *Ancient India*, **4**: 180-310.

WOLPOFF M. H., 1971. — Metric Trends in Hominid Dental Evolution. Case Western Reserve University, *Studies in Anthropology*, **2**: 1-244.

ZUBOV A. A., 1980. — Anthropological characteristics of the union territory of Delhi on the basis of odontological features. *In: New Anthropological Data for Northern India: Results from the Joint Indo-Soviet Expedition 1971*, Abdushalishvili M. G. & Malhotra K. C., Eds., Moscow, Academy of Sciences of USSR: 218-240 (In Russian).

TABLE 1. Morphological variations of maxillary anterior teeth.

SHOVEL SHAPE

	I^1		I^2		C	
grade	n	(%)	n	(%)	n	(%)
0	3	(10.7)	6	(16.2)	6	(25.0)
1	7	(25.0)	14	(37.8)	11	(45.8)
2	15	(53.6)	14	(37.8)	7	(29.2)
3	3	(10.7)	3	(8.2)	0	(0.0)
Total	28	(100.0)	37	(100.0)	24	(100.0)

CINGULAR TUBERCLE

	I^2		C	
grade	n	(%)	n	(%)
0	27	(84.4)	15	(55.6)
1	5	(15.6)	12	(44.4)
Total	32	(100.0)	27	(100.0)

MEDIAN LINGUAL RIDGE

	I^1		I^2	
grade	n	(%)	n	(%)
0	11	(42.3)	27	(93.2)
1	4	(15.4)	1	(3.4)
2 (TD)	11	(42.3)	1	(3.4)
Total	26	(100.0)	29	(100.0)

MARGINAL INTERRUPTION

	I^1		I^2	
grade	n	(%)	n	(%)
0	27	(100.0)	15	(48.4)
1 (mésial)	0	(0.0)	7	(22.6)
2 (distal)	0	(0.0)	7	(22.6)
3 (median)	0	(0.0)	2	(6.4)
Total	27	(100.0)	31	(100.0)

TABLE 2. Morphological variations of maxillary molar teeth.

CARABELLI'S TRAIT (M^1)

grade	n	(%)
0	20	(74.0)
groove (1-3)	4	(14.8)
y (4)	1	(3.8)
cusp (5-7)	2	(7.4)
Total	27	(100.0)

HYPOCONE VARIATION

	M^1		M^2		M^3	
grade	n	(%)	n	(%)	n	(%)
4	35	(83.3)	2	(4.9)	1	(2.9)
4—	7	(16.7)	30	(73.1)	4	(11.8)
3+	0	(0.0)	9	(22.0)	27	(79.4)
3	0	(0.0)	0	(0.0)	2	(5.9)
Total	42	(100.0)	41	(100.0)	34	(100.0)

	M^1		M^2		M^3	
	n	(%)	n	(%)	n	(%)
Metaconule						
grade 0	21	(75.0)	15	(60.0)	11	(57.9)
1	7	(25.0)	10	(40.0)	8	(42.1)
Total	28	(100.0)	25	(100.0)	19	(100.0)
Protoconule						
grade 0	17	(81.0)	22	(100.0)	14	(82.4)
1	4	(19.0)	0	(0.0)	3	(17.6)
Total	21	(100.0)	22	(100.0)	17	(100.0)
Parastyle						
grade 0	38	(100.0)	34	(97.1)	30	(96.8)
1	0	(0.0)	1	(2.9)	1	(3.2)
Total	38	(100.0)	35	(100.0)	31	(100.0)

TABLE 3. Morphological variations of mandibular molar teeth.

Dental Trait	M^1		M^2		M^3	
grade	n	(%)	n	(%)	n	(%)
Groove Pattern						
Y	23	(92.0)	12	(32.4)	3	(11.1)
+	2	(8.0)	18	(48.6)	7	(25.9)
X	0	(0.0)	7	(18.9)	17	(63.0)
Total	25	(100.0)	37	(100.0)	27	(100.0)
Cusp Number						
6	7	(16.3)	0	(0.0)	2	(5.3)
5	32	(74.4)	3	(6.1)	24	(63.2)
4	4	(9.3)	46	(93.9)	11	(28.9)
3	0	(0.0)	0	(0.0)	1	(2.6)
Total	43	(100.0)	49	(100.0)	38	(100.0)
Entoconulid (C-6)						
0	34	(91.9)	44	(1.00)	33	(97.1)
1	3	(8.1)	0	(0.0)	1	(2.9)
Total	37	(100.0)	44	(100.0)	34	(100.0)
Metaconulid (C-7)						
0	36	(90.0)	43	(1.00)	35	(1.00)
1	4	(10.0)	0	(0.0)	0	(0.0)
Total	40	(100.0)	43	(100.0)	35	(100.0)

TABLE 4. Morphological Variations of Deciduous Teeth.

SHOVEL SHAPE

	dc¹		dc²	
grade	n	(%)	n	(%)
0	3	(27.3)	4	(66.7)
1	6	(54.5)	0	(0.0)
2	2	(18.2)	2	(33.3)
Total	11	(100.0)	6	(100.0)

TUBERCULUM DENTALE

	dc̲	
n	(%)	
1	(16.7)	
3	(50.0)	
2	(33.3)	
6	(100.0)	

CIRCULAR ENAMEL HYPOPLASIA

	dc̲		dc̄	
	n	(%)	n	(%)
	20	(83.3)	11	(57.9)
	4	(16.7)	8	(42.1)
	—	—	—	—
	24	(100.0)	19	(100.0)

CARABELLI'S TRAIT (dm²)

grade	n	(%)
0	2	(18.2)
1-3	8	(72.7)
4-6	1	(9.1)
Total	11	(100.0)

CUSP NUMBER

	dm¹		dm²		
grade	n	(%)	grade	n	(%)
2	3	(30.0)	3	1	(9.1)
3M	3	(30.0)	4	10	(90.9)
3H	2	(20.0)	—	—	—
4	2	(20.0)	—	—	—
Total	10	(100.0)	Total	11	(100.0)

CUSP NUMBER

	dm₁		dm₂	
grade	n	(%)	n	(%)
4	4	(40.0)	0	(0.0)
5	4	(40.0)	8	(72.7)
6	2	(20.0)	2	(18.2)
7	0	(0.0)	1	(9.1)
Total	10	(100.0)	11	(100.0)

dm₂ VARIATIONS

	C-6		C-7		Protostylid	
0	8	(72.7)	10	(90.9)	5	(62.5)
1	3	(27.3)	1	(9.1)	3	(37.5)
Total	11	(100.0)	11	(100.0)	8	(100.0)

TABLE 5. Mean crown diameters of permanent teeth from Neolithic Mehrgarh (in mm).

	Mesiodistal					Buccolingual				
Tooth	x̄	n	sd	min	max	x̄	n	sd	min	max
MAXILLA										
I1	8.72	29	0.51	7.8	9.8	7.28	33	0.37	6.6	7.9
I2	7.12	31	0.43	6.3	8.5	6.68	34	0.39	5.6	7.5
C	7.75	37	0.34	6.9	8.4	8.41	37	0.49	7.5	9.8
Pm3	7.10	36	0.41	5.6	7.8	9.56	37	0.41	8.8	10.5
Pm4	6.86	32	0.37	6.0	7.4	9.50	34	0.52	8.7	10.6
M1	10.63	39	0.50	9.7	11.8	11.89	41	0.49	10.8	13.5
M2	9.94	38	0.48	8.7	11.1	11.81	38	0.58	10.7	13.1
M3	9.29	30	0.86	7.8	10.8	11.20	31	0.91	8.7	13.0
MANDIBLE										
I1	5.48	26	0.34	4.8	6.0	6.06	30	0.33	5.6	6.8
I2	6.12	31	0.33	5.3	6.7	6.40	34	0.29	5.8	7.1
C	6.82	36	0.38	5.8	7.6	7.68	38	0.53	6.6	9.3
Pm3	7.04	38	0.40	6.2	7.8	7.98	40	0.52	7.1	9.5
Pm4	7.17	39	0.46	6.2	8.1	8.44	42	0.52	7.4	9.5
M1	11.54	38	0.55	10.4	12.9	11.12	39	0.43	10.3	12.0
M2	10.88	41	0.63	9.6	12.6	10.49	40	0.50	9.4	11.9
M3	11.01	36	0.75	9.6	12.5	10.30	37	0.60	9.1	11.4

TABLE 6. Mean tooth crown diameters at Neolithic Mehrgarh.

		MAXILLA					MANDIBLE				
Tooth	Var	$\bar{x}$	(n)	sd	min	max	$\bar{x}$	(n)	sd	min	max
di 1	MD	7.06	(11)	0.40	6.60	7.70	4.48	(12)	0.48	3.20	5.10
	BL	5.54	(11)	0.17	5.30	5.85	4.26	(12)	0.24	3.90	4.70
	CA	39.17	(11)	2.95	34.98	45.05	19.03	(12)	2.21	15.04	23.46
di 2	MD	5.75	(13)	0.28	5.30	6.20	5.11	(10)	0.27	4.80	5.70
	BL	5.24	(13)	0.30	4.70	5.60	4.68	(10)	0.22	4.40	5.20
	CA	30.14	(13)	2.71	24.91	33.60	23.95	(10)	2.24	22.05	29.64
dc	MD	7.31	(14)	0.77	6.00	8.90	6.31	(11)	0.41	5.30	6.80
	BL	6.32	(14)	0.50	5.40	7.10	5.82	(11)	0.28	5.30	6.20
	CA	46.51	(14)	7.90	32.40	57.85	36.76	(11)	3.56	28.09	41.48
dm 1	MD	7.62	(13)	0.41	6.90	8.40	8.83	(12)	0.48	8.10	9.80
	BL	9.35	(13)	0.36	8.70	9.90	7.56	(12)	0.28	7.10	8.00
	CA	71.23	(13)	5.48	60.72	80.36	66.74	(12)	5.07	59.76	77.42
dm 2	MD	9.51	(14)	0.61	8.60	10.90	10.66	(10)	0.55	9.60	11.70
	BL	10.47	(14)	0.41	9.70	11.00	9.40	(10)	0.40	9.00	10.10
	CA	99.75	(14)	9.48	83.42	119.90	100.31	(10)	8.33	88.32	118.17
SUM	CA	286.80 mm²					246.79 mm²				

TABLE 7. Comparison of mean crown diameters (MD and BL) by Period (IA, IB) for Neolithic Mehrgarh (left side in mm). * 0.05 level of size.

	Mesiodistal								Buccolingual							
	Level IA				Level IB				Level IA				Level IB			
Tooth	n	x	SD	SE	n	x	SD	SE	n	x	SD	SE	n	x	SD	SE
MAXILLA																
I1	5	8.74	0.72	0.32	18	8.69	0.46	0.11	8	7.31	0.32	0.11	19	7.26	0.36	0.08
I2	7	7.29	0.56	0.21	19	7.02	0.40	0.09	10	6.83	0.39	0.12	19	6.58	0.39	0.09
C	9	7.80	0.22	0.07	20	7.80	0.42	0.09	10	8.63	0.53	0.17	19	8.38	0.43	0.10
P3	10	7.09	0.29	0.09	19	7.17	0.36	0.08	11	9.53	0.45	0.13	19	9.53	0.30	0.07
P4	8	6.89	0.39	0.14	18	6.75	0.36	0.08	10	9.49	0.59	0.19	18	9.39	0.47	0.11
M1	14	10.81	0.55	0.15	19	10.59	0.48	0.11	14	11.96	0.59	0.16	21	11.89	0.45	0.10
M2	11	10.02	0.53	0.16	19	9.89	0.55	0.13	11	11.92	0.78	0.24	19	11.81	0.49	0.11
M3	9	9.10	0.71	0.24	16	9.46	0.89	0.22	10	10.93	1.026	0.33	16	11.48	0.84	0.21
MANDIBLE																
I1	6	5.73	0.23	0.10	13	5.43	0.30	0.08	6	6.08	0.44	0.18	16	6.06	0.36	0.09
I2	8	6.08	0.26	0.09	17	6.20	0.34	0.08	9	6.46	0.21	0.07	18	6.39	0.27	0.06
C	11	6.91	0.39	0.12	18	6.78	0.35	0.08	12	7.79	0.52	0.15	19	7.70	0.55	0.13
P3	11	7.12	0.34	0.10	19	6.99	0.40	0.09	12	8.04	0.64	0.19	20	8.00	0.40	0.09
P4	12	7.39	0.55	0.16	20	7.06	0.42	0.09	13	8.41	0.63	0.18	22	8.52	0.43	0.09
M1	11	11.85	0.51	0.15	19	11.50	0.52	0.12	12	11.23	0.40	0.12	19	11.10	0.43	0.09
M2	13	11.19	0.67	0.19	22	10.70	0.60	0.13	13	10.60	0.57	0.16	22	10.44	0.50	0.11
M3	11	11.07	0.91	0.28	19	11.03	0.77	0.18	12	10.35	0.63	0.18	19	10.34	0.63	0.15

TABLE 8. Mean cross-sectional crown area for Neolithic Mehrgarh (left side, mm^2).

MAXILLA	$\bar{x}$	(n)	SD	min	max
I1	63.63	28	6.50	53.46	74.88
I2	47.84	30	4.53	38.64	62.05
C	64.98	34	5.12	52.44	74.70
P3	67.98	35	6.15	49.28	78.75
P4	65.16	31	6.42	53.40	78.44
M1	126.69	38	10.16	110.00	159.30
M2	117.71	37	9.24	97.44	136.74
M3	104.72	29	16.83	69.60	139.10
MANDIBLE					
I1	33.23	23	3.20	26.88	40.12
I2	39.26	28	3.20	32.33	44.88
C	52.65	36	6.13	39.60	67.89
P3	56.46	37	5.94	44.02	69.35
P4	60.69	39	6.83	46.50	73.47
M1	128.85	37	9.36	109.20	151.20
M2	114.26	40	11.21	91.18	149.94
M3	113.71	36	13.73	89.18	135.00

Upper 658.71 + Lower 599.11 = 1257 mm^2

TABLE 9. Dental trait frequencies in prehistoric South Asian skeletal series.

		Mehrgarh		Inamgaon		Sarai Khola		Timargarha	
Dental trait	Tooth	f	(n)	f	(n)	f	(n)	f	(n)
Shovel shape	I^1	.107	(28)	.000	(24)	.000	(12)	.000	(7)
Median Lingual Ridge	I^1	.577	(26)	.560	(25)	.182	(11)	.375	(8)
Marginal Interruption	I^1	.000	(27)	.000	(25)	.100	(10)	.125	(8)
	I^2	.516	(38)	.350	(20)	.100	(10)	.571	(7)
Cingulum Variation	I^1	.182	(11)	.042	(24)	.091	(11)	.000	(7)
Hypocone Size	M^1	.833	(42)	.659	(41)	.710	(21)	.770	(22)
Carabelli's Trait	M^1	.260	(27)	.325	(40)	.380	(13)	.500	(18)
Metaconule (C-5)	M^1	.250	(28)	.146	(41)	.230	(13)	.200	(19)
Cusp Number	M_2	.061	(49)	.167	(24)	.000	(19)	.118	(17)
Deflecting Wrinkle	M_1	.250	(8)	.114	(35)	.000	(15)	.230	(13)
Entoconulid (C-6)	M_1	.081	(37)	.108	(37)	.059	(18)	.000	(22)
Metaconulid (C-7)	M_1	.100	(40)	.056	(36)	.053	(19)	.080	(24)
Protostylid	M_1	.053	(19)	.000	(37)	.000	(15)	.043	(23)

TABLE 10. Comparative morphology of South Asian deciduous teeth.

		Prehistoric				Living	
		Mehrgarh		Inamgaon		Jats	
Dental trait	Tooth	f	(n)	f	(n)	f	(n)
Shovel Shape	(di^1)	.182	(11)	.154	(39)	.139	(36)
Tuberculum dentale	(dc)	.883	(6)	—	—	.075	(80)
Carabellis's Trait	(dm^2)	.091	(11)	.088	(45)	.118	(306)
Canine breadth Index	(dc/di^1)	103.5	(11)	99.3	(19)	102.8	(84)
Cusp Number	(dm^1, 2)	.300	(10)	.381	(44)	—	—
Cusp Number	(dm^2, 4)	.909	(11)	.653	(46)	.523	(314)
Cusp Number	(dm_1, 5)	.400	(10)	.426	(47)	—	—
Cusp Number	(dm_2, 5)	.727	(11)	.803	(61)	.941	(322)
Entoconulid (C-6)	(dm_2)	.273	(11)	.180	(61)	.012	(322)
Metaconulid C-7)	(dm_2)	.091	(11)	.017	(60)	.000	(322)
Protostylid	(dm_2)	.375	(8)	.016	(61)	—	—

TABLE 11. Tooth size of prehistoric skeletal series from Southern Asia.

Site	Country	Cultural Association	TCA (mm^2)	MCA (mm^2)	Source
Niah Cave	Sarawak	Neolithic	1312	—	Brace & Vitzthum, 1984
Jericho (PPNB)	Israel	Neolithic	1277	703	Smith, 1970
Natufian	Israel	Epipaleolithic	1264	703	Smith, 1970
MEHRGARH (MR3)	PAKISTAN	NEOLITHIC	1257	706	Lukacs *et al.*, 1985
Jarmo	Iraq	Neolithic	1248	680	Dahlberg, 1960
Abou Gosh	Israel	Neolithic	1240	685	Arensburg *et al.*, 1978
Non Nok Tha	Thailand	Bronze	1224	681	Brace, 1978
Mahurijhari	India	Iron	1220	677	Lukacs, 1982
Inamgaon	India	Chalcolithic	1218	671	Lukacs, 1985
Ban Chiang	Thailand	Metal Age	1216	682	Pietrusewsky (ms)
Bellan Bandi Palassa	Sri Lanka	Mesolithic	1210	713	Kennedy, 1965
Timargarha	Pakistan	Iron Age	1173	642	Lukacs, 1983b
Jericho	Israel	Bronze	1120	613	Smith, 1970
Sarai Khola	Pakistan	Iron Age	1107	613	Lukacs, 1983b
Harappa	Pakistan	Bronze	—	606	Dutta, 1983
Burzahom	India	Neolithic	1017	560	Basu & Pal, 1980

TABLE 12. Mean crown areas for deciduous teeth of prehistoric and living South Asians (sexes pooled, in mm^2).

	Prehistoric samples									Living samples	
	Mehrgarh			Inamgaon			Timargarha			Gujarati Hindu[1]	
	$\bar{x}$	(n)	SD	$\bar{x}$	(n)	SD	$\bar{x}$	(n)	SD	$\bar{x}$	SD
MAXILLA											
I^1	39.17	(11)	2.95	36.13	(19)	3.89	34.21	(4)	3.39	34.20	3.93
I^2	30.14	(13)	2.71	27.99	(20)	3.64	26.45	(6)	3.66	26.11	3.35
C	46.51	(14)	7.90	40.26	(27)	5.45	40.06	(9)	5.37	40.72	4.89
M^1	71.23	(13)	5.48	67.68	(32)	5.89	68.95	(8)	7.41	64.57	7.11
M^2	99.75	(14)	9.48	95.13	(32)	11.00	87.86	(8)	5.74	91.15	9.69
Maxillary crown area	286.8			267.19 (6.84 %)[2]			257.53 (10.21 %)			256.75 (10.48 %)	
MANDIBLE											
I_1	19.03	(12)	2.21	17.74	(20)	1.90	14.88	(4)	2.67	15.84	1.81
I_2	23.95	(10)	2.24	21.81	(22)	2.62	20.61	(6)	3.20	20.32	2.41
C	36.76	(11)	3.56	31.62	(22)	3.83	32.51	(9)	3.62	32.24	3.52
M_1	66.74	(12)	5.07	62.21	(36)	6.37	58.10	(13)	5.95	59.80	6.96
M_2	100.31	(10)	8.33	97.34	(36)	10.16	90.44	(13)	7.36	91.13	9.59
Mandibular crown area	246.79			230.72 (6.51 %)			216.54 (12.26 %)			219.33 (11.13 %)	
Total crown area	533.59			497.91 (6.69 %)			474.07 (11.15 %)			476.08 (10.78 %)	

1 n = 100 for Gujarati Hindu sample.
2 percent smaller than Mehrgarh sample.