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Upper Pleistocene Fossil Hominids From Sri Lanka

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ABSTRACT Between 1978 and 1983 hominid skeletal remains were collected from the cave sites of Batadomba lena and Beli lena Kitulgala in Sri Lanka (formerly Ceylon). These are the most ancient specimens of anatomically modern *Homo sapiens* found thus far in South Asia, radiocarbon dates placing them in the Upper Pleistocene. Morphometric analysis of the remains of some 38 individuals from the two sites indicates that these populations were characterized by medium stature, moderate to pronounced cranial and postcranial robusticity, medium-size permanent tooth crown measurements, prognathic alveolar facial proportions, and low incidence of osseous and dental pathological conditions. Comparisons of these ancient Sri Lankans with other prehistoric skeletal series from South Asia and elsewhere support the hypothesis that muscular-skeletal robusticity was a significant physical adaptation of earlier hunting-foraging populations. A trend towards reduction of sexual dimorphism and development of more gracile body form and smaller teeth appears to have accelerated with the socioeconomic transition to food-production strategies involving agriculture and pastoralism and refinement of technologies for food procurement and preparation, as documented by morphometric studies of later prehistoric inhabitants of South Asia.

The caves of Batadomba lena (6 degrees 46 minutes North, 80 degrees 12 minutes East) and Beli lena Kitulgala (6 degrees 58 minutes North, 80 degrees 25 minutes East) in southern Sri Lanka have yielded hominid fossil remains from charcoal-bearing deposits with radiocarbon dates which place them in the Upper Pleistocene. The hominid skeletal specimens were collected by Siran U. Deraniyagala between 1978 and 1983 and sent to the senior author for study at the Human Biology Laboratory, Cornell University (Kennedy et al., 1986a). These are the most ancient skeletal specimens of anatomically modern *Homo sapiens* found thus far in South Asia. Radiocarbon dates for charcoal from the hominid skeletal levels at Batadomba lena are 15,830 ± 1,260 years B.P. (PRL-858) and at Beli lena are 12,260 ± 870 years (PRL-861).

Within the past two decades, palaeontological research in South Asia has added significantly to a knowledge of Pleistocene hominids. The calvarium of *Homo* sp. indet. from Hathnora in the Narmada valley of central India, found in 1982 in deposits reported to be Middle Pleistocene (Sonakia, 1984, 1985a, 1985b), pre-dates the Darra-I-Kur hominid temporal bone fragment found in 1966 in northeastern Afghanistan in association with a Mousterian-type lithic industry and radiocarbon dated at 30,000 ± 1,900–1,200 years B.P. (Gx1122) (Dupree, 1972). Well-preserved skeletons of over 60 individuals from Sarai Nahar Rai and Mahadaha on the Gangetic plain of northern India have provided a questionable terminal Pleistocene

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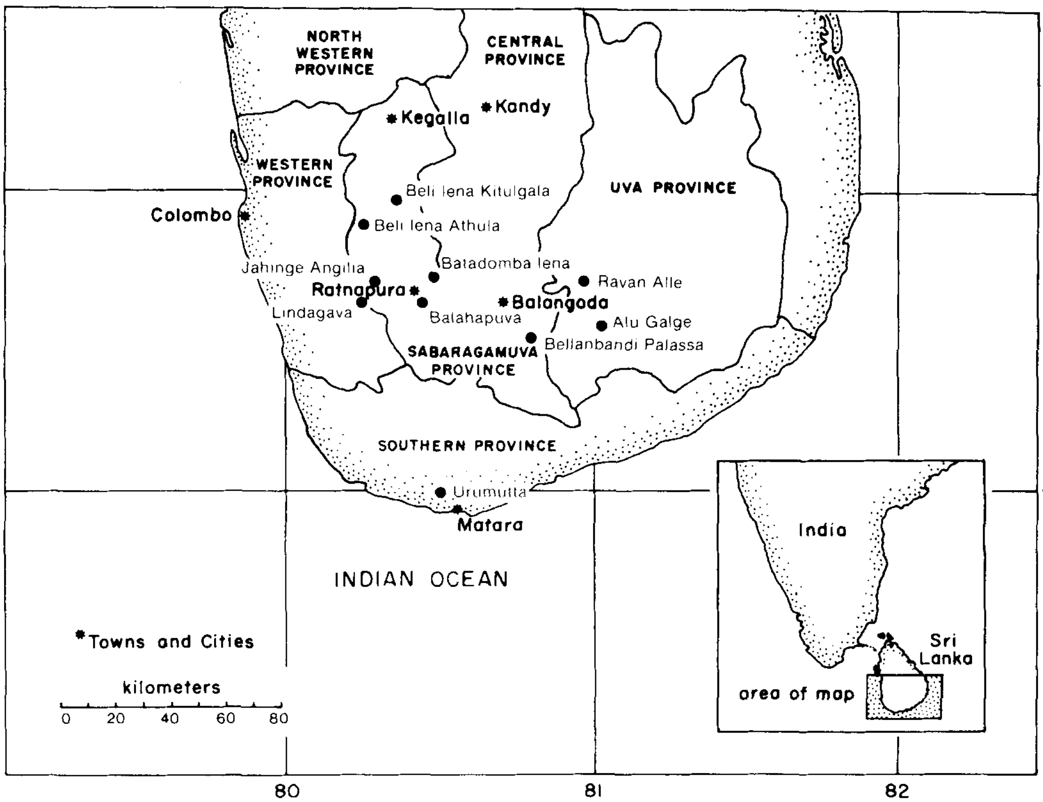

Fig. 1. Map of southern Sri Lanka with localities noted in text.

date of 10,050 ± 110 years B.P. (TF-1104) from a sample of unburnt human bone from Sarai Nahar Rai (Agrawal and Kusumgar, 1973; Kennedy, 1984a; Kennedy et al., 1986b). Other fossil hominid remains of probable Pleistocene antiquity were collected in India as early as the 1830s, but these were lost or destroyed before examination by qualified scientists (Kennedy, 1980). Post-Pleistocene Mesolithic human skeletons and others from later prehistoric cultural periods are more fully represented in collections from India, Pakistan, and Sri Lanka (Kennedy and Caldwell, 1984).

The first discovery of prehistoric human skeletal remains in Sri Lanka is attributed to the Swiss cousins, Paul and Fritz Sarasin (1908), who excavated Nilgala Cave in 1907. Fragments of human bone were found in a stratigraphic context of stone and bone artifacts and faunal remains. During earlier visits to Sri Lanka in 1883–86, 1890, and 1902, the Sarasins collected quartz flakes from caves and rockshelters on the island, but their return in 1907 was motivated by their interest in determining if the types of microlithic artifacts they had found in caves inhabited by Toala tribesmen in the Celebes in 1902 were like those found beneath floors of caves still inhabited by Vedda hunter-foragers in Sri Lanka. Not only did the Sarasins abolish the prejudice that the southernmost region of South Asia was uninhabited by human populations before the dawn of the historic period in the fifth century B.C., but they demonstrated that the quartz flake artifacts collected from the floors of caves and rockshelters during previous visits to the island (but not recognized as prehistoric artifacts) had been manufactured by the ancient ancestors of the Veddas. Additional prehistoric human remains were found in Sri Lanka in 1910 when a British antiquarian explored a cave overlooking the streambed at Ratnapura, Sabaragamuva Province (Seligman and Seligman, 1911), and two years later fragments of human bone were removed from a cave at Urumutta near Matura, Southern Province (Lewis, 1912).

Although these human bones and artifacts could not be dated, their recovery prompted British civil servants, foreign visitors, and native Sri Lankans to investigate the many caves and rockshelters on the island (P.E.P. Deraniyagala). By the second decade of this century, prehistoric archaeological research was developing rapidly through the efforts of C. Hartley (1914), E.J. Wayland (1914), and A.M. Hocart (1924). Since 1937, archaeologists associated with the Archaeological Department and the Ceylon National Museum in Colombo encountered prehistoric human remains in a number of caves, rockshelters, and open-air sites. From the localities of Jahinge Angilia, Balahapuva, and Lindagave, all in Sabaragamuva Province, cranial and dental fragments were collected which P.E.P. Deraniyagala (1963, 1965) identified as hominid. He associated these remains with a Pleistocene fauna and lithic artifacts which defined the *Ratnapura Culture*. Post-Pleistocene materials were associated with the *Balangoda Culture*, a complex which includes a microlithic industry called *Bandarawelian* (Noone and Noone, 1940) and *Indian Late Stone Age* (Allchin, 1959) by other archaeologists. Batadomba lena was first excavated in 1939 when P.E.P. Deraniyagala (1953) collected human skeletal remains and artifacts. Additional skeletal and archaeological specimens were found in Uva Province at Ravan Alle in 1945 (Deraniyagala, PEP, 1953) and at Alu Galge in 1954 (Deraniyagala, PEP, 1955). In 1956, at the open-air site of Bellanbandi Palassa in Sabaragamuva Province, P.E.P. Deraniyagala (1958, 1963) found a mortuary series of over 15 individuals. The skeletons have been described (Kennedy, 1965) and the deposits dated by a thermoluminescent reading of fired rock crystal associated with the skeletons to 6,500 $\pm$ 700 years B.P. (L5-6, BP 3/15a) (Wintle and Oakley, 1972). Beli lena Athula in Sabaragamuva Province was excavated in 1972, and recovery of some human skeletal remains has been reported (Gunaratne, 1972). This site is not to be confused with Beli lena Kitulgala, also in Sabaragamuva Province, which is the cave site excavated by S.U. Deraniyagala in 1978 and one of the two localities described in this article. The history of prehistoric research in Sri Lanka has been described by P.E.P. Deraniyagala (1960) and by his son, S.U. Deraniyagala (1981, 1985) (Fig. 1).

Later human skeletal remains from the island are associated with Iron Age megalithic sites and those of the historic period; thus Sri Lanka possesses a prehistoric human skeletal record spanning a temporal period from circa 16,000 years ago to the dawn of historic times, which Orientalists set at 483 B.C. on the basis of quasi-historical written records. However, the archaeological record extends to 28,000 years B.P. (PRL-16/7C), as determined by radiocarbon dates of charcoal for the lower levels of Batadomba lena which contain geometric microlithic tools. This very early appearance of microlithic technology in Sri Lanka is not encountered on the adjacent Indian mainland, where the earliest dates for microlithic levels are 10,645–9,654 years B.P. (PRL-715) for Baghor II and 10,070–9,070 years B.P. (PRL-787) for Bhimbetka, both sites in Madhya Pradesh (Possehl, 1986). The 28,000 B.P. date for Batadomba lena is reliable on the basis of multiple assays of charcoal samples from the 2.8 m level at the site. This may be the earliest date for a microlithic industry. In Africa the earliest true backed-microlithic industry developed by 19,000 years B.P. at the Kalemba rockshelter in eastern Zambia (Miller, 1972). Contemporary with this Nachikufan I industry is the Rolberg industry of South Africa which dates to a period between 19,000 and 12,000 years B.P. at Nelson Bay Cave (Klein, 1974) and Boomplaas (Deacon, 1979). In Europe, the trend towards microlithic blade production is particularly marked after 20,000 years B.P. within the traditions of the late Upper Palaeolithic, although true microlithic industries do not predominate until around 8,000 years B.P. (Gamble, 1986).

MATERIALS

Human remains from Batadomba lena and Beli lena Kitulgala both occurred within an undifferentiated matrix of occupation debris. Floral and faunal elements include insects, gastropods, cf. *Paludomus* (freshwater) and *Acavus roseolabiatus* (arboreal), freshwater shellfish, fish bones (family Cyprimidae), and bone fragments of birds, reptiles, and mammals (primarily cervids and bovids). Charred epicarps of the wild breadfruit *Artocarpus nobilis* are identified. These biota are essentially identical with those existing in this region of Sri Lanka today, suggesting relative stability of wet zone jungle environment at 450 m elevation over the past 30,000 years. Sri Lanka remained within the tropical belt throughout the Pleistocene, its higher elevations at Pidurutalagal (2,528 m) and Adam's Peak (2,244 m) in the central highlands essentially unmodified by glacial activity in the Himalayan region of northern India and northwestern Pakistan during cold phases of the Pleistocene.

TABLE 1. Dental measurements and indices

Measurements	Mesio-distal (md) diameter (mm)	Bucco-lingual (bl) diameter (mm)	$\frac{Md + BL}{2}$
Batadomba lena 1			
Maxilla			
RM2	10.30	11.20	10.75
RM1	10.00	11.50	10.75
RPM2	6.80	9.10	7.95
RPM1	6.70	8.90	7.80
RC	7.70	5.70	6.70
LI1	6.80		
LI2	6.10		
LM3	9.80	11.00	10.40
Mandible			
RM2	10.40	11.40	10.90
RC	7.50		
RI1	4.30		
LI1	4.40		
LC	6.60		
Beli lena 2			
Maxilla			
LM2	10.30	10.50	10.40
LM1	11.50	10.90	11.20
LPM2	7.50	8.00	7.75
LPM1	8.20	8.70	8.45
LC	8.00		
LI2	8.30		
LI1	8.40		
Mandible			
RM3	10.00	8.90	9.45
RM2	9.80	9.30	9.50
RM1	10.80	10.00	10.40
RPM2	7.90	8.40	8.15
RPM1	7.00		
RC	6.90		

Batadomba lena			
Mandible			
BD-16-H-30-6			
RM2	9.70	9.90	9.80
RM1	10.30	9.80	10.05
RPM2	7.00	7.10	7.05
LM2	10.40	9.40	9.90
Beli lena			
Loose teeth			
KB-78/79-X-H			
Maxilla			
RM3	9.50	9.60	9.15
RM3		9.80	9.65
RPM2	6.80	7.50	7.15
RC	7.00		
RI2	5.40		
LI1	6.50		
LM3	7.30	9.40	8.35
LM3	8.90	8.80	8.85
Mandible			
RM3	10.10	10.00	10.05
RM3	11.50	9.60	10.55
RM2	10.30	10.00	10.15
RM2	10.80	9.10	9.95
RM2	10.30	8.10	9.15
ml	10.30	8.00	9.20
RPM2	6.90	6.60	6.75
RPM1	8.70	6.30	7.50
RPM1	6.30	8.20	7.25
RC	7.20		
Beli lena			
Loose teeth			
KB-78/79-2E-15, KB-78/79-2-B-X-H, KB-78/79-1-A-X-H, KB-78/79-3-B-H-H, KB-78/79-i-C-X-H, KB-78/79-i-C-X, KB-78/79-3-A-7			
Maxilla			
RM3	11.50	9.60	10.55
RM3	10.90	11.50	11.20
RM3	9.30	8.50	8.90
RM1	10.40	10.10	10.25
RM1	9.40	9.50	9.45
RPM2	6.10	8.50	7.30
Mandible			
RM2	10.40	9.90	10.15

The quality of preservation of the hominid bones from the two sites is variable. Some bones are heavily mineralized. Warping and fracturing are prevalent. Teeth are generally well preserved. What appear to have been primary burials were interred in natural hollows in the occupation floors of both caves. There are no indications of pit lines nor does excavation of graves for accommodation of the bodies appear to have taken place. Parts of other individuals are scattered among the occupational levels and, in association with the more complete skeletons, protected in the hollows of the floor. To distinguish the latter specimens from the more complete and integrated skeletons they are referred to as "mixed specimens." This does not imply comingling of any specimens at the time of their excavation, but strongly suggests that they are evidence of secondary or fractional burials and periodic disturbance of earlier skeletal depositions. There is a total series of some 38 individuals from the two sites. The hominid fossil record from Batadomba lena includes the skull and postcranial bones of an adult male between 25 and 30 years of age at time of death (BDL-1), the postcranial bones of an adult female between 35 and 40 years at time of death (BDL-2), and individual skeletal parts and teeth of comingled and isolated specimens representing over 14 other individuals from this cave. Among the mixed specimens is a complete mandible of an adult male (BDL-16-H-30-6), a partial mandible of another adult, probably female (BDL-15-G-7-C-15), and cranial bones of a 4- to 5-year-old child. The Beli lena Kitulgala series includes the skeleton of an adult of uncertain sex, but with several morphological features that suggest it may be female (BLK-1), the skull of a child 10 to 11 years of age at time of death (BLK-2), plus mixed specimens of more than ten individuals. From this total sample, four specimens from Batadomba lena and three specimens from Beli lena Kitulgala are suitable for detailed morphometric and comparative analysis. With respect to the total series, Batadomba lena has four males, two females, and two individuals of uncertain sex of which there are six adults, one child, and one individual of uncertain age. Beli lena Kitulgala has one male, two females, and three individuals of uncertain sex of which there are four adults, one juvenile, and one child (Table 3).

There are 28 permanent teeth from Batadomba lena of which 17 are suitable for mea-

TABLE 2. Teeth available for morphometric analysis

Site/specimen number	Total teeth present (n = 82)		Measurable teeth (n = 55)	
	Maxillary	Mandibular	Maxillary	Mandibular
Batadomba lena				
BDL-1	13	8	8	5
BDL-16-H-30		7		4
Beli lena Kitulgala				
BLK-2	7	6	7	6
BLK-78/79-X-H	21	13	8	10
BLK-78/79-2E-15	1		1	
BLK-78/79-2-B-X-H	1		1	
BLK-78/79-1-A-X-H	1		1	
BLK-78/79-3-B-X-H	1		1	
BLK-78/79-i-C-X-H	1		1	
BLK-78/79-i-C-X	1		1	
BLK-78/79-3-A-7		1		1
Total	47	35	29	26
	82		55	

TABLE 3. Cranial and postcranial bones for morphometric analysis[1]

	Batadomba lena specimen No.			Beli lena Kitulgala specimen No.		
	1	2	Mixed	1	2	Mixed
Calvaria						
Frontal	+	–	–	+	+	+
Parietal	R	–	R	L	RL	RL
Occipital	+	–	–	+	+	–
Temporal	RL	–	–	L	RL	R
Sphenoid	–	–	–	R	RL	–
Face						
Maxilla	RL	–	–	R	L	R
Zygoma	L	–	–	–	RL	–
Nasal	RL	–	–	–	RL	–
Mandible						
Corpus	RL	–	RL(2)	–	R	R
Ramus	RL	–	RL(2)	L	R	R
Thorax						
Vertebra				18 frags		
Cervical	–	3	–	–	–	1
Thoracic	–	10	–	1	–	–
Rib	RL	3	R	R1	–	–
Upper extremity						
Clavicle	L	R	RL	–	–	–
Scapula	RL	RL	–	L	–	–
Humerus	RL	L	L	–	–	–
Radius	L	L	L	L	–	L(2)
Ulna	RL	L	–	L	–	–
Carpal	–	L6	L	R4;L1	–	–
Metacarpal	L4	R2;L6	–	R3	–	–
Phalanx	L2	R5;L4	–	R14	–	–
Lower extremity						
Femur	L	–	–	–	–	–
Tibia	RL	R	RL	–	–	–
Fibula	–	–	L	R	–	–
Patella	L	–	–	–	–	–
Tarsal	R7;L6	–	–	–	–	RL
Metatarsal	R5;L5	–	–	–	–	–
Phalanx	R2;L5	–	–	–	–	–
Pelvis						
Ilium	–	–	–	R	–	–

[1] +, Presence of bone; R, right side; L, left side; numeral, number of bones; –, absence of bones.

surement. There are 52 permanent teeth and one deciduous tooth from Beli lena Kitulgala of which 38 are suitable for measurement. This is a total of 55 measurable teeth from a total sample of 82 teeth from both sites (Tables 1 and 2). There are only four other deciduous teeth in the sample, all severely damaged and only one suitable for morphometric analysis. However, bones and crowns of unerupted teeth, mainly molars, of infants and subadults appear in both localities.

METHODS AND ANALYSIS

There are six phases of the laboratory study conducted at Cornell University: 1) mensural and morphological description of all bones and teeth with attention to age and sex determinations, reconstruction of statures from measurements of long bone lengths, identification of pathological conditions and anomalies, examination for evidence of trauma and markers of occupational stress, and a general description of the total morphological pattern of the two skeletal series; 2) comparative morphometric analysis with other prehistoric hominid skeletal specimens from South Asia and from beyond the borders of the Indian subcontinent; 3) reconstruction of crania from casts of original specimens; 4) biochemical and trace element analyses of human skeletal osseous and dental tissues; 5) radiographic analysis of dental specimens; and 6) floral and faunal analysis of organic remains recovered from the immediate soil matrix.

Those skeletal specimens from Batadomba lena and Beli lena Kitulgala which are sufficiently well preserved to allow determinations of age and sex suggest a random pattern

Fig. 2. Right lateral three-quarter view of frontal bone of BDL-1.

Fig. 3. Superior view of cranial vault of BDL-1.

of burial: there is no evidence to indicate preferential interment by age or sex at either cave site. A similar pattern of male and female burial occurs at Bellanbandi Palassa, but all specimens recovered from this open-air site are adults.

Morphometric analysis reveals a pronounced degree of muscular-skeletal robusticity of the cranial and postcranial bones, particularly in males. Skeletal robusticity refers to the presence of prominent markers of muscular attachments on bones and may involve relative increase in bone size, continuous variables that are quantifiable as indices of robusticity for long bones of the skeleton (Martin and Saller, 1957; Brothwell, 1972). In anatomically modern *Homo sapiens*, males tend towards higher degrees of skeletal robusticity than females. However, sexual dimorphism is not obvious in the stature estimates available for a male and female specimen from Batadomba lena, as based upon stature regression formulae for long bone lengths established by Trotter (1970) for American whites. Her standards have been found to be more reliable when applied to ancient and living South Asians than those proposed by other investigators (Fully and Pineau, 1960; Athawale, 1964). Femora and tibiae are incomplete in the series but on the basis of humeral lengths, stature estimates are 1,650 mm for the Batadomba lena adult male (BDL-1) and 1,620 mm for the female from the same site (BDL-2). These stature estimates fall within the range of medium body height for world populations today (Takahashi, 1971). A study of stature measurements of adult male and female Veddahs conducted by Hill (1941:43–46) reports that "approximately half of the Veddahs measured possess a height between 1,550 and 1,650 mm., whilst an additional third have statures below 1,500, but above 1,400; making a total of 83% between 1,400 and 1,650 mm. . . . The tallest Veddahs so far measured do not greatly exceed the average Sinhalese figure. . . . The average stature of Sinhalese males according to the Census of India is 1,625 mm." These values may be compared with estimated statures of males from Sarai Nahar Rai which are from 1,739 to 1,920 mm (Kennedy, 1984a).

Robusticity of cranial architecture is best observed in the better-preserved adult male skull from Batadomba lena (BDL-1) (Figs. 2, 3). The bones of the vault are thick; the maximum frontal thickness is 7.5 mm, and the right parietal eminence thickness is 6.5 mm. These measurements are taken on the left frontal eminence and left parietal eminence. There is pronounced postorbital constriction (minimum frontal breadth is 97 mm), a broad and continuous supraorbital torus, prominent temporal lines, but a relatively shallow nasion depression. The vault is long and narrow with a moderately inclined forehead region and low elevation at vertex. The external occipital protuberance is very large and forms a projection 16-mm wide which extends transversally and parallel to the superior nuchal crest. The angle of descent of the nuchal region is abrupt relative to the curvature of the occiput superior to the external occipital protuberance. The face of BDL-1 exhibits a broad (22 mm) and concave nose, moderately deep palate (19.5 mm at locus of left M1), and prominent alveolar prognathism. The nasal sills are dull, and subnasal grooves are deeply furrowed (Fig. 4). The mandible is of moderate size but extremely robust with prominently everted gonia and well-marked attachments for the pterygoids, sharp mylohyoid crests, and a moderately projecting median mental eminence. There is slight anterior projection of the incisors and canines, and the corpora are thick (13 mm for the right corpus at level of right permanent lower M1) (Fig. 5).

Cranial features of this order of size and robusticity are observed in other male specimens in the series, but BDL-16-H-30-6 from Batadomba lena is represented by a mandible of unusually massive proportions (Fig. 6). The minimum breadth of its right ramus is 39 mm (compared to 36 mm for the right ramus of BDL-1). With its bicondylar breadth of 134.5 mm and bigonial breadth of 107.5 mm, the BDL-16-H-30-6 mandible has dimensions approaching those of the mandibles of Middle Pleistocene hominids from Heidelberg, Germany, and Ternifine, Algeria.

Beli lena Kitulgala offers fewer cranial remains, the best preserved being that of the skull of the child BLK-2 (Fig. 7). The adult skeleton BLK-1 is represented by fragments of the left side of the cranial vault and pieces of right maxilla. The thinness of the dimensions of these bones and their low mensural values, combined with the reduced muscular relief of the postcranial bones, suggest that these belong to a female of gracile skeletal proportions. There is a single mandibular fragment associated with BLK-1. Specimen BLK-KB-78/79-3-A-7 (one of the mixed speci-

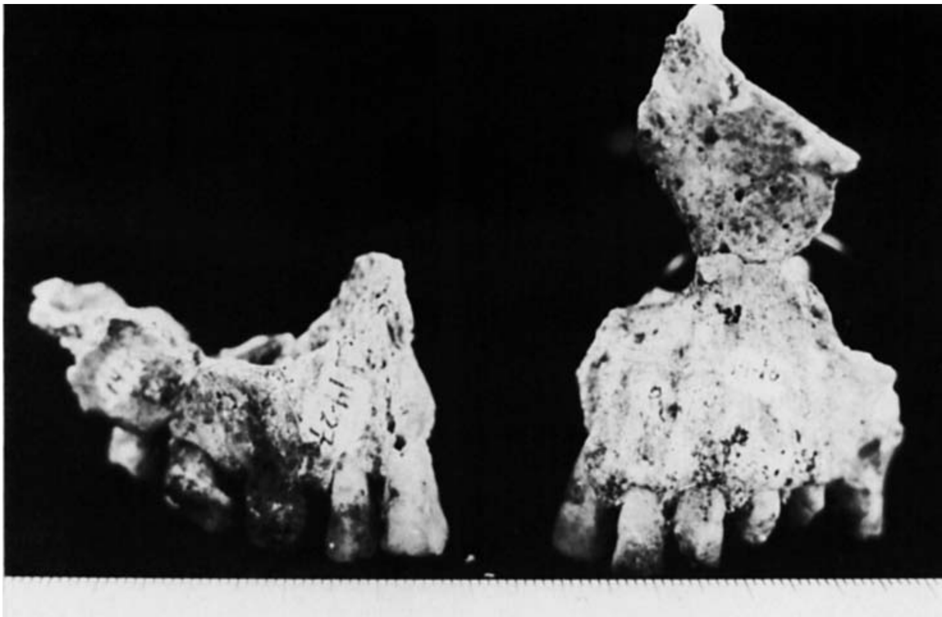

Fig. 4. Anterior view of right and left maxillae with dentition of BDL-1.

Fig. 5. Occlusal view of dentition and mandible of BDL-1.

mens) is the mandible of an adult, and its morphometric features are also very gracile. The recovery of more robust skeletal fragments from Beli lena Kitulgala indicates that male individuals were interred in the cave along with females and subadults. Male femora bear large linea aspera, and male ulnae have deep supinator fossae and prominent supinator crests.

The metric data for the permanent dentition (Table 1) reveal that for molar teeth the mesio-distal diameter of the occlusal surface exceeds in size the bucco-lingual diameter in 59% of the teeth examined. The order of

Fig. 6. Right lateral three-quarter view of mandible of BDL-16-H-30-6.

Fig. 7. Right lateral view of child skull of BLK-2.

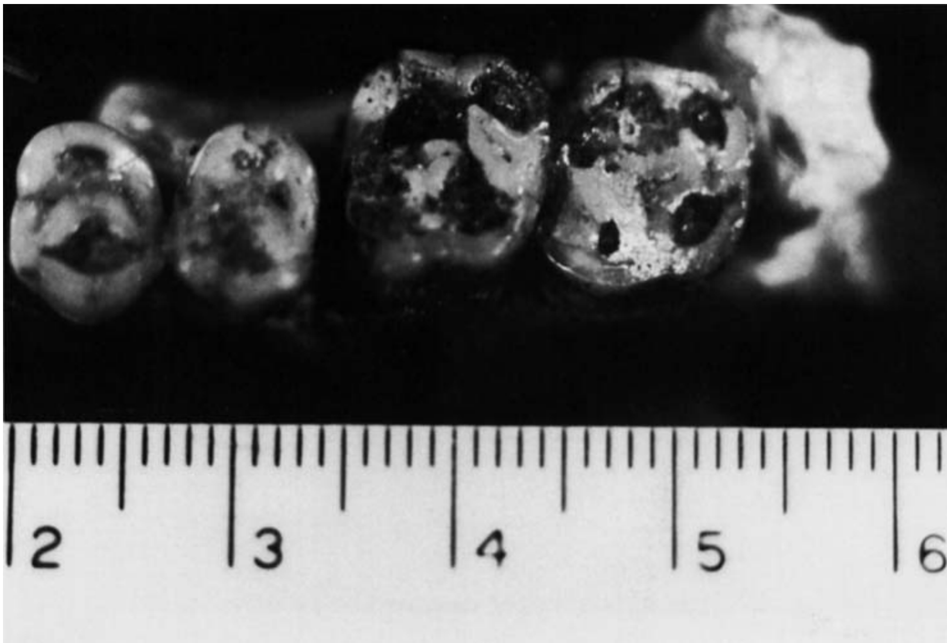

Fig. 8. Occlusal view of dentition of right maxillary fragment of BDL-1.

Fig. 9. Occlusal view of dentition of left maxillary fragment of BLK-2.

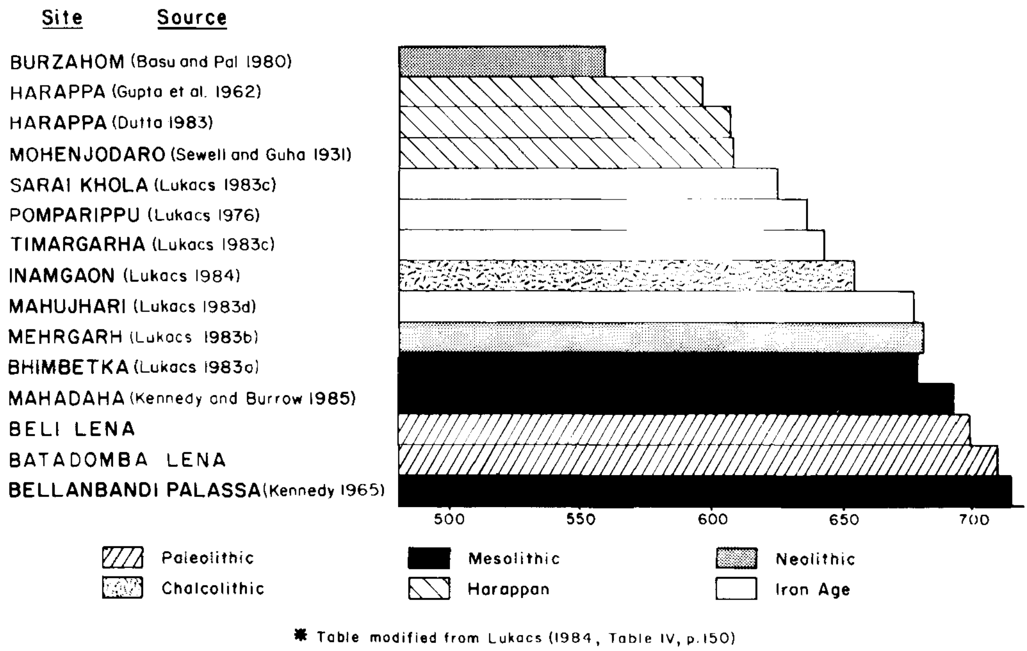

Fig. 10. Summed molar crown area (mm^2).

molar size for molar rows which are preserved from both Sri Lankan series is M1 > M2 > M3. The summed molar crown area is useful in comparative studies of dental series as a measure of size of the grinding portion of the dentition (Wolpoff, 1971) (Fig. 10). Given comparative tooth size data of prehistoric and living Asian and native Australian skeletal series expressed by total molar crown area, which has a range of 845 mm^2 for Murray Basin Australians (Brace, 1980) and 613 mm^2 for Ainu (Brace and Nagai, 1982), the values obtained from Batadomba lena and Beli lena of 711 mm^2 and 700 mm^2, respectively, fall within the size range of medium molar teeth (Lukacs, 1985). Morphological variations and wear patterns of the dentition are the following:

Specimen BDL-1: Permanent teeth present in the alveoli of the left maxilla are the central and lateral incisors, canine, first and second premolars, and first molar; those present in the alveoli of the right maxilla are the first and second premolars and first, second, and third molars. Permanent teeth which are loose include the upper right canine and the upper left third molar. Permanent teeth of the mandibular dentition which are present in the alveoli are the right and left central incisors, right and left lateral incisors, right and left canines, the right second molar, and the root of the left first molar. Broken roots of the lower left molars are preserved. Crowns of the lower right and left lateral incisors are severely damaged. Attrition is most pronounced on the anterior teeth of the maxillary and mandibular dentitions, but the lower right second molar exhibits moderate to severe wear, according to scales proposed by Brothwell (1972). The loose upper left third molar has three cusps and exhibits the least degree of wear of all the teeth of this specimen for which the crowns are preserved. The apices of the three roots of this upper left third molar are fused. The upper right third molar is tricuspid and its three roots are fused. The square occlusal form of the lower right second molar suggests that it had four cusps. The heavily worn canines of the upper and lower dentition have broad occlusal surfaces and single roots. Dentine is exposed on all of these anterior teeth. There are small lingual pits on the upper left first and second incisors. The order of molar size is M1 > M2 > M3.

Specimen BDL-16-H-30: Permanent teeth present in the alveoli of this mandible are the right second molar, right first molar, right second premolar, left second molar, and distal portion of the crown of the left first molar. Radiographs indicate absence of right and left third molars. Eruption and loss of the third molars, followed by resorption of the alveolar regions, appears unlikely given the bilaterality of this feature and absence of any markers of resorptive changes in the areas immediately posterior to the erupted second molars. Broken roots remain in the alveoli of the right first premolar, left canine, and left first premolar. A shell fragment is embedded in the alveolus immediately distal to the right second molar. Attrition is pronounced on the occlusal surfaces of all molar teeth. The right first molar has five cusps in a Y5 groove pattern. The right second molar has a + 4 cusp and groove pattern. Cusp number and groove pattern cannot be observed for the more heavily worn molar teeth. Mesotaurodonty is present in the upper and lower molar teeth, a feature this specimen shares with the child specimen from Beli lena (BLK-2). The occlusal surface of the right second premolar is severely worn, and considerable dentine is exposed. The direction of wear is even across the occlusal surfaces of the molar teeth.

Specimen BLK-2: The permanent lower right second molar appears hyper-erupted since it extends beyond the plane of the occlusal surfaces of the adjacent permanent lower first molar by 3.3 mm. The permanent upper left second molar is recessed by 4.0 mm into its alveolar crypt with respect to the plane of the occlusal surface of its adjacent permanent upper first molar. These deviations of dental alignment are artifacts of preservation. All erupted teeth show minimal wear, but a moderate degree of attrition appears on the permanent lower right second premolar, lower right canine, and upper left canine. Shoveling is pronounced on the lingual surfaces of the permanent upper left central and lateral incisors. Both incisors have thick lingual tubercles marked by enamel striations which are oriented longitudinally over their lingual surfaces. Similar, but longer, striations appear longitudinally over the labial surface of the enamel of these incisors. These lines do not appear to be due to artificial dental deformation nor are they typical enamel hypoplasial lines. The permanent upper right first molar has six cusps, while the other upper molars have four cusps. The lower right second molar has a +4 cusp and groove pattern. The unerupted permanent lower left third molar has a Y5 cusp and groove pattern. The crown of a lower right third molar appears in the matrix with the specimen. Mesotaurodonty is a feature of the erupted lower molar teeth.

Specimen BLK-78/79-X-H: Thirty-four loose teeth, 23 of them broken, appeared together in the cave deposit. All but one tooth is of the permanent dentition. Identifiable within this series are the following teeth: an upper right tricuspid third molar with three fused roots and no evidence of wear on the occlusal surface; an upper right tricuspid third molar with a complete crown and broken roots and no evidence of wear on the occlusal surface; an upper left second molar with a complete crown and with the lingual root broken at its apex and showing severe wear which is most apparent along the distal margin of the occlusal surface; two right lower second molars which are complete and exhibit moderate occlusal wear, both with a +4 cusp and groove pattern and three divergent roots; another lower right second molar which is complete except for damage to the apex of the mesial root, with a +4 cusp and groove pattern and minimal degree of wear of the occlusal surface; an unerupted lower right third molar with a complete crown, broken double roots, and a Y5 cusp and groove pattern; an unerupted lower right second molar with a +4 cusp and groove pattern; an upper right second molar crown with moderate degree of occlusal wear; an unerupted upper left third molar crown which is complete and with a Y5 cusp and groove pattern; a lower right first premolar which is complete, shows moderate to slight wear of the occlusal surface, with a double fused root; a lower right second premolar with complete crown and partial root; an upper right lateral incisor with a complete crown which exhibits a prominent lingual tubercle and broken root; an upper left central incisor with complete crown and broken root which has a prominent lingual tubercle and moderate degree of shoveling; a lower right canine crown with broken root; an upper right canine which is complete and shows severe wear and an abscess at the mesial surface of the cervical junction of the crown and root; a lower left canine with broken root and severe wear of the occlusal surface; a lower right canine which is complete and shows very severe wear of the occlusal surface and a single root deflected distally; an unerupted upper right second premolar without the root; an unerupted lower right first molar with a +4 cusp and groove pattern and two divergent roots; a lower first premolar crown; a deciduous upper right canine crown.

Specimen BLK-78/79-2E-15: Permanent upper right third molar with moderate to pronounced degree of wear of the occlusal surface, four cusps, and three fused roots which are distally oriented.

Specimen BLK-78/79-2-B-X-h: Unerupted permanent upper right first molar with prominent crenulations of the occlusal surface, four cusps, and three fused roots which are divergent.

Specimen BLK-78/79-1-A-X-H: Unerupted crown of a permanent upper right third molar with prominent crenulations, four cusps, and three fused roots.

Specimen BLK-78/79-3-B-X-H: Permanent upper right third molar with slight degree of occlusal wear, three cusps, and three fused roots.

Specimen BLK-78/79-i-C-X-H: Permanent upper right first molar with slight occlusal wear, three cusps, and three fused roots.

Specimen BLK-i-C-X: Permanent upper right second premolar with moderate occlusal wear and a single root which is straight.

Specimen BLK-78/79-3-A-7: Permanent lower right second molar with moderate occlusal wear, a +4 cusp and groove pattern, and three divergent roots.

The degree and pattern of occlusal wear of the teeth from Batadomba lena and Beli lena Kitulgala exhibit the severe stress commonly encountered in prehistoric hunting-foraging populations, the anterior teeth showing greater loss of enamel than the posterior teeth. Shoveling of central and lateral incisors and lingual tubercles are characteristics of many early and contemporary Asiatic populations (Carbonnel, 1963). Dental pathologies, postmortem tooth loss, and supernumerary teeth are essentially absent in the Pleistocene Sri Lankans we have examined, but suppression of the permanent third molars occurs in two specimens. Mesotaurodonty is present in the permanent molar teeth of two individuals in the series.

Postcranial bones are most fully represented at Batadomba lena. Measurements and indices of the postcranial bones from both sites are reported in the detailed study now in press (Kennedy et al., 1986b). Among the striking morphological observations of postcranial material is the right humerus of BDL-1 which has a well-defined intertubercular groove, prominent attachment for deltoideus and eurybrachic proportions. The right ulna of the same specimen exhibits a short, but well-marked supinator crest and robust attachments for brachialis and pronator teres. The fossa inferior to the coronoid process is deep, and the anconeus attachment is marked by a moderate-size crest. These features appear to be markers of occupational stress that may relate to supination and hyperextension of the arm, as in spear-throwing (Kennedy, 1983). This same specimen has robust tibiae with prominent grooves for flexor hallucis longus, as well as a stout and heavily pilastered left femur. The BDL-2 left humerus has a Robusticity Index of 20.06, which is high for standards derived from measurements of European female humeri (Martin and Saller, 1957). The bones of the lower extremity of BDL-2 are limited to a right tibia. Grooves for tibialis posterior and flexor digitorum longus are very prominent on this bone. Other unusual features of this specimen are noted below in a discussion of pathological markers and anomalies. Except for a fragment of right ilium belonging to BLK-1, pelvic bones are not represented in the human remains from either of the two sites.

Pathological markers are few in dental and osseous tissues. There is porotic patching in the glabellar region of BDL-1 and on the ectocranial and endocranial surfaces of the frontal bone of the child specimen BLK-KB-78/79-2-E-15. The latter condition suggests porotic hyperostosis, a stress marker so far reported for only one other pre-Neolithic skull from South Asia. Other pathologies include an osteocartilaginous exostoses of the fourth metacarpal bone of the left hand of BDL-1, osteophytosis of cervical and thoracic vertebrae of the same specimen, and an abscess of a permanent upper right canine tooth of BLK-KB-78/79-X-H. A healed fracture is evident on the distal fragment of a left fibula which may belong to BDL-1. Specimen BDL-2 has osteophytosis of cervical-4 and thoracic-10 vertebrae, and prominent lipping and porosity marks both of these bones. Nonpathological features of this same specimen include prominent robusticity of the right scapula and an extensive radial tuberosity of the left radius. This bone exhibits prominent attachments for the extensor pollicis brevis which is indicative of powerful left thumb activity. Interpretation of this possible occupational marker involving excessive use of the right shoulder and left hand in a female specimen presents an interesting challenge to the skeletal biologist. In the same connection, it is noted that the left ulna has moderate development of the supinator crest, and the attachment for brachialis is deep, rugose, and extensive. The right tibia shows lateral ankle-flexion facets. Neither BLK-1 or BLK-2 specimens have pathological markers on the bones.

RESULTS

The recent recovery and study of hominid fossil remains from Batadomba lena and Beli lena contribute to a clearer understanding of the evolution of Upper Pleistocene *Homo sapiens* in Sri Lanka, the southernmost extension of South Asia, and establishes the place of ancient populations of the Indian subcontinent within the broader framework of later hominid evolution. Results of the present investigation are summarized in the following statements.

1. The antiquity of settlement of Sri Lanka by *Homo sapiens* may now be extended backward in time to the Upper Pleistocene, the skeletal-bearing deposits from Batadomba lena yielding radiocarbon dates of circa 16,000 years B.P., while the archaeological evidence dates the occupation of the cave to circa 28,000 years B.P. These data modify earlier claims concerning the relatively recent (Holocene) migration of human populations to the island (Kennedy, 1981) and support P.E.P. Deraniyagala's (1962) conviction that settlement of Sri Lanka took place during the Pleistocene.

2. The dating of the Beli lena Kitulgala human remains to circa 12,000 years B.P. suggests relative continuity of occupation of the island from terminal Pleistocene times to 6,500 years B.P. when the locality of Bellanbandi Palassa was inhabited by humans whose skeletal remains have been recovered and studied.

3. Morphometric analysis of the human remains from Batadomba lena and Beli lena Kitulgala reveals that a number of the same anatomical variables, as defined by univariate and bivariate measures, are shared by the skeletal series from Bellanbandi Palassa. A certain proportion of these similarities may be attributed to parallelisms arising within the ancient populations as a consequence of similar adaptive responses under the control of natural selection to similar ecological settings, to ontogenetic responses under like socioeconomic conditions, or to random effects. However, it is difficult to account for these striking likenesses of total morphological pattern from these factors alone. Rather, it is proposed that a close biological affinity existed between the Upper Pleistocene and post-Pleistocene populations. This is most successfully demonstrated by numerous shared nonmetric variables, some of which are known to be under genetic control in contemporary populations. Continuity of certain morphometric variables within the indigenous population over a temporal span of some 16,000 years is not surprising, perhaps, given the circumstances of Sri Lanka's relative geographical isolation until the fifth century B.C. when the island was settled by invading people from the Indian mainland. These invaders were the Indo-European-speaking founders of Sinhalese culture which is characterized by rice paddy cultivation, Buddhism, and local kingdoms. Sinhalese settlement did not penetrate all parts of the island with equal intensity, and enclaves of relative isolation in the central and eastern portions of the island continued to be occupied by bands of tribal people well into the early part of the present century.

4. In the 1965 study of the skeletons from Bellanbandi Palassa, it was proposed that the phenotypic pattern most closely resembling that of the series is found among the Veddas, the aboriginal population of the island known within the historic period (Kennedy, 1965). Similarities are not only quantitatively provocative, but striking as well in terms of particular isolated physical features that distinguish both Veddas and the ancient people of Bellanbandi Palassa from other South Asian populations. Given the evidence for a close genetic affinity of the Upper Pleistocene hominids with post-Pleistocene populations from Bellanbandi Palassa, it follows that the Veddas of the historic period and ethnographic present may constitute an end-point in the ancient biological continuum. It must be recognized, of course, that the living remnants of this once more widely dispersed tribal population have undergone some phenotypic modification resulting from contacts with Sinhalese, Tamil, Malay, and other peoples who came to Sri Lanka over the course of the past two and one-half millenia.

5. The medium values for body height derived from long bone lengths of two specimens from Batadomba lena fall within the correlates of South Asian stature variables

and climatic zones observed by Takahaski (1971). He noted that taller statures occur most frequently in the arid zones of the northwestern portion of the Indian subcontinent; shorter statures prevail in the hot, humid, and rainy regions of the southern and eastern tropical belt. This same clinal pattern has been suggested for earlier populations in South Asia on the basis of the prehistoric skeletal record (Kennedy, 1984b). Extremes of stature in terminal and post-Pleistocene times are represented in this part of the world by the tall-statured people of Sarai Nahar Rai and Mahadaha on the Gangetic plain in northern India and the short-statured people of Bellanbandi Palassa in the southernmost reaches of the South Asian landmass. Dietary factors may play a significant role in this stature cline, but the hunting-foraging economic strategy was universal during the Upper Pleistocene of South Asia and continued in parts of peninsular India until the third millenium B.C.

6. The human remains from Batadomba lena and Beli lena Kitulgala find their place within a model of body size and muscular-skeletal robusticity reduction for *Homo sapiens* which Wolpoff (1980) has proposed. Comparisons of the fossil record of anatomically archaic and anatomically modern *Homo sapiens* reveal a trend towards reduction of these features over the past 100,000 years of hominid evolution. This trend appears to have accelerated for those populations making the transition from hunting-foraging to food-producing strategies and is most apparent in populations with long histories of pastoralism or sedentary agriculture within village and urban settings. Natural selection is assumed to be the evolutionary mechanism behind reduction of sexual dimorphism by modification of muscular-skeletal robusticity. Village and urban life with its increased percentage of carbohydrate nutritional resources and decreased access to flesh foods high in protein rendered smaller body size, with consequent reduction of sexual dimorphism, more highly adaptive for survival. With the development of more advanced technologies for procurement of food and its preparation, a cultural buffer was established between the food procurer and nutritional resources. The decrease in sexual dimorphism and muscular-skeletal robusticity, along with decrease in stature, has been documented for prehistoric populations of South Asia (Kennedy, 1984b), and the fossil hominids from Sri Lanka find their place within this trend.

7. These skeletal series from Sri Lanka are relevant to an earlier study of prehistoric crania from South Asia involving principal components analysis (Kennedy et al., 1984). Of the axes and clusters defined in this type of multivariate analysis, one group of specimens included series from Bellanbandi Palassa, the Gangetic sites of Sarai Nahar Rai and Mahadaha, and Langhnaj, a late Mesolithic site in Gujarat. The variables which effected clustering of these series of prehistoric hunter-foragers include the morphometric features of facial architecture, namely external and internal palatal breadths, bifrontal diameter, intraorbital breadth, bizygomatic breadth, and nasion-prosthion height. The distribution of these morphometric characters are in contrast to factors involved in multivariate clustering of food-producing populations of various degrees of technological development which were included in the sample. For these later series, bigonial breadth, maximum cranial breadth, bicondylar breadth, and nasal breadth are the size-shape variables which exert the greatest "pull" away from the average. To these series were added morphometric data of 23 crania from Upper Palaeolithic sites in Europe. These specimens, derived from prehistoric hunting-foraging populations, all fell within the multivariate cluster for South Asian hunter-foragers in this principal components analysis study. It was concluded that the variables which cluster hunter-foragers within the same sample are related to features of facial architecture and size which are, in turn, reflective of robusticity. Reduction of facial size and robusticity is apparent in the series which includes food-producing populations. It will be possible to include the crania and mandibles of Batadomba lena and Beli lena Kitulgala within a principal components analysis when reconstructions are completed. However, the striking similarity of morphometric variables of these specimens to those from Bellanbandi Palassa and other hunting-foraging series of the Indian mainland points to a total morphological pattern that falls within the cluster defining the hunting-foraging group.

8. Reduction of tooth size between early and late prehistoric series in South Asia parallels the trend in body size and muscular-skeletal reduction (Lukacs, 1983b, 1984, 1985). This phenomenon was observed in Eu-

ropean Palaeolithic and Mesolithic series (Frayer, 1978) and in Australasian and Far Eastern populations (Brace and Mahler, 1971). In South Asia, the smallest teeth appear among populations of the northern and northwestern sectors of the subcontinent, becoming larger in the western and central Deccan and largest in southern India and Sri Lanka (Brace and Montagu, 1977). While this clinal pattern relates to living populations, it pertains as well to prehistoric groups. The archaeological record indicates that higher technologies, including those of food procurement and preparation, are of greater antiquity in northern India and Pakistan than in peninsular India and Sri Lanka, as attested by the emergence of the Harappan civilization around 5,000 years B.P. Neolithic deposits at Mehrgarh in Baluchistan appear as early as 8,000 years B.P. It is argued (Brace, 1978) that there has been a trend towards tooth size reduction in those parts of the world where more advanced technologies developed, with a consequent relaxation of selective pressures for possession of large teeth. While large teeth may be highly adaptive for meeting the demands of severe masticatory stress and the use of the mouth as a tool for holding, tearing, and abrading nondigestible materials within the food foraging strategy, teeth were no longer subjected to these demands in societies with more advanced technologies and greater dependence upon a food resource base of farming and pastoral practices. In short, the longer period of time a population has practiced advanced technologies, the smaller are its teeth , and there is a parallel reduction of body size and muscular-skeletal robusticity with the attainment of this level of socioeconomic change. The medium-size teeth of the Upper Pleistocene specimens from Sri Lanka and their nearness in size to teeth of other prehistoric hunting-foraging populations from mainland India (as demonstrated by the comparison of summed molar crown areas) are what might be expected in the light of dental data compared for other parts of South Asia and for sites outside of the subcontinent (Fig. 10).

Similarity of molar tooth size among Palaeolithic and Mesolithic dental series of Sri Lankans may be explained on the basis of parallel hunting-foraging lifeways, food preparation procedures, and technological strategies. The biface core tradition of handaxes and cleavers which characterizes the Lower Palaeolithic Acheulian tool kit of mainland India did not penetrate south of the Cauvery River in Tamilnadu or into Sri Lanka. Nor do the same kinds of borers and scrapers of the Indian Middle Palaeolithic and blade tools of the Indian Upper Palaeolithic appear in Sri Lanka by Upper Pleistocene times. The continuity of flake tools from the Palaeolithic into the Mesolithic in Sri Lanka is a unique feature of the island's prehistory. However, the greater frequencies of geometric and nongeometric microlithic tools of the Sri Lankan Mesolithic testify to technological developments over the period of the Upper Pleistocene to the fifth century B.C. and justify a separation of the Sri Lankan Palaeolithic from the Mesolithic. This archaeological record may have important implications in relating technological factors to tooth size in Sri Lanka. The summed molar crown areas of specimens from Palaeolithic Batadomba lena and Beli lena Kitulgala are not significantly different from values obtained in specimens from Mesolithic Bellanbandi Palassa.

These results are derived from the preliminary analysis of the Upper Pleistocene hominids of Batadomba lena and Beli lena Kitulgala. At the time of this writing, reconstruction of cranial bones of BDL-1 is underway, and casts of the same specimen have been made. Chemical and trace elements analysis of bone specimens will be undertaken in 1987. Multivariate studies can be expanded from the data generated by reconstructed specimens and complete dental records. Officers at the Archaeological Department, Government of Sri Lanka, are preparing for publication the archaeological reports of the two cave sites, and a more detailed study of the human skeletal remains will appear in the volume, *Ancient Ceylon*, now in press (Kennedy et al., 1986a).

DISCUSSION AND CONCLUSIONS

This preliminary report of human remains recently recovered from Batadomba lena and Beli lena Kitulgala in Sri Lanka contains the first description of *Homo sapiens* fossils of the Upper Pleistocene (circa 16,000 and 12,000 years B.P.) found thus far from the southern portion of the Indian subcontinent. The geometric microlithic tools from the basal levels of the cave deposits are associated with radiocarbon dates of circa 28,000 years B.P., the earliest occurrence of this industry in South Asia and evidence of the Pleistocene settlement of Sri Lanka.

Laboratory study of the 38 individuals represented by skeletal and dental remains recovered from the two Sri Lankan caves indicates populations of body height of 1,520–1,650 mm with moderate to pronounced robusticity of cranial and postcranial muscular-skeletal features, very large molar teeth, prognathic alveolar facial proportions, and low incidence of bone and tooth pathologies. The total morphological pattern of these Upper Pleistocene hominids bears similarity to anatomical features encountered in the post-Pleistocene (6,500 years B.P.) skeletal series from Bellanbandi Palassa. The Veddas are an historical and, until this century, ethnographically recognized tribal population in Sri Lanka, sharing a number of morphometric features with prehistoric Sri Lankans from these earlier sites (Kennedy, 1965). This suggests a long-standing biological continuum of hunter-foragers on the island.

Hypotheses to explain reduction of muscular-skeletal robusticity and tooth size have influenced present-day palaeoanthropological interpretations, particularly among those investigators who are uncomfortable with models based upon gene flow and population migration concepts to account for biological affinities between prehistoric and living populations. The venerable practices of "racial palaeontology" were based upon assumptions that biological lines were more homogeneous in the past than is the case today, and that the morphological variables shared by populations separated by time or space were indicative of close genetic ties. This has been a popular model in the earlier biological anthropology of South Asia (Guha, 1935; Sarkar, 1972). The prospect that similar traits in separated populations might arise independently as parallel adaptive responses to like environmental stresses was overshadowed by the conviction that shared characters usually pointed to genetic (racial) affinities. The analysis of these recently recovered fossils from Sri Lanka leads us to favor a different model in an explanation of muscular-skeletal and tooth size reduction of *Homo sapiens* of the later Pleistocene. Furthermore, the present study provides palaeodemographic data suggestive of continuity of settlement of Sri Lanka over the past thirty millenia which bear important implications for understanding the biological history of Sri Lanka's aboriginal hunting-foraging populations.

However the morphometric variables of the Upper Pleistocene Sri Lankans from Batadomba lena and Beli lena Kitulgala are interpreted by future investigators, it is anticipated that this preliminary report will be of interest to our contemporaries awaiting the announcement of these new fossil discoveries from South Asia. Those from the more ancient cave deposits at Batadomba lena are generally contemporary with fossil hominid remains recovered from outside South Asia at the French sites of Cap Blanc, Chancelade, Les Hoteaux, La Madeleine, and Mas d'Azil, from the Chaleux and Goyet caves of Namur in Beligum, and from Oberkassel in Germany. The Beli lena Kitulgala material is generally contemporary with hominid remains from Candide Cave in Italy, Abri Bergy in Lebanon, Taforalt in Morocco, at the Layer D. horizon of the Matjes River site in Cape Province, South Africa, at Hotu Cave in Iran, and at Tepexpan in Mexico. From these and other Upper Pleistocene sites it is possible to define the biological variability and evolution of anatomically modern *Homo sapiens* prior to the onset of physical modifications which accelerate with the transition from hunting-foraging to food-producing socioeconomic strategies.

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