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Quaternary International 192 (2008) 20–42

Large mammal fossil occurrences and associated archaeological evidence in Pleistocene contexts of peninsular India and Sri Lanka

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Available online 24 July 2007

Abstract

The Indian subcontinent represents a rich source of diverse paleoanthropological data in the form of pollen assemblages, various isotopic records, vertebrate and invertebrate fossil assemblages, and prehistoric stone tools in a range of palaeoecological contexts. Most of the Quaternary fossil evidence, including hominin specimens, comes from the fluvial sediments of the Narmada and other similar rivers. Although abundant and well-preserved vertebrate fossil assemblages are known from the Siwalik Hills and Karewa deposits in the north, similar evidence is less well-known from peninsular India and Sri Lanka to the south. With the exception of two occurrences in Gujarat and Bihar, there is an almost complete absence of Neogene fossil evidence older than the Middle Pleistocene in peninsular India and late Middle Pleistocene in Sri Lanka. The richest non-fluvial sources of vertebrate fossils are represented by the Kurnool cave-complex in southern India and numerous cave and open-air deposits in Sri Lanka, the majority of which are Upper Pleistocene age. This unique faunal record of peninsular India and Sri Lanka probably played a critical role in influencing the dispersal, settlement, and subsistence behaviors of Pleistocene hominins. This paper summarizes the known Pleistocene megafauna fossil occurrences from peninsular India and Sri Lanka and includes key lithic associations with these assemblages.

Keywords: Peninsular India; Sri Lanka; Pleistocene; Large mammals; Geographic distribution; Lithic associations

1. Introduction

Bounded by the Himalayas to the north, the Arabian Sea to the west, the Indian Ocean to the south, and the Bay of Bengal to the east, the Indian subcontinent is an important ecological zone to study and understand Pleistocene faunal and human behavioral dynamics within an Asian monsoon context (Korisettar and Rajaguru, 2002; Korisettar and Ramesh, 2002; Petraglia, 2005). Most of the known paleoanthropological evidence comes from a variety of ecological and geographic contexts throughout the subcontinent (Sankalia, 1974; Mishra, 1994; Misra, 1987, 1989, 2001; Dennell, 2004a; Petraglia, 2005; Chauhan, 2006). Most of the vertebrate fossil evidence is restricted to the Siwalik Hills and Karewa deposits in the north and extensive Quaternary fluvial deposits in the peninsular region (Badam, 1979a, 1988; Badam and Sathe, 1995). The Siwalik sediments and associated vertebrate fossils range from the Middle Miocene to the early Middle Pleistocene in age and extend from Myanmar in the east to northern Pakistan in the west (Nanda, 2002; Basu, 2004; de Vos, 2007). This region does not preserve a substantial amount of Middle and Upper Pleistocene sediments, except in the form of uplifted and incomplete fluvial terrace systems that have been affected by erosion and agriculture (Mukerji, 1976). Rather, Middle and Upper Pleistocene sediments and the associated faunal evidence primarily derive from the numerous drainage systems found throughout peninsular India (Gupta, 1995; Badam, 2002). There are two principle geographic corridors for faunal migrations between the Indian subcontinent and the rest of Asia: (a) Afghanistan, Pakistan in the northwest and (b) Myanmar in the northeast (Pilgrim, 1925; also see map in Nanda, this volume). Except for species adapted to cold conditions and high-altitude environments, the Himalayas must have acted as a topographic barrier to and from Central Asia. For instance, there is evidence of faunal migrations from South Asia into other parts of Eurasia

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doi:10.1016/j.quaint.2007.06.034

during the Pleistocene (Martínez-Navarro and Palombo, 2004). In that regard, the faunal record of the Indian subcontinent should provide a crucial biogeographic link between the Eurasian and African evidence to the west and the Asian data to the east.

The aim of this paper is to summarize the known occurrences of large mammalian fossil assemblages in peninsular India and Sri Lanka and briefly list key archaeological occurrences in geological or surface association with this evidence. The principal faunal evidence in peninsular India comes from major river valleys, such as the Narmada, Godavari, Manjra, Son, Ghod, Krishna, and Mahanadi rivers. Many of the sites have also yielded non-mammalian vertebrate specimens (e.g., Patnaik and Sahni, 1994), invertebrate fossils (see Badam, 2002), pollen assemblages, and fossilized wood fragments (e.g., Corvinus, 1971). Since there is still much confusion regarding the chrono-stratigraphic boundary between Middle and Upper Pleistocene sediments in the Narmada Valley and absolute ages for similar formations in other river valleys, no attempt has been made here to chronologically separate or taxonomically organize all listed mammalian species. The Kurnool cave fauna and some other assemblages are known to be exclusively Upper Pleistocene in age. Despite the lack of absolute dates and the ambiguous phylogenetic relationships between extinct and extant species, it is still possible to make some general observations regarding the diversity, number, and geographic distribution of Pleistocene large mammal taxa known to date. This paleontological record has direct implications on our understanding of early human subsistence patterns as well as the subsequent domestication of certain species in the region.

2. History of research and associated problems

Earliest mention of vertebrate fossils was made in the 14th century regarding material in the Siwaliks and then in the early 19th century, H.T. Colebrooke reported fossils from Bengal and others began to notice the fossil richness of the Narmada and Siwalik sediments (Badam, 2002). During the 19th and early 20th centuries, most work was carried out in the Siwalik Hills, primarily due to their fossil richness and the presence of extinct ape species, which were then thought to be ancestral to humans (Lukacs, 1984). In peninsular India, the majority of the work had been done in the Narmada valley (e.g., de Terra and Paterson, 1939). Following Independence, paleontological surveys spread to other parts of the subcontinent and were increasingly focused on locating and identifying vertebrate fossil occurrences and related paleoenvironmental data in relation to Paleolithic assemblages (e.g., Sankalia, 1956; Khatri, 1966; see Badam, 1988). Some of the Indian investigators who have pursued goal-oriented Quaternary palaeontological investigations in India in the last six decades include M.R. Sahni, E. Khan, A. Sahni, K.N. Prasad, C. Tripathi, P.P. Satsangi, A.C. Nanda, B.S. Kotlia, G.L. Badam, R. Vaishist, R. Gaur, P.K. Basu, S. Biswas, D.C. Dassarma, A. Sonakia, U. Chattopadhyaya, V. Sathe, and R. Patnaik. Specifically with respect to Quaternary palaeontological or zooarchaeological investigations in peninsular India, researchers such as K.N. Prasad, G.L. Badam, P.K. Thomas, P.P. Joglekar, U.C. Chattopadhyaya, V. Sathe, and R. Patnaik have contributed to the majority of our current understanding of faunal dynamics in the region (see Thomas and Joglekar, 1994; Chattopadhyaya, 2002). Foreign scientists have also contributed significantly to many of the investigations and interpretations, particularly in the Siwalik region of Pakistan (e.g., de Terra and Paterson, 1939; Hooijer, 1951; de Vos et al., 1987; Hussain et al., 1992; Barry et al., 1995, 2002; Dennell et al., 2005, 2006) and Nepal (Nanda and Corvinus, 1992, 2000; Corvinus and Rimal, 2001) but not as much in peninsular India (excepting the 19th and early 20th centuries).[1] Research on dental histology has been done on younger fossils, particularly bovids (e.g., Sathe, 2000) and basic taphonomic observations have also been made occasionally (e.g., Badam et al., 1986; Badam, 1994; Saunders and Dawson, 1998; Sathe, 2004).

The majority of the paleontological work in peninsular India has been generally descriptive in nature and very little work has been done on such related aspects as comparative taxonomic relationships and stable isotopes. In the past, researchers have utilized these regional faunal records, especially of ungulates, for very basic palaeoenvironmental reconstructions of swamp, pond, lacustrine, riverine gallery forest, grassland and floodplain environments, although these have generally been of low resolution (see Korisettar and Rajaguru, 1998). This approach is obviously not adequate when considering that large rivers have diverse ecosystems throughout their entire course, such as the Narmada which spans 1300 km (e.g., Pandeya et al., 1972). Although there is general evidence of faunal successions occurring at regional levels in these geographic areas, the precise chronological framework remains incomplete. There is currently no cohesive database or a comprehensive source of reference available to paleoanthropologists and vertebrate palaeontologists working in other parts of the Old World. In addition, the diversity and abundance of fauna as known from Plio-Pleistocene contexts such as the Siwaliks and Karewas, is not equally represented in the Quaternary assemblages in peninsular India (Nanda, this volume), possibly owing to survey and taphonomic or preservational bias (Badam, 1988). As a result, the predatory guild during the Pleistocene and its implications on early human scavenging opportunities is not well known in peninsular India. Our most reliable evidence comes from contemporary contexts and the Siwalik record (Dennell et al., in this volume). Despite the abundance of fossil vertebrate sites in the subcontinent, virtually no convincing evidence of hominin modification of any faunal specimens is known. Ultimately, the chronological and

[1]Badam (1979a, 2002) and Badam and Sathe (1995) provide useful historical reviews of palaeontological investigations in South Asia in more detail than is possible here.

geographical dichotomy between the older Siwalik and Karewa deposits to the north, and the younger Quaternary sediments of peninsular India to the south makes it difficult to accurately identify taxonomic or phylogenetic relationships between these two datasets (however, see Nanda, this volume). This is partly due to the poor fossil preservation in the Siwalik Boulder Conglomerate which represents a critical temporal link between the two regions. Collectively, however, both regions offer a continuous faunal sequence from the mid-Miocene to the Holocene period within a geographically bound eco-zone.

3. Eco-geography of peninsular India and associated vertebrate fossil localities

Peninsular India comprises a diverse spectrum of ecological and topographical zones combined with a complex geological history. The north is dominated by the Greater and Lesser Himalaya and the Siwalik Hills-ranges almost geographically parallel and temporally successive to each other. This mountainous terrain includes northern Pakistan, northern India, most parts of Nepal and Bhutan, and is followed by the Indo-Gangetic plains. South of these plains is the great Thar Desert (in eastern Pakistan and northwestern India), and the Aravalli and Vindhyan range of hills. These hills are located north of the Deccan Plateau, a prominent landscape of peninsular India, which includes the Western and Eastern Ghats (ranges of hills). Although most parts of India are recognized as being tropical or sub-tropical (Mohapatra, 1985), such rugged landscapes (the Ghats) are especially prominent along the coasts of peninsular India, south-eastern India (Kerala), and northeastern India or east of Bangladesh. The subcontinent is also interspersed with complex drainage systems and associated ecological and geographic features such as deciduous woodlands, tropical evergreen forests, savanna landscapes, semi-arid and arid scrub lands, arid sand deserts, and periglacial loessic landforms (Korisettar and Rajaguru, 2002); caves, canyons, rockshelters, lakes, pools, and springs are also found in high numbers. With the exception of the Narmada and Tapi Rivers, most rivers flow from east to west and all exhibit unique fluvio-sedimentary regimes (Gupta, 1995). The primary bedrock in peninsular or central part of India is invariably Deccan Trap (basalt) and the Vindhyan Hills (quartzite and sandstone) (Tiwari, 2001). Their presence over such a large area and associated tectonic-erosional processes may have prevented extensive sedimentation during the Plio-Pleistocene, partially reflected by the almost complete absence of such sedimentary exposures in most river valleys and regions between these basins (Rajaguru and Badam, 1976; Tiwari, 2001). For example, from preliminary palaeomagnetic assessments, Agrawal et al. (1988) have surmised that *all* Quaternary sediments in the Narmada valley fall within the Brunhes Chron (however, see Rao et al., 1997 for conflicting interpretations-also mentioned below). Nonetheless, some Early Pleistocene sediments may lie deeply buried in places and be currently unknown. In other cases, where Early Pleistocene ages have been reported for specific sedimentary features in Rajasthan (e.g., Dhir et al., 2004) for example, systematic investigations for fossil or archaeological material have not been carried out. Sediments at Bori that initially yielded Early Pleistocene ages (Rajaguru et al., 1993) were later found to be unreliable and the current age for this site is now thought to be around 670 ka or younger (Mishra, 1995; Mishra et al., 1995) but even this latest assessment requires further corraboration. The only reported Early Pleistocene or Plio-Pleistocene fossil evidence south of the Siwalik Hills is from Piram Island on the east coast of Gujarat in western India (Prasad, 1974) and possibly from Bhagalpur in Bihar from eastern India (Verma et al., 1998). The Piram Island assemblage, however, may be equivalent to the Dhok Pathan fauna from the Siwalik Hills, i.e., late Miocene, and the Bhagalpur fauna is thought to be much younger, i.e., late Middle to Upper Pleistocene in age (A.C. Nanda, pers. comm.). While Tiwari and Bhai (1997) have stated that the oldest Narmada sediments (i.e., the Pilikarar Formation and the lower part of the Dhansi Formation are of Early Pleistocene age [from preliminary palaeomag sampling], Tiwari (2001, p. 631) also includes "Ferricreted pediment cover of Lower Godavari, Wainganga, Hasdo, Mahanadi, and other smaller tributaries…" as being of Early Pleistocene age. However, such occurrences need to be confirmed with rigorous geochronological applications. In any case, strata of both the Dhansi and Pilikarar Formations have not yielded any temporally-diagnostic faunal elements that are comparable to the Upper Siwalik evidence and associated specimens are generally weathered or abraded. The low profile of Plio-Pleistocene sediments in peninsular India also makes it difficult to archaeologically pinpoint the timing of the earliest human colonization of the region if the lithic evidence is deeply buried under alluvium (Singh, 2005), or reburied in younger stratigraphic contexts (Chauhan, 2006). Following the reviews by Badam (1979a, 1988, 2002), the Indian faunal evidence has not been summarised in an international journal. The majority of the faunal information from Sri Lanka and associated descriptions in this paper come from Deraniyagala (1992) and Kennedy (2000). The most significant faunal occurrences are outlined below from north to south and additional minor localities are discussed collectively (see Fig. 1 and Table 1).[2]

[2]This summary is *not* exhaustive and much of the evidence has been obtained from previous syntheses (e.g., Badam, 1979a, b, 1988, 2002; Sahu, 1988; Badam and Sathe, 1995; also see reference list in Nanda, this volume). Badam (1979b) provides a useful table (p. 318) illustrating the extensive taxonomic nomenclature used by different workers on Narmada vertebrate assemblages. For the sake of avoiding confusion regarding species distinction, *all* published taxa have been used in Table 1 of this article, rather than attempting to rectify and organize the taxonomic nomenclature at this stage. However, there are discrepancies in the published literature between the interpretations of different taxa, and many of these need to be re-assessed and possibly re-classified (A.C. Nanda, pers. comm.; de Vos, 2007).

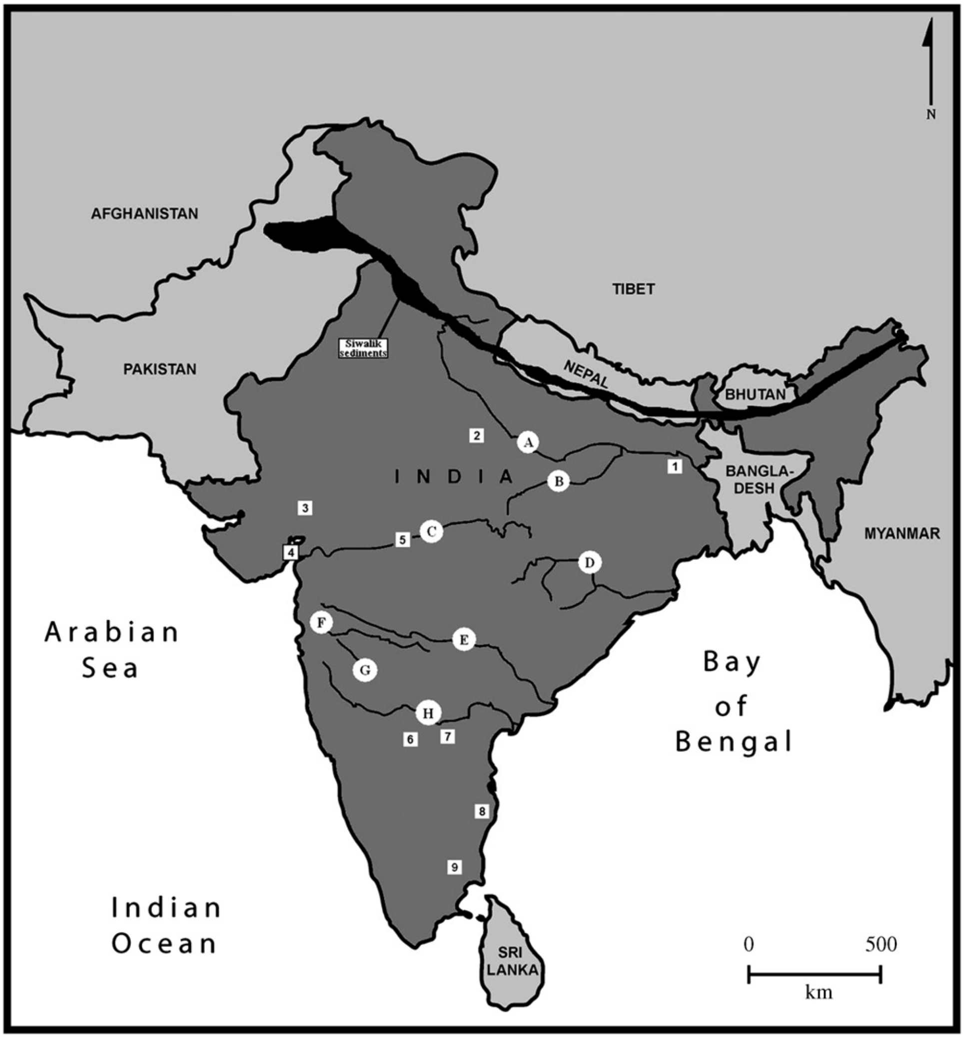

Fig. 1. Pleistocene vertebrate fossil sources in peninsular India (The letters represent river valleys and the numbers represent select localities/find-spots). A: Ganga; B: Son; C: Narmada; D: Mahanadi; E: Godavari; F: Manjra; G: Ghod; H: Krishna; 1: Bhagalpur; 2: Kalpi; 3: Tajpur; 4: Piram Island; 5: Hathnora; 6: Nittur; 7: Kurnool caves; 8: Attirampakkam; 9: Maruvattoor. *Note*: Additional minor sites are not shown on this map but are discussed or mentioned in the text.

3.1. Ganga valley

The Ganga River originates in the Garhwal region of the Himalaya and descends onto the plains at Rishikesh. It comprises two headstreams, the Alaknanda and Bhagirathi and flows for over 2500 km, with a total drainage area of over 860,000 km^2 (Siddharatha, 1999). The sediments of the Indo-Gangetic plains have been divided into ‘Older’ and ‘Younger’ alluvial units, and little fossil evidence is known from this entire geographic region. Few fossil localities have been reported from this basin although adjoining tributaries have yielded more material. Chakravarty (1931, 1935, 1938) reported *Stegodon insignis* and *Palaeoloxodon namadicus* near Varanasi and Allahabad in the 1930s and in 1968, Khan reported a complete skull of *Elephas antiquus* from the lower or older strata of the Ganga alluvium, near Gurgaon in Haryana.

One of its tributaries, the Son, is discussed separately below; however, the nearby Belan and Seoti valleys, both originating in the Vindhyan plateau have also yielded *Equus* sp., *Equus onager khur*, *Bos* sp., *Bubalus* sp., *Gazella* sp., *Antilope* sp., *Cervus* sp., and *Elephas* sp., mostly in conglomeratic or gravel contexts; Dassarma also mentions the occurrence of *Tetraprotodon* from the same region (see Badam, 1979a). Most recently, Tewari et al. (2002) have reported a Middle Paleolithic site at Kalpi in the Gangetic Plain, with lithic artifacts in association with cut-marked bones and bone tools. This is a significant discovery as such evidence is extremely rare in South Asia. The site was dated to about 45 ka, using Infrared Stimulated Luminescence (IRSL), and some of the associated fauna include *Elephas*, *Equus*, and bovids including *Bos*. In the past (since the 19th century), hippopotamus, camel, *Stegodon* sp., *Stegodon insignis*, and *Palaeoloxodon namadicus* have also been reported from this region (see Verma et al., 1998). Sahni

Table 1
List of large mammal vertebrates from peninsular India. (Compiled from: Badam, 1979a, 1988; Murty 1985; Badam and Sathe 1995; Sahu, 1988; Biswas, 1997; Prasad 1996; Raju and Venkatasubbaiah, 2001)

	Ganga	Son	Parvati	Narmada	Mahanadi	Godavari	Manjra	Ghod	Krishna	Sagileru	Kurnool Caves	Northeast India	West Bengal	Tamil Nadu	Gujarat	Total occurances
Primates																
Homo erectus/archaic H. sapiens				+												1
Presbytis entellus											+					1
Semnopithcus entellus											+					1
Cynocephalus sp.											+					1
Papio sp.											+					1
CARNIVORA																
Ursus namadicus				+												1
Ursus footei											+					1
Ursus labiatus											+					1
Ursus sp.				+							+					2
Melursus sp.											+					1
Panthera tigris											+					1
Panthera sp.		+											+			2
Felis tigris/leo											+					1
Felis chaus											+					1
Felis rubiginosa											+					1
Felis sp.		+									+					2
Viverra karnuliensis											+					1
Crocuta cf. *sivalensis*													+			1
Hyaena crocuta		+									+					2
Canis sp.		+						+			+					3
Cuon alpinus tripathii			+													1
PERISSODACTYLA																
Rhinoceros karnuliensis											+					1
Rhinoceros (cf.) *unicornis*		+		+		+										3
Rhinoceros deccanensis							+									1
Rhinoceros sp.	+	+														2
Equus namadicus		+		+	+	+	+	+	+				+	+		9
Equus caballus				+	+											2
Equus hemionus		+														1
Equus hemionus khur				+												1
Equus onager khur	+															1
Equus asinus					+			+	+		+				+	+5
Equus sp.	+	+				+		+		+	+			+		7
PROBOSCIDEA																
Elephas namadicus/maximus				+		+	+	+				+				5
Elephas hysudricus				+		+	+	+				+				5
Elephas antiquus	+				+											2
Elephas indicus		+														1
Elephas sp.	+	+				+		+	+							5
Stegodon namadicus				+												1
Stegodon ganesa				+			+									2
Stegodon insignis	+			+		+	+									4
Stegodon sp.	+															1
Palaeoloxodon namadicus	+			+		+							+			4
Hypselephas hysudricus														+		1
ARTIODACTYLA																

Tetraprotodon palaeindicus	+															1
Hexaprotodon/Hippopotamus namadicus				+		+										2
Hippopotamus palaeindicus		+		+		+										3
Hexaprotodon palaeindicus				+			+	+								3
Hexaprotodon sivalensis				+												1
Hippopotamus sp.		+														1
Bubalus bubalis			+	+	+	+										4
Bubalus palaeindicus			+		+	+							+			4
Bubalus maruvattoorensis														+		1
Bubalus sp.	+	+						+	+					?		4
Bos namadicus		+		+	+	+	+	+	+				+			8
Bos/Bibos cf. *gaurus*		+		+												2
Bos planifrons				+												1
Bos taurus									+							1
Bos indicus		+			+											2
Bos sp.	+				+	+			+	+	+		+	+		8
Leptobos sp. (*Bos namadicus*)				+				+								2
indeterminate bovid			+													1
Boselaphus tragocamelus		+									+					2
Boselaphus namadicus													+			1
Boselaphus sp.				+					+					+		3
Cervus duvauceli		+		+		+	+						+			5
Cervus aristotelis											+					1
Cervus axis											+					1
Cervus unicolor		+					+	+			+		+			5
Cervulus muntijac?											+					1
Cervus sp.	+	+		+	+	+			+	+						7
Antilope cervicapra		+		+			+			+	+		+			6
Antilope sp.	+			+												2
Axis axis		+					+				+		+			4
Axis porcinus		+														1
Tragulus cf. *meminna)*											+					1
Ruminanta sp.		+														1
Muntiacus muntjak		+									+		+			3
Tetracerus quadricornis		+									+					2
Gazella sp.	+															1
Gazella benneti											+					1
Gazella gazella		+									+					2
Ovis/Capra		+			+						+			?		3
Sus scrofa cristatus											+		+			2
Sus karnuliensis											+					1
Sus namadicus				+												1
Sus palaeindicus								+								1
Sus sp.		+		+			+						+			4
Total Taxa	14	30	4	29	11	16	13	13	9	4	35	2	15	6	1	

Note: All taxa listed do not represent individual species. For example, *E. insignis* and *E. ganesa* are now recognized a single species, as are *E. hysudricusa* and *H. hysudricus*; and are *E. namadicus, E. antiquus, and P. namadicus* . Fossils of *Homo sapiens* have been recovered from several localities throughout the subcontinent.

and Mitra (1980) also include *Rhinoceros* as a part of the Ganga alluvium fauna. For more possible Early Pleistocene fossil occurrences on the Gangetic plains at Bhagalpur in Bihar see Tewari et al. (2002).

3.2. Son valley

The Son River originates near Amarkantak (as does the Narmada) and flows northeasterly for more than 500 km, through the Vindhyan plateau and the Kaimur hills, prior to converging with the Ganga River (Siddharatha, 1999). The sediments in the Middle Son valley, where most of the palaeoanthropological work has been carried out, consist of four key formations (from oldest to youngest): Sihawal, Patpara, Baghor, and Khetaunhi (Williams and Royce, 1982). The principal palaeontological work is represented by the preliminary assessment of Blumenschine and Chattopadhyaya (1983) as a part of the multidisciplinary project directed by Sharma and Clark (1983) in the Middle Son Valley. They essentially describe evidence from seven principal localities as being the most fossiliferous: Kharabara (Son Locality 45), Ramnagar (40), Baghor (5), Tariha Dhaba (53), Odara (34), Baliar (19), and Pawariah (18). The fossils studied by Blumenschine and Chattopadhyaya (1983) account for 30% of the entire assemblage which was sorted at the time. Currently 75% of all collected specimens have not been identified, partly due to the adherence of calcareous matrix on many of the specimens. Nonetheless, all specimens are estimated to be of terminal Pleistocene age and were collected within or on exposures of the coarse member of the Baghor Formation between the sites of Baghor and Patpara. The fauna is thought to be consistent with the geological evidence for arid conditions during the terminal Pleistocene glacial maximum, which supported mosaic vegetation with grasslands occurring probably over much of the floodplain and woodland (Blumenschine and Chattopadhyaya, 1983). Arid conditions during this time-period elsewhere in India is supported by the presence of ostrich eggshell fossils (*Struthio* sp.) throughout the subcontinent (Badam, 2005).

Later, Badam et al. (1989) reasserted that some fossil localities are known from the Khetaunhi Formation but none are known from the Sihawal Formation. Some of the reported localities include Ramdiha, Doraon, Kunjhar, Baghor, and Khunteli. Badam et al. (1989) agree with Blumenschine and Chattopadhyaya (1983) regarding the general palaeoenvironmental description of the region and further support the possible existence of swamps-basically similar environments as in the Belan, Mahanadi, and Narmada valleys. The large mammals from the Baghor Formation comprise *Bos namadicus*, *Bos*/*Bibos gaurus*, *Bubalus* sp., *Antilope cervicapra*, *Boselaphus tragocamelus*, *Tetraceros quadricornis*, *Gazella gazella*, *Axis axis*, *Cervus unicolor*, *Cervus duvauceli*, *Muntiacus muntjak*, *Sus* sp., *Hippopotamus* sp., *Rhinoceros* sp. *Equus namadicus*, *Equus asinus*/*hemionus*, *Elephas* sp., *Panthera* sp. and some other carnivores (Badam, 2002); the interface between the Baghor and Patpara Formations has yielded fossils of *Bos namadicus*, *Bos gaurus* (later changed to *Bibos gaurus*, see below), *Hippopotamus* sp., *Equus* sp., *Cervus* sp., and *Axis axis*/*porcinus* (Badam et al., 1989). In addition, Sahu (1988) also mentions the presence of *Elephas indicus*, *Hippopotamus palaeoindicus*, *Bos* sp., *Bubalus* sp., *Cervus*, and *Ovidae*/*Capridae*, from the Belan and Son valleys, all belonging to the Upper Pleistocene.

Fig. 2. The site of Hathnora. The hominid fossils come from the conglomerate.

3.3. Narmada valley

The Narmada River originates at Amarkantak in central India and flows west almost 1300 km through the Vindhyan hills before draining into the Gulf of Cambay (Siddharatha, 1999). The valley represents the best-known Pleistocene fluvial sequence in the Deccan region of central and peninsular India. It is also known for being the richest source of Pleistocene vertebrate fossils in peninsular India (see Badam and Salahuddin, 1982; Biswas, 1997) and has also yielded a *Homo* cranium currently attributed to *H. erectus*, *H. heidelbergensis*, or archaic *H. sapiens* by various researchers (Salahuddin et al., 1987–88; Kennedy et al., 1991; Kennedy, 1999; Rightmire, 2001; Cameron et al., 2004; Athreya, 2006) and possible post-cranial material as well (Sankhyan, 1997, 2005) from the Surajkund Formation at Hathnora (Fig. 2) (Sonakia, 1984; Khan and Sonakia, 1992; Sonakia and Biswas, 1998).[3] The *Homo* cranium yielded a fluorine/phosphate ratio of 7.53, suggesting a date of the late Middle Pleistocene (Badam, 2002), and allegedly consistent with a generally Middle Pleistocene fauna from the same horizon (Sonakia, 1984; Badam, 1989; Sonakia and Biswas, 1998). Although these faunal specimens have been used to interpret the palaeoenvironment during deposition of the hominin-yielding stratum, the deposits comprise

[3]Theobald reported a human fossil which was later reported as lost in the Asiatic Society in Kolkota (Kennedy, 2000).

calcretized gravels, interbedded with sand and clay horizons. This indicates that much of the material, including the hominin fossils, Paleolithic artifacts, and the vertebrate fauna within the Hathnora conglomerate horizon have been fluvially reworked to some extent (see Cameron et al., 2004) and cannot be used to correlate or interpret this evidence without absolute dates (Patnaik et al., n.d.; see Salahuddin 1986–87 for discussion of a Late Acheulian association at the site). Consequently, the faunal assemblages from such deposits currently remain unreliable for reconstructing past habitats and/or vertebrate community guilds at those locations and for the time periods represented (de Vos, 2007). The author and his colleagues are currently working towards re-dating and refining the stratigraphy at Hathnora, the results of which may have implications on the phylogenetic interpretations of the hominin cranium (Chauhan et al., 2006).

Theobold (1860) was the first to undertake a systematic study in the Narmada Basin and divided the main Narmada sediments into Lower and Upper Groups, which also separated the fauna that was found within both 'Groups' (Badam and Sathe, 1995). Subsequently, numerous attempts (see Joshi et al., 1978) were made at organizing additional formations and comparing them with Siwalik stratigraphy, particularly the Boulder Conglomerate Formation of the Upper Siwalik Subgroup. Since Theobold's observations, over a dozen investigators have worked in the region at one time or another, including the Geological Survey and the Anthropological Survey of India (see Khatri, 1966; Badam, 1979b). De Terra and Paterson (1939) and Badam (see list of references) worked between Hoshangabad and Narsinghpur. Sen and Ghosh (1963) investigated sections between Amarkantak and Hoshangabad and Khatri (1961, 1966) made numerous vertebrate fossil collections at various places in the central Narmada.[4] G.E. Pilgrim was the first investigator to compare the Godavari and Narmada assemblages and compile a complete list of the Pleistocene vertebrate fauna known at the time (Badam, 1988). W. Theobold's faunal zones have persisted in the vertebrate assemblages of central India and the palaeoecological contexts of early humans in India (e.g., Khatri, 1961; Badam, 1979a, b; Misra, 1987, 1997, 2001; Salahuddin, 1987–88; Sahu, 1988; Misra et al., 1990; Biswas, 1997; Agrawal and Kharakwal, 2002). The two faunal zones, the Upper and Lower Groups represent parts of the Boulder Conglomerate and younger sandy-pebbly gravels, silts, and sands above it (Badam, 1979b; Badam and Salahuddin, 1982).[5] The 'Lower Narmada' group (Middle Pleistocene) is thought to yield *Equus namadicus*, *Bos namadicus*, *Bubalus palaeindicus*, *Hexaprotodon namadicus*, *Sus namadicus*, *Elephas hysudricus*, and *Stegodon insignis-ganesa*; the 'Upper Group' (early Upper Pleistocene) is thought to yield *Equus namadicus*, *Bos namadicus*, *Hexaprotodon palaeindicus*, *Elephas hysudricus*, *Stegodon insignis-ganesa* (Joshi et al., 1978), *Cervus* sp., *Cervus duvauceli*, and *Rhinoceros unicornis* (Sahu, 1988). Salahuddin (1987–88) carried out a detailed comparison of various *Hexaprotodon*/*Hippopotamus* specimens known at that time. Essentially, he concluded that "...both *H. palaeindicus* and *H. namadicus* are synonym of each other" (ibid., p. 18) and that differences in both were due to sexual dimorphism and should now be referred to as a single species—*H. palaeindicus namadicus*; Matthew (1929, p. 555) also doubted the generic distinctiveness of *Hexaprotodon*. In addition to the aforementioned fossils, Badam and Grigson (1990) also report the first definitive occurrence of *Bibos gaurus* from the Upper Pleistocene Narmada sediments, a species that was originally identified as *Bos gaurus*. Badam (1988) also reports *Antilope cervicapra* from the Narmada valley.

Badam (1988) is of the opinion that *Elephas maximus*, *Cervus duvauceli*, *Rhinoceros unicornis* are not found in the older part of the Narmada sediments (Middle Pleistocene) but are present only in the Upper Pleistocene of the Narmada and other Deccan fluvial systems. Although Sen and Ghosh (1963) have also argued that there are two faunal zones within the Boulder Conglomerate, Khatri did not observe any faunal changes between the two units from his work in the 1960s and 1970s (Badam, 1979a). Supekar (1985) later recovered fossils of *Elephas hysudricus*, *Bubalus bubalis* and *Equus caballus* from the same general region as Khatri's area (in the vicinity of Mahadeo-Piparia). Dassarma and Biswas (1978) collected the first-known *Hexaprotodon sivalensis* specimen from 'Lower Alluvium' and *Hexaprotodon namadicus* (slightly advanced) from 'Upper Alluvium' as well as *Hippopotamus palaeindicus* (Badam, 1979b).

Recent geological work has resulted in the recognition of seven primary Formations in the central part of the Narmada basin (Pilikarar, Dhansi, Surajkund, Baneta, Hirdepur, Baurus, Ramnagar), the most fossiliferous deposits belong to the Surajkund and Baneta Formations (see Tiwari and Bhai, 1997; Tiwari, 2001). Based on the work of Khatri (1966), vertebrate fossils seem to occur in various types of sedimentary matrix (Fig. 3) throughout the entire central part of the Narmada Basin. From

[4] Khatri's collections are currently housed at the Indraprastha Museumof the Indian Archaeological Society in New Delhi and are soon to be published as a museum catalog (V. Sathe: personal communication).

[5] The 'Boulder Conglomerate' facies from the central Narmada valley is *not* related to the Boulder Conglomerate Formation of the Upper Siwalik subgroup in the Siwalik Hills to the north. The latter is a proper stratigraphic Formation while the Narmada 'Boulder Conglomerate' does not appear to be one (de Terra and Paterson, 1939; Patnaik et al., n.d.). The comparisons of both Boulder Conglomerate units were all the more ambiguous when considering that the Narmada version has constantly yielded vertebrate fossils (including hominin) while the Siwalik counterpart rarely yields fossils. The most important point is that while the Siwalik Boulder Conglomerate Formation contains occasional boulders, its geological counterpart in the Narmada valley hardly contains any boulders *sensu stricto*. The majority of the clastic material in such fluvial strata in the Indian peninsular valleys is invariably pebbles and cobbles; boulders are more common in fan contexts.

Fig. 3. A long-bone fossil encased in calcareous matrix of the Surajkund Formation near Hathnora.

radiocarbon and fission track applications and associated geochemistry and geomorphological observations, Tiwari (2001) states that the Pilikarar Formation is of Early Pleistocene age, the Dhansi Formation is of Middle to Early Pleistocene age, the Surakjund Formation is of Middle Pleistocene age, the Hirdepur (25–13 ka) and Baneta Formations are of Upper Pleistocene age, the Baraus Formation is early Holocene, and that the Ramnagar Formation is younger than 4.5 ka. The Ramnagar Formation has been known to yield occasional fragmentary and sub-fossilized or unfossilized bones of extinct mammalian species. Most of the archaeological and palaeontological investigations have taken place in the central part of the basin, from where a large number of Pleistocene taxa are known. Resulting collections are restricted to either Middle or Upper Pleistocene deposits; absolute dates for many of the stratified specimens are currently lacking and the majority of collections were made from surface contexts (e.g., Khatri, 1966). A systematic study of Holocene fossils from this basin has yet to be undertaken and would help considerably in understanding the phylogenetic link between the Pleistocene and modern-day mammalian species including the domesticated breeds (see Thomas and Joglekar, 1994). Some of the more well-known fossil localities include Hoshangabad, Devakachar, Mahadeo-Piparia, Hathnora, and numerous sections along the tributaries of the Narmada (e.g., Sher) among numerous others (e.g., Joshi et al., 1978).

Fragmentary fossils of *Elephas*/*Stegodon* and *Hippopotamus* have been reported by the Geological Survey of India (Udhoji and Tiwari, 1997) from the possible Early Pleistocene deposits of the Dhansi Formation. However, the author and his colleagues observed only a single highly-weathered herbivore tooth from this section over the course of three field seasons. As discussed earlier, one explanation for the low-density of fossil material from this time period may be due to the limited exposure of appropriate sediments. In sum, the Quaternary faunal composition of the Narmada valley needs to be re-assessed in the context of a more robust geochronological framework and with a thrust on behavioral association with Paleolithic stone tools.

3.4. Mahanadi valley

The Mahanadi River originates near Pharsia village in the Raipur District in Chattisgarh flowing for almost 900 km before emptying into the Bay of Bengal in eastern India; its total drainage area is over 140,000 km^2 and comprises at least seven major tributaries (Siddharatha, 1999). Little work has been done in this valley compared to other regions of peninsular India and the vertebrate fauna recovered here includes *Bos* sp., *B. namadicus*, *B. indicus, Bubalus bubalis*, possibly *Cervus* sp., and *Equus namadicus*, *Equus caballus, Equus asinus*, and *Ovis*/*Capra* from Nandghat, Simga, Somnath, and Rajnandgaon (Badam, 1979a; Joshi et al., 1980). With the exception of the last locality, all fossiliferous sites have also yielded Middle Paleolithic artifacts (Joshi et al., 1980).

3.5. Godavari valley

The Godavari River is the largest in the southern zone of central India- it originates in the western *Ghats* at Trimbek in Nasik District of Maharashtra, and flows for over 1400 km to the east and southeast and into the Bay of Bengal (Siddharatha, 1999). The valley environments are generally flat floodplains on Deccan Traps apart from deep gorges near the sea. Over ten tributaries contribute to the Godavari, and the entire river is bounded by the Balaghat range and Ajanta hills. In respect to archaeological and palaeontological investigations, only the central Godavari has been properly investigated. Mega-vertebrate fossils have been recovered from the main Godavari as well as some of its tributaries, often with stone artifacts. Badam (1979a, p. 195, 1981) lists some known sites and associated fauna: Godavari valley: *Bos namadicus* at Gangapur, *Bos* sp. at Nandur and Paithan; Pravara valley: *Bos namadicus* at Chirki, *Elephas*, *Equus*, and *Bos* at Hathiwell; Mula valley: *Bos namadicus*, *Bubalus bubalis*, and *Elephas* (tusk) in two trenches at Mula dam; and Purna valley: *Bos namadicus*, *Elephas hysudricus*, *Stegodon insignis*, and *Elephas* sp. at Yeldari dam. Additional fossil material from the same region includes *Elephas namadicus* (a tusk) near Paithan; *Elephas antiquus*, *Hippopotamus palaeoindicus*, and *Equus namadicus* in the Painganga valley; *Bos* sp. in the Karimnagar District by Badam and Jain (1988); (also see Pilgrim, 1905); and *Bos namadicus*, *Bubalus palaeindicus*, *Equus namadicus*, *Hexaprotodon namadicus*, *Cervus* sp., *Palaeoloxodon namadicus*, and *Stegodon insignis* by Tripathi (Badam, 1979a). In addition to those taxa, Sahu (1988) also records *Elephas maximus* and *Rhinoceros unicornis* from the Godavari sediments.

3.6. Manjra valley

The Manjra River is a tributary of the Godavari, flowing for almost 500 km almost parallel to it, originating at Jamkhed Hill near Gaurwadi village in central Maharashtra (Joshi et al., 1981; Badam et al., 1984). The first palaeontological and archaeological survey in this valley was carried out in 1976–77 by Joshi and colleagues (1981). Different parts of the valley have yielded Mesolithic assemblages and the lower reaches have yielded Middle Paleolithic artifacts. Interestingly, the upper and middle reaches have not yielded any lithic evidence (Sathe, 1989). In respect to Pleistocene faunal assemblages, the sites of Dhanegaon, Wangdari, Tadula, and Ganjur have yielded only fragmentary remains of *Elephas maximus*, *Elephas hysudricus*, *Stegodon insignis-ganesa*, *Cervus duvauceli*, *Cervus unicolor*, *Axis axis*, *Antilope cervicapra*, *Equus namadicus*, *Bos namadicus*, *Bubalus palaeindicus*, *Sus* sp., and *Hexaprotodon palaeindicus* and some of these assemblages have been compared to similar material from the Narmada and Godavari dated to between 27 ka to ca. 40 ka (V. Sathe: pers. Comm.). In the valley, Badam et al. (1984) recognize *Hippopotamus* sp. instead of *Hexaprotodon* and also list *Bubalus bubalis* as occurring in the Manjra valley; the latter identification along with *Sus* sp. are in need of a re-assessment (V. Sathe, pers. com.). The elephant fossils were recovered from palaeo-lake (ox-bow) contexts (Badam et al., 1984). Many of these specimens are exceptionally well-preserved and hold promise for revealing accurate palaeoenvironmental signatures, especially to explain the absence of hominin occupation in this area during the Upper Pleistocene in contrast to the Ghod Valley, for example.

3.7. Ghod valley

The Ghod River is a tributary of the Bhima river in upland Maharasthra and originates in the western *Ghats* about 75 km northeast of Pune and flows over Deccan Traps. The drainage pattern of the Ghod is dendritic and there is noticeable change in the surrounding vegetation/ecology from west to east. Again, this valley has not been investigated adequately and very little fossil material is known from here. Some of the earlier work is represented by that of Kajale et al. (1976) and Badam and Kajale (1977a, b) who reported the first known *Hexaprotodon palaeindicus* from this region, and others such as V.S. Wakanker and Z.D. Ansari later collected artifacts and vertebrate fossils of *Bos namadicus* and *Elephas* sp. (Badam, 1979a). The sites of Inamgaon, Sirasgaonkanta, Chinchini, Chandoli, Khadki, and Kalamb have yielded a variety of Pleistocene mammals- *Elephas maximus*, *Elephas hysudricus*, *Bos namadicus*, *Bubalus* sp., *Hexaprotodon palaeindicus* (dated to ~20 ka by ^{14}C on associated shell specimens), *Cervus unicolor*, *Equus namadicus*, *Equus asinus*, *Equus* sp., *Sus palaeindicus* and *Canis* sp. (see Badam, 1979a, p. 201, 1985, p. 65). The *Sus* fossils have been dated to about 39 ka based on associated carbonized wood (Badam, 2002) and this valley has also yielded Middle and Upper Paleolithic artifacts within the fossiliferous deposits. In addition to these taxa, Badam (1985) (Badam et al., 1983) and Sahu (1988) also list *Leptobos* sp. which is now identified as *Bos namadicus*; and Badam et al. (1996–97) also describe fossils of *Bubalus* sp. in Late Pleistocene deposits near Walki in the Bhima valley.

3.8. Krishna valley

The Krishna River originates on the eastern slopes of the Mahabaleshwar Plateau and flows on a southeastern course for about 1400 km, and comprises of at least six to seven large tributaries including Ghatprabha, Malprabha, Bhima, and Tungbhadra (Siddharatha, 1999). It appears to have shifted its course a few times but not as extensively as the Ganga. In comparison to other valleys, this region has also received little palaeontological attention (Badam, 1988). Following Foote's (1876) report of *Bos namadicus* and *Rhinoceros deccanensis* at Chikdauli, R.V. Joshi carried out investigations in the Malaprabha basin and K. Paddayya has also reported *Bos namadicus*, cervid antlers, and *Elephas* species (see Badam, 1979a, 1985). Prasad and Yadagir (1980) have reported fossil bones and teeth of *Bos* sp., *Bos taurus* and *Bos namadicus* in the Krishna basin in Late (?) Pleistocene deposits and also Middle Paleolithic stone-tool assemblages in the same deposits and surrounding areas. Badam (1985) summarized the known fauna from the Krishna Basin as also including, in addition to the above taxa, an *Elephas* tusk near the Dhom Dam and dated to approximately 35 Ka. Despite similarities in ecology and basin morphology with other rivers in peninsular India, the Krishna has yielded comparatively less faunal and archaeological evidence, possibly due to a combination of survey bias and taphonomic processes affecting the preservation and exposure of specimens (Badam, 1988).

3.9. Kurnool cave-complex

The Kurnool caves are located in the Nandyal Basin in the state of Andhra Pradesh in the southeastern part of India and represent the best-preserved and most abundant Upper Pleistocene vertebrate fauna in peninsular India (Lydekker, 1886; Prasad, 1996; Raju and Venkatasubbaiah, 2001). They were first reported by Newbold in the 1840s at Billa Surgam, and subsequently, R.B. Foote and his son, and Cammiade (1927) reported additional caves (Reddy, 1980; Deshpande-Mukherjee et al., 2005). However, systematic excavations were first carried out by Murty in the 1970s (e.g., Murty, 1974). The karst caves are located in limestone formations known as the Kurnool series and the sediments are almost 10 meters thick at places (Badam, 1979a). Archaeologically, the caves are most famous for yielding rich bone and stone tool industries of Mesolithic and Upper Paleolithic technology, often in stratigraphic association with vertebrate faunal remains (Murty, 1975; Murty and Reddy, 1976). Many of the faunal remains from the cave deposits are charred or show evidence of intentional breakage (i.e., indicative of butchery). Even today, small mammals, such as *Hystrix indica* and *Lepus nigiricollis*, are hunted and consumed by tribal groups in the subcontinent (e.g., Murty, 1985; Ansari, 1999–2000).

The large mammal species recovered at the Kurnool cave complex are listed in Table 1. Some of the taxa include *Semnopithecus entellus*, *Felis tigris/leo*, *Felis chaus*, *Felis rubiginosa*, *Hyaena crocuta*, *Vivera karnulensis*, *Rhinoceros karnulensis*, *Bos* or *Bubalus*, *Equus asinus*, *Boselaphus tragocamelus*, *Antilope cervipara*, *Gazella bennetti*, *Cervus axis* or *Axis axis*, *Sus cristatus*, *Ursus*, *Presbytis entellus*, and *Capra/Ovis* sp. (Raju and Venkatasubbaiah, 2001). The collective presence of *Antilope cervicapra*, *Gazella gazella*, *Cervus unicolor*, *Boselaphus tragocamelus* is indicative of scrub and tall grass cover during Upper Pleistocene times; *Ursus* specimens also indicate thick forest cover and *Bos* and *Bubalus* demonstrate the presence of grassland patches within the forests (Badam, 1979a). Most ungulates except domesticated sheep have disappeared from this region though antelopes and cervids are still present. The presence of *Rhinoceros* (not found now in the region) illustrates swampy areas with extensive grass cover (Deshpande-Mukherjee et al., 2005). In general, both the extinct and extant fauna in the region suggests thicker vegetation in a hilly and plateau environment and a more humid climate during the Upper Pleistocene than today.

4. Additional isolated finds throughout India

In addition to the extensive fluvial and some cave-context assemblages described above, several isolated fossil finds have been made throughout various parts of India. Some of these finds are a result of palaeontological investigations while others represent fossil specimens recovered at prehistoric sites.

4.1. Northeastern India

Thus far, only *Elephas maximus* and *Elephas hysudricus* have been recovered from Assam and Meghalaya, respectively (see Badam, 1979a). Unfortunately, not much more material is known from northeast India (excepting the Siwalik deposits here). This is unfortunate because although not a part of peninsular India, the northeast region may represent a critical biogeographic corridor between the Pleistocene fauna, including *Homo* populations, of South Asia (Nanda, this volume) and Southeast Asia (e.g., Hooijer, 1949; Tougard, 2001).

4.2. West Bengal

Sastry (1968) mentions elephants, carnivores, equids, bovids, cervids, and suids from the Gandeshwary valley in West Bengal; carnivores included *Panthera* cf. *leo*, and *Crocuta* cf. *sivalensis* (Dutta, 1976). Badam (2002) also reports fossils collected by Basak et al. (1998) and Dassarma and colleagues (1980s) from the Tarafeni valley and other parts of West Bengal: *Bos namadicus*, *Axis axis*, *Antilope cervicapra*, *Sus* sp. and *Palaeoloxodon* sp. Dassarma et al. (1982) also mention *Bos* sp., *Bubalus palaeindicus*, *Equus namadicus*, *Boselaphus namadicus*, *Cervus unicolor*, *Cervus duvauceli*, *Muntiacus muntjac*, and *Sus cristatus* and recognizes the *Palaeoloxodon* sp. as being *P. namadicus*.

4.3. Rajasthan

In a recent publication, Paliwal (2003) has reported the discovery of large vertebrate post-cranial fossils thought to be of an elephant. This find is unique in the fact that it is the only known fossil occurrence of Quaternary age in the Thar Desert of northwest India. Unfortunately, the species identification and its age are ambiguous and this region warrants additional surveys to recover similar finds. Found in a section of gypsum deposits, the author states that it may be either *Elephas maximus* or *Stegolophodon* and assigns it a late Pleistocene-to-mid-Holocene age.

4.4. Gujarat

As mentioned earlier, there are very few reported occurrences of Early Pleistocene sediments and associated vertebrate fossil material in peninsular India or the region south of the Siwalik Hills. Piram Island, off the east coast of Gujarat may be one of those sites and has yielded a variety of taxa as reported by Prasad (1974), including equid, rhino, bovid, and elephant. The site has been investigated since the early 19th century by foreign and Indian paleontologists whose collections are now scattered in India, England, and Ireland. The Piram Island evidence is not provided in Table 1 as the fossils here may be considerably older and different than those from peninsular India. Prasad mentions that his collections in 1965 represent the most comprehensive work there. Unfortunately, the fossils occur in a cemented ferruginous conglomerate which is usually only exposed at low tide, and are yet to be dated. The fossils have been compared to similar specimens from the Nagri and Dhok Pathan Formations in the Siwaliks, possibly indicating a Pliocene age (Sahni and Mitra, 1980; A.C. Nanda, pers. comm.). If accurate, the exposures at Piram Island represent one of the few such early vertebrate fossil sites of this kind in peninsular India and need to be investigated further in light of possible faunal movement along a coastal route from East Africa.

4.5. Tamil Nadu

A partial skull of *Hypselephas hysudricus* and fragmentary remains of *Bos* sp., *Equus namadicus* and additional vertebrate material has been reported from Tamil Nadu

(Mamgain and Sastry, 1967; Prasad and Daniel, 1968; Khan, 1971; Saha, 1976), as well as *Bubalus maruvattoorensis* by Ghosh et al. (1972); (also see Sahni and Mitra, 1980). A Holocene sub-fossil of *Boselaphus tragocamelus* (a limb bone) was reported by Pappu et al. (1994) from this region, establishing an evolutionary link between Pleistocene and extant *nilgai* species in the subcontinent, especially since older fossils of this species have not been recovered.

5. The Sri Lankan evidence

The island country of Sri Lanka is paleoanthropologically less well-known in comparison to most parts of South Asia but contains a rich prehistoric sequence that has a significant bearing on the evolution and expansion of anatomically modern humans in the subcontinent (Kennedy and Deraniyagala, 1989). Indeed, some of the most well-preserved and oldest fossil evidence for the presence of *Homo sapiens* in the subcontinent comes from the cave deposits of Sri Lanka (Kennedy, 1999). The entire island comprises over 67,000 km^2 and despite its small size, also contains a rich ecological diversity including lowland rainforests, lateritic semi-arid zones (northwest), temperate plains in the central highlands, and extensive coastal environments around the entire country, all of which preserve variable amounts of paleoanthropological evidence. Based on monsoon patterns, the entire country has been divided into Wet (western and southwestern) and Dry Zones (the remainder areas) (Deraniyagala, 1992). It is currently unclear when and how many times northern Sri Lanka and the southern tip of peninsular India, were connected through a land bridge at the Palk Strait during the Pleistocene. These sea-level fluctuations must have played a major role in allowing the movements of both faunal and hominin populations as well as their indigenous evolution during periods of geographic isolation. At the moment, it is clear that related evidence older than the late or terminal Middle Pleistocene is scarce in Sri Lanka and Middle Paleolithic and younger lithic and bone-tool assemblages dominate the prehistoric archaeological record here (see Kennedy, 2000; Premathilake, 2006).

Some of the first formal studies on the vertebrate palaeontological evidence were carried out by Wayland (e.g., 1914) in the early part of the 20th century, as an extension of similar efforts in other parts of the subcontinent. An area that was quickly recognized to continuously yield vertebrate fossils was the gem fields and alluvial gravels of Ratnapura in the southwestern wet lowlands in the 1930s (e.g., Deraniyagala, 1945). These deposits traditionally came to be known as the Ratnapura Beds and the fauna from here as Ratnapura Fauna (Deraniyagala, 1992). In addition to the open-air sites in the Ratnapura gem fields (e.g., Ellawala), some faunal assemblages have also been recovered from the numerous caves found throughout Sri Lanka, usually as a consequence of archaeological excavations. Some examples are Nilgala Cave, Ravanalla, Batadomba-Lena, and Mandagalge, some of which have yielded modern human fossils (Kennedy, 1999).

The large mammalian fauna from the Ratnapura Beds are listed in Table 2 and include the following species (Deraniyagala, 1992): *Elephas hysudricus*, *Elephas namadicus*, *Elephas maximus sinhaleyus*, *Hexaprotodon sinhaleyus*, *Rhinoceros sinhaleyus*, *Rhinoceros kagavena*, *Rhinoceros* sp., *Homopithecus sinhaleyus*, *Leo leo sinhaleyus*, *Cuon javanicus*, *Bibos gaurus sinhaleyus*, *Bubalus bubalis migona*, *Bos* sp., *Bos zeylanicus*, *Muva sinhaleya*, *Axis porcinus*, *Cervus unicolor unicolor*, *Axis axis ceylonensis*, and *Sus sinhaleyus*. An alleged hominin fossil was also reported from Jahinge Angiliya Kumbura and assigned a new taxon, *Homo sinhaleyus* (Deraniyagala, 1992) or *H. sinhalensis,* which upon later re-examination appeared to be suspect as a fossil due to the complete lack of organic cellular structure (K.A.R. Kennedy, pers. comm.). All of these mammalian species have been found in variable spatial frequency and often in shared stratigraphic associations in the Ratnapura Beds. Additionally, Deraniyagala (1992, pp. 60–61) states that: "If any reliance can be placed on the assumption that the various faunal elements set out above are contemporaneous within each association, and that redeposition has not played a significant role, the above data suggest that: (a) *Hexaprotodon*, *R. kagavena*, *Homopithecus*, *Hystrix sivalensis*, *Leo leo*, *Bibos*, several bovines (including perhaps *Bos namadicus*), *E. maximus*, *A. axis*, and *C. unicolor* were approximately contemporaneous. (b) *R. sinhaleyus*, although found with *E. maximus*, might not have overlapped with several of the other forms of the Ratnapura Fauna." However, he also states that "Redeposition, as a source of stratigraphic interference,

Table 2
Pleistocene large mammal species from Sri Lanka. Most are Ratnapura Fauna

Carnivora
Leo leo sinhaleyus
Cuon javanicus
Perrisodactyla
Rhinoceros sinhaleyus
Rhinoceros kagavena
Rhinoceros sp.
Proboscidea
Elephas hysudricus
Elephas namadicus
Elephas maximus sinhaleyus
Hexaprotodon sinhaleyus
Artiodactyla
Bibos gaurus sinhaleyus
Bubalus bubalis migona
Bos sp.
Bos zeylanicus
Muva sinhaleya
Axis porcinus
Cervus unicolor unicolor
Axis axis ceylonensis
Sus sinhaleyus

could upset all of the above hypotheses. Until the Ratnapura Beds are investigated from an explicitly chrono-stratigraphic standpoint, no further chronological resolution is likely to be achieved.'' (p. 61).

The first known find of *Palaeoloxodont* elephants and the six-incisor hippopotamus *Hexaprotodon* in these sediments established a possible correlation with the Middle or Upper Pleistocene fauna found in peninsular India (Deraniyagala, 1992). Samples of wood fragments have also been found from the Ratnapura Beds, along with pollen samples, both indicating a mosaic environment with an extensive drainage pattern (Vishnu-Mittre and Robert, 1965). The presence of *Rhinoceros sinhaleyus* indicates a prevalence of swamp conditions. The species shares broad phenotypic similarities with *R. kagavena*, which possessed more specialized teeth that were larger and higher crowned than the former species. It has been correlated with *R. sondaicus* of SE Asia and a taxonomic link with *R. karnulensis* in southern India remains uncertain. A possible giant ape, *Homopithecus sinhaleyus*, is known from only two teeth and has been compared with *Gigantopithecus* of northern India. One tooth was found at Lindagava-Kumbura and the other (an upper left 1st incisor without its root) was recovered one kilometer away at Balahapura in association with *Hexaprotodon sinhaleyus*, *R. kagavena*, and *E. maximus*, *Axis axis*, and *Cervus unicolor*. Although Deraniyagala (1992, p. 65) makes broad chronological and taxonomic comparisons between the Ratnapura Fauna and comparable evidence from peninsular India, there have been no detailed comparisons or attempts at dating these specimens directly (although a rhinoceros specimen from Pelmadulla was said to be radiocarbon dated to about 47 ka (p. 69)). In fact, by about 28 kyr, the majority of the Sri Lankan large mammalian fauna may have attained a modern composition with little subsequent change, if any. For example, the fauna found in some cave deposits (e.g., Beli-lena Kitulgala and Batadoma-lena) do contain distinct forms and some Ratnapura specimens such as palaeoloxodonts, hippopotamus, and rhinoceros have never been recovered in cave deposits. In any case, it is clear that some of the Pleistocene and extant mammalian species suggest an endemic faunal composition, possible a result of intermittent geographic isolation from peninsular India when sea-levels were high at different times.

The Ratnapura Beds have also yielded lithic artifacts though rarely in behavioral association with the faunal specimens. This lithic evidence is not very diagnostic and most probably post-dates the Late or terminal Acheulian evidence in India, some of which is thought to extend up to the Upper Pleistocene (see Mishra, 1994, 1995). The earliest Sri Lankan lithic evidence comprises core-and-flake assemblages which persist until the Holocene at some sites. In the past, there has been some doubt regarding the contextual integrity of these Ratnapura finds and many faunal and lithic specimens appear to derive from reworked sediments. The non-diagnostic lithic evidence has also resulted in an unreliable relative chronological framework for the associated faunal specimens. Conversely, it is currently difficult to chronologically separate some Ratnapura faunal specimens of Late Pleistocene and early Holocene age.

6. Lithic associations with faunal occurrences

Most of the fossils found throughout peninsular India in fluvial contexts are often associated with gravels, silts, calcretes, sands, and clays. Such sedimentary deposits have also yielded numerous stone tools ranging from the Lower Paleolithic to Neolithic in both surface and stratified contexts (e.g., de Terra and Paterson, 1939; Sankalia, 1956; Paddayya 1969; Joshi et al., 1978; Badam, 1979a, 1989; Dennell, 2004b). Fossils and artifacts are frequently found in calcretised (cemented) deposits such as pebble or cobble conglomerates and, at times, faunal remains in more secure contexts have been processed to obtain absolute dates for the lithic assemblages (e.g., Tewari et al., 2002). A variety of tool types occur with the vertebrate fossils, including choppers, handaxes, cleavers, polyhedrals, discoids, points, borers, scrapers, blades, flakes, burins and bone tools (see Tables 1 and 2 in Badam, 2002, pp. 230 and 237). Most faunal-lithic associations represent secondary deposition in both low and high energy environments and do not demonstrate any evidence of modification by hominins such as cut-marks, scrape marks, pitting, and so forth (e.g., Badam et al., 1986). Majority of these associations comprise Middle Paleolithic or Middle Stone Age contexts and are in Upper Pleistocene contexts (Table 3). Very few Lower-Middle Pleistocene sediments have yielded such associations, possibly a lack of poor faunal preservation in such older contexts. The frequent surface occurrences of faunal-lithic assemblages in the Siwalik region actually represents a mixing of Middle and Late Pleistocene lithic assemblages with older vertebrate fossils (Chauhan and Gill, 2002; Chauhan, 2005). Except for the Ratnapura Beds in Sri Lanka, which have yielded core-and-flake assemblages and presumably younger flake dominated lithic assemblages in spatially-broad stratigraphic association with vertebrate fossils, the majority of the cave deposits have yielded comparatively little vertebrate fauna. A large portion of artifacts recovered in these caves were often produced on bone, antler, or shell and many such sites date to the terminal Upper Paleolithic and Mesolithic periods-e.g., Beli-lena Kitulgala, Batadomba-lena, Alu-galge, Telulla, Udupiyan-galge, Beli-galge, Bambarabotuva, Nilgala, Ravanalla (Deraniyagala, 1992). Although, the Paleolithic assemblages recovered from the Ratnapura Beds are known to be in broad stratigraphic association with vertebrate fossils, both types have not been found in spatial association with each other and none come from controlled or systematic excavations at primary archaeological deposits.

The Kurnool caves represent the only known faunal contexts in India in well-preserved cave sediments which have also yielded abundant lithic and bone tools from

Table 3
Some reported occurrences of faunal and lithic associations in peninsular India

Site (valley)	Industry	Fauna	Age	Reference l
Isampur (Hunsgi)	Early Acheulian	Herbivore teeth bovids, equids, cervids	~1.2 ma	Paddayya et al. (2002)
Bori (Kukdi)	Early Acheulian	*Bos*, *Elephas*, *Equus*	~600 ka	see Mishra et al. (1995)
Chirki (Pravara)	Early Acheulian	*Bubalus*	>390	Pappu (2001)
Sadab (Hunsgi)	Acheulian	*Elephas*	290 ka	Szabo et al. (1990)
Teggihalli (Hunsgi)	Acheulian	*Bos*	287 ka	"
"		*Elephas*	>350 ka	"
Gaya (Paimer)	Acheulian	*Axis*, *Cervus*, *Bos*, *Bubalus*	Undated	Badam (1979b)
Attirampakkam (Kortallyar)	Acheulian	*Bubalus*/*Bos* sp., *Equus* sp., *Boselaphus* or caprine	Undated	Pappu et al. (2003)
Kalegaon (Godavari)	Lower Palaeolithic	*Bos namadicus*	Undated	Badam (1979a)
Gangapur (Godavari)	Lower Palaeolithic	*Bos namadicus*	Undated	"
Nevasa (Pravara)	Lower-Middle Palaeolithic	*Bos*	Undated	"
Hathnora (Narmada)	Lower-Middle Palaeolithic	Various including *Homo*	Mid-Pleistocene?	Salahuddin et al. (1986–87)
Nittur (Tungabhudra)	Soanian-type	*Bos namadicus*	Undated	Ansari (1970)
various (Narmada)	Acheulian-Middle Palaeolithic	Various	Undated	Chauhan et al. (2006)
Paithan (Pravara)	Middle Palaeolithic	*Bos* sp.	Undated	Rajaguru (1968–69)
Mula Dam (Mula)	Middle Palaeolithic	*Bos namadicus* and *Elephas*	Undated	"
Kalpi (Ganga)	Middle Palaeolithic	Various	~45 ka	Tewari et al. (2002)
Various (Mahanadi)	Middle Palaeolithic	*Bos* sp., *B. namadicus*, *Cervus* sp., *Equus namadicus*	Undated	Sahu (1988)
Dhandh (Bhima)	Middle Palaeolithic	*Bos* sp.	Undated	Sahu (1988)
Hagargundi (Bhima)	Middle Palaeolithic	*Bos namadicus*, cervid antler, *Elephas*	Undated	Badam 1985
Tajpur (Meshvo)	Middle Palaeolithic	*Equus* cf. *asinus*	Undated	Badam (1977)
Wajjal (Hunsgi)	Middle Palaeolithic	Various	Undated	Badam (1979a)
(Parvati)	Middle Palaeolithic	Indeterminate bovid	Undated	Pandey (1990)
(Sagileru)	Middle/Upper Palaeolithic	Species of *Bos, Cervus, Equus,* and *Antilope cervicapra*	Late Pleistocene to Early Holocene	Shankar et al. (2006)
Various (Ghod)	Upper Palaeolithic	Various	Undated	Badam (1988)
Kurnool caves	Upper Palaeolithic	Various	Undated	Murty (1975) p

Mesolithic and Upper Paleolithic periods. This evidence and similar material from Kalpi in the Ganga Valley are the only-known unequivocal *behavioral* associations in South Asia between fauna and lithics, including hominin-modified faunal elements such as large mammal vertebra and cranium. One recent report of a potential butchery site dating to the Middle or Early Pleistocene comes from Kashmir, where local geologists allegedly recovered elephant bones in association with stone tools (Pushkarna, 2001). Unfortunately, the investigators have yet to publish their material in a scientific journal as the discovery has only been described briefly in a magazine article. The investigators report a complete *Elephas* cranium with "man-made grooves" and also mention the collection of "57 stone tools" and "two bone tools" (Pushkarna, 2001, p. 17). The elephant fossil was thought to be 780 ka in age by G.M. Bhat, although it has also been stated that the fossil may be similar to *Elephas namadicus*, a species thought to have lived between 10 myr and 70 kyr (Pushkarna, 2001). Although intriguing and potentially important, this evidence from Kashmir has yet to be confirmed by experienced paleoanthropologists including specialists in Paleolithic archaeology, taphonomy and cut-mark analyses. Considering the current state of the evidence, we have virtually no information regarding the subsistence behavior of South Asian hominins. The following four Paleolithic localities are currently the most important as they represent faunal associations where dating has been attempted: (a) Isampur, (b) Chirki-on-Pravara, (c) Hathnora, and (d) Kalpi.

6.1. Hunsgi-Baichbal basins

The oldest-known Paleolithic site dated through the faunal remains in southern India is the Isampur locality in Hunsgi valley in southern India (Paddayya et al., 2002). Electron spin resonance (ESR) dating on two herbivore teeth was carried out and yielded an average age of ca. 1.2 Ma for the associated Acheulian quarry assemblage. However, this result should be considered as being preliminary until it is corroborated through further geochronological efforts in the subcontinent. As a cautionary note, no Acheulian sites of comparable age (with the exception of 'Ubeidiya in Israel) have yet been identified between the earliest East African localities and the Indian subcontinent in order to support such an early

Mode 2 dispersal. Fossil remains of bovid, equid, and cervid species were also recovered from the same deposits (Paddayya et al., 2002). Szabo et al. (1990) carried out U-series dating on several of these fossil specimens in association with Paleolithic artifacts from the neighboring Baichbal valley, suggesting a Mid-Late Pleistocene age for the species. For example, dental samples of *Elephas* from Sadab yielded a date of about 290 ka and *Bos* and *Elephas* specimens from Teggihalli yielded ~287 ka and a minimum age of ~350 ka, respectively. *Bos*, *Elephas*, and *Equus* fossils from Bori, in the Kukdi Valley, have been assigned a broad age of ~670 ka on the basis of tephra dating (Mishra, 1995; Mishra et al., 1995), however, this site and its geological context is controversial and needs further investigation. It is significant that vertebrate fossils from different locations at the site yielded fluorine/phosphate ratios ranging from 8.05–8.92, thus relatively confirming a broad Middle and late Pleistocene age for the material (Kshirsagar and Badam, 1990). For instance, Mishra (1994, pp. 61–62) cites Kshirsagar and Paddayya (1988–89): "While the Early Acheulian is associated with fossils saturated in fluorine (Fluorine/Phosphate ratios of 6–8), the Late Acheulian is associated with fossils having a Fluorine/Phosphate ratio of 5–6."

6.2. Chirki-on-Pravara

Sankalia (1956) first reported the occurrence of *Bos* fossils from Nevasa, with Lower and Middle Paleolithic artifacts. Later work in the region by Corvinus (1981, 1983) resulted in the meticulous excavations of a rich Early Acheulian site at Chirki, where she additionally recovered (though poorly-preserved) *Bubalus* fossils as well as *Dicotylodon* wood remains (Corvinus, 1971). Divided into Upper and Lower Pravara Beds, the sediments here yielded Middle and Upper Pleistocene vertebrate fossils and artifacts (Corvinus, 1968) and represents one of the best examples of direct stratigraphic and spatial associations between lithics and faunal remains in an Indian context. Subsequent dating by the Uranium-Thorium method yielded an age of >390 ka for the lowermost cultural levels (Mishra, 1994). In the Godavari valley including its tributaries such as the Pravara, exclusive Lower Paleolithic artifacts have been found with fossils of *Bos namadicus* at Kalegaon and Gangapur and exclusive Middle Paleolithic artifacts have been found with fossils of *Bos* sp. at Paithan (Rajaguru, 1968–69), then dated to 19 ka by ^{14}C but which needs to be re-calibrated, and with fossils of *Bos namadicus* and an *Elephas* tusk at Mula Dam; both Lower and Middle Paleolithic artifacts have been found with *Bos namadicus*, *Elephas* sp., *Equus* sp., and *Bos* sp. (see Badam, 1979a, p. 195).

6.3. Hathnora

The fossil hominid site of Hathnora (Sonakia, 1984) has also allegedly yielded Late Acheulian and Middle Paleolithic artifacts and fragmentary vertebrate fossils (see species list under the Narmada section in Table 1) (Salahuddin et al., 1987–88; Badam, 1989; Sonakia and Biswas, 1998; Patnaik et al., n.d.). Most recently, a U-Series date on a bovid scapular fragment stratigraphically associated with the hominin fossils showed a minimum age of ~236 ka, and it is likely that fluvial reworking and more than one episode of uranium isotope saturation has occurred (Cameron et al., 2004). As it stands, multiple fossil and sediment samples from the same strata need to be dated in order to constrain such ambiguous age brackets. The author and his colleagues are currently processing herbivore dental samples from the strata associated with the fossil-hominin (Sonakia, 1984) for new ESR and Uranium-series age estimates (Patnaik et al., n.d.). In addition to Hathnora, stratigraphic and surface associations between vertebrate fossils and lithic specimens have been frequently reported by numerous investigators over the last century (e.g., de Terra and Paterson, 1939; Khatri, 1961; Joshi et al., 1978; Sonakia, 1984; Supekar, 1985; Badam, 1989). This data has been recently supplemented by the author and his collaborating colleagues in the central Narmada valley between 2003 and 2007 from horizons belonging to various Middle and Upper Pleistocene Formations (Chauhan et al., 2006; Patnaik et al., n.d.). As in most other fluvial contexts, artifacts and fossil specimens are often found in shared stratigraphic contexts, though usually in relatively low densities. More often than not, the condition of both types of specimens is less abraded or virtually fresh in fine-grained contexts, but rolled or abraded in high-energy contexts such as gravel or conglomerate horizons (Fig. 4). In the past, most fossil assemblages from the Narmada Quaternary sediments have been collected from surface contexts, suggesting both fluvial transport as well as exposure from the underlying sediments and/or adjoining sections indicating a primary context (Fig. 5). Stratified fossil and lithic specimens are often found sandwiched between calcretised horizons above and paleosol deposits below (Fig. 6) (e.g. de Terra and Paterson, 1939; Khatri, 1966; Patnaik et al., n.d.). Thus far, no behavioral association has been identified in the Narmada Basin between the vertebrate fossils and lithic specimens at shared locations.

6.4. Kalpi

The Middle Paleolithic site of Kalpi, mentioned earlier, has yielded lithics and fauna in stratigraphic contexts and convincing behavioral associations and has been dated to about 45 Ka using Infrared Stimulated Luminescence (IRSL) (Tewari et al., 2002). The artifact assemblage comprised of diminutive quartzite choppers as well as cores, possible manuports, atypical points, scrapers, debitage. The bone-tool assemblage is significantly larger and includes end-scrapers, points, notched tools, burins, and atypical end scrapers; some specimens including one tool indicate signs of charring (Tewari et al., 2002, p. 1).

Fig. 4. Gravel exposures at Gurla beach across from Hathnora. Note the abraded fossil specimen in the center and the rolled quartzite flake in the top right corner.

Fig. 5. Pleistocene sediments at the type site of Surajkund. The third lithic specimen on the right in the inset is the Late Acheulian cleaver eroding out in the center of the photograph. The fossil long-bone was recovered from the same stratum about 5–6 meters away. The other two Acheulian bifaces were also recovered from the Surajkund Fm. in stratified context.

6.5. Other isolated finds

The following is a brief summary of some faunal-lithic occurrences in open-air and cave contexts, all of which currently remain undated: Belan and Seoti valleys: G.R. Sharma has reported artifacts from the Lower Paleolithic to the Mesolithic from the same deposits as the fossils in the Belan and Seoti valleys; this work was later expanded significantly (see Sharma and Clark, 1983). Paimer valley: Acheulian artifacts were collected from Upper Pleistocene deposits which also yielded *Axis* sp., *Cervus* sp., *Bos* sp., *Bubalus* sp., and *Emys* sp. from the Paimer valley near Gaya in Bihar (Badam, 1979b). Mahanadi valley: As mentioned earlier, deposits in the Mahanadi River have yielded *Bos* sp., *Bos namadicus*, possible *Cervus* sp., and *Equus namadicus* as well as Middle Paleolithic artifacts. Parvati valley: Pandey (1990) reported Middle Paleolithic artifacts (scrapers, borers, flakes, and cores) in surface gravel contexts with indeterminate bovid fossils (either *Bos namadicus*/*Bubalus bubalis*) from the sites of Mohammadpura and Parvati Chowki in the Parvati Valley. Bhima valley: G. Corvinus and colleagues have reported a *Bos* sp. with Middle Paleolithic artifacts on the Bhima River near Dhand (see Sahu, 1988). Paddayya also discovered fragmentary fossils of *Bos namadicus*, cervid antlers, and *Elephas* in stratigraphic association with Middle Paleolithic artifacts at Hagargundi on the left bank of the Bhima (Paddayya, 1969). Meshvo valley: A fossil long-bone of *Equus* cf. *asinus* was recovered by Sankalia at the Meshvo River near Tajpur (or Tejpur) village, Gujarat with Middle Paleolithic points and scrapers (Badam, 1977). Sagileru Valley: Recently, Shankar et al. (2006) reported Paleolithic side-scrapers and blades on chert and quartzite in stratigraphic association with fragmentary fossils of *Antilope cervicapra* and *Bos*, *Cervus*, and *Equus* species, from various locations in the Sagileru Valley in the Cuddapah District of Andhra Pradesh. The investigators report that both the fossils and artifacts derive from a unit comprising Late Pleistocene to Early Holocene alluvial silts, as they overlie volcanic ash deposits provisionally assigned to the Youngest Toba Tuff (~74 ka) from morphological correlations of glass shards with similar evidence from elsewhere in India (Westgate et al., 1998). The artifacts and fossils were collected from the areas of Porumamilla, Kalasapadu, and Vankamari (Shankar et al., 2006). Kurnool caves: The most famous example comes from the Kurnool caves, described earlier. Despite the significance of this site-complex, there are currently no reliable absolute dates for the faunal and lithic assemblages; however, new information and interpretations are anticipated from recent investigations (James and Petraglia, 2006). The earliest occupation goes back to the Upper Paleolithic and also includes Mesolithic and Neolithic material, and almost all sediments are restricted within the Upper Pleistocene in age. Hunsgi basin: In his compilation of the Krishna, Ghod, and Hunsgi faunal assemblages, Badam (1985, p. 66) lists the following taxa from Hunsgi: *Bos namadicus*, *Equus namadicus*, *Elephas* sp., *Bubalus* sp., Cervidae, *Equus asinus*, and *Boselephus* (as well as turtle remains)-all listed under the 'Krishna' column in Table 1. Here, Korisettar and colleagues (1976–77) also located unique tuffaceous beds with plant impressions and Middle Paleolithic tools at Wajjal, a stream in the Hunsgi basin. Attirampakkam: Pappu et al. (2003) have reported the occurrence of mammal footprints (elephant and bovid) and three fossil herbivore teeth from Attirampakkam in Tamil Nadu which comprises behavioral evidence spanning from the Lower Paleolithic to the Mesolithic. Some of the dental specimens are being dated using ESR (S. Pappu; B. Blackwell, pers. comm.) and have been identified as *Bubalus* or *Bos*, *Equus* sp., and caprine or *Boselaphus*, indicating an open and wet landscape (Pappu et al., 2003).

Fig. 6. A cleaver and vertebrate fossil fragment between a consolidated layer of calcium carbonate (above) and paleosol deposits (below). The cleaver is enlarged in the bottom right image. Both specimens were recovered from the same stratum and only several meters from each other.

Nittur: Ansari (1970) has reported *Bos namadicus* fossils with Lower and Middle Paleolithic tools at Nittur on the Tungabhudra River in southern India, and which were later studied by Sathe et al. (1986).

7. Discussion and conclusion

While the vertebrate assemblages from the Siwalik region have been well-studied and often come from secure, fine-grained geological contexts, open-air Pleistocene assemblages in peninsular India are generally found in secondary fluvial deposits (Badam, 1988). Exceptional examples are represented by specific fossil localities in the central Narmada Basin (e.g., Talaya Ghat) and the Manjra valley (e.g., Harwadi), where semi-articulated individuals have been excavated (Sathe, 1989) (Fig. 7). Prior to the application of absolute dating techniques, the faunal assemblages from the Narmada and other similar valleys were utilized to relatively date certain strata and associated cultural material and vice versa. Associated geomorophological signatures, such as erosional features were also used to support the broad age brackets assigned to the faunal and archaeological assemblages; however, the perception of the temporal duration of Pleistocene phases was considerably different than today. From the current state of evidence, most Quaternary fluvial sediments in peninsular India do not appear to be older than the Middle Pleistocene (Tiwari, 2001), although the lower part of the Dhansi Formation and most of the Pilikarar Formation in the Narmada valley may date to at least the Brunhes-Matuyama boundary, or well into the Early Pleistocene (Tiwari and Bhai, 1997). In fact, absolute dates have not been obtained for most of these occurrences and as a result, some exposures or strata may be significantly older (e.g., late Pliocene) or younger than previously thought. A good example of this comes from the recent investigations by Pappu et al. (2003) at Attirampakkam, where they demonstrated that sediments previously thought to be of Cretaceous age for many decades, are actually of Pleistocene age. Similar geological situations may exist elsewhere in peninsular India where older Plio-Pleistocene sediments (even if horizontally restricted) have not yet been identified or promising sediments have been misidentified. From this lack of absolute dates and a geographic and chronological increase in the occurrence of some fossil species, it is currently difficult to pinpoint the First and Last Appearance Datums and identify index species representative of certain time periods (Badam, 1988). Such inferences have been made on the basis of presence/absence of certain taxa in a given region and time period. Therefore, the peninsular record currently remains ambiguous and requires extensive re-examination.

Fig. 7. A large-mammal fossil cluster from the Manjra Valley. (Photo courtesy: Vijay Sathe).

From the known palaeontological data, the Son and Narmada valleys, and the Kurnool caves have yielded the highest number of vertebrate taxa (average of about 32 species). These are followed by the following regions or basins: Godavari, West Bengal, Ganga, Manjra, Ghod, Krishna, Mahanadi, and the remaining localities with minimal fossil taxa. The Pleistocene large mammal fauna of Sri Lanka is comparatively less diverse than the Indian evidence and includes a significantly fewer number of species. However, all these counts should be viewed as being tentative, particularly when such required information as the Minimum Number of Individuals and the Number of Individual Specimens was not always published or meticulously recorded during specimen collection in the field (Nanda, this volume). For example, *Felis* sp. may simply be an undiagnostic specimen of *Felis chaus* and so forth. In addition, *Elephas namadicus*, *E. antiquus*, and *Palaeoloxodon namadicus* are now considered to represent the same species rather than three separate ones (see Biswas, 1997) and the same applies to *E. hysudricus* and *Hypselephas hysudricus*. Researchers in the past have recognized *Stegodon ganesa* and *Stegodon insignis* as two separate species, while Badam (1979b) and subsequent workers have argued that the morphological differences between the two are merely related to sexual dimorphism-*Stegodon ganesa* as male and *Stegodon insignis* as female. Subsequent literature addresses both as a single species *S. insignis-ganesa*. In respect to the identification of bovids, giraffids and cervids, such specimens also require revision as their dentition is very similar to each other (A.C. Nanda, pers. comm.). Pleistocene primate fossils in peninsular India and Sri Lanka, including *Homo* specimens, are extremely rare. No fossil evidence of ancestral species to the *langur* (*Presbytis entellus*) and macaques has been geographically recovered as known from their present-day distributions. This may be due to a number of factors such as inadequate surveys and taphonomic bias (see Dennell, this volume). Reasons for the lack of hominin fossils in peninsular India may be more complex: the depositional history of Pleistocene basins, taphonomic processes following skeletal deposition such as a lack of adequate burial, carnivore ravaging, or even hominin behavioral patterns such as differences in locations of habitation, death, discard/treatment of body by other hominids.

While some Pliocene and early Pleistocene fauna may be related to faunal expansions from Asia and Africa such as *Theropithecus* and *Pachycrocuta* from Upper Siwalik sediments (Delson, 1993; Dennell and Roebroeks, 2005), many Middle and Upper Pleistocene large mammals possibly developed indigenously. This would be particularly true if a major geographic barrier such as the Himalayas presumably prevented faunal dispersals between peninsular India and large parts of Eurasia. Badam (1979a) has stated that most genera, if not species, known from the Pleistocene record exist today in peninsular India. For example, the rhinoceros known from Pleistocene peninsular India is similar to the modern-day form found in northeast India (Gurung and Singh, 1996), indicating a significant eco-geographic shift in its home range. Additional examples provided by Badam include *Bubalus palaeoindicus, Bubalus bubalis* (the modern water buffalo), *Cervus unicolor*, and *Cervus duvauceli* (the modern *barasingha* deer). Similarly, the *nilgai* or *Boselaphus tragocamelus* also appears to be of South Asian origin, along with *Bos*, *Sus*, *Elephas*, and *Equus. Bos namadicus* is one of the most common bovid species in the subcontinent and probably ancestral to *Bos indicus* (Badam, 1988). Depending upon the accuracy of their respective identification and age estimates, it is reasonably clear that many taxa have become extinct during the Middle and Upper Pleistocene, such as *Stegodon*, *Hexaprotodon*, and *Hippopotamus*. Badam (1988, 2002) recognizes *Hexaprotodon namadicus* and *Sus namadicus* as index fossils of the Middle Pleistocene; though Salahuddin (1987–88) has emphasized a need to reassess the identification of *Hexaprotodon* specimens. Among other species, a type of giraffe, *Sivatherium*, as known from the Siwaliks, appear to be absent in peninsular India during the Pleistocene. Additionally, the complete extinction of some fauna such as hippopotami and ostriches throughout the subcontinent may be a result of changing environmental conditions during the Upper Pleistocene, possibly coinciding with the intensive occupation of modern humans. However, longitudinal and multidisciplinary investigations are required to explicitly identify such factors of extinction, whether they involved hominin interference (e.g., Surovell et al., 2005) or simply changes in climatic and ecological conditions (e.g., Guthrie, 2006).

In a recent study on correlating collagen loss with fossil/lithic site location in Asia, Holmes et al. (2006) have demonstrated that the quality and mode of preservation of such material in southern Asia is comparable to the evidence from parts of Africa. Therefore, the comparatively low amount of vertebrate fossils in South Asia may be due simply to the lack of adequate surveys and the lack of appropriate sedimentary exposures. Where open-air sites are more abundant, faunal preservation is likely to be minimal due to the lack of sedimentary deposition. Although the Kurnool caves and the Sri Lankan caves have yielded ample fauna, the well-stratified Bhimbetka and Adamgarh rock-shelter complexes have not, possibly a result of variable sedimentary, environmental, and taphonomic mechanisms, including the nature of bedrock geology and local climatic regimes. Consequently, palaeontologists have found it difficult to adequately compare South Asian faunal assemblages with other regions, making it difficult to hypothesize inter-regional faunal interactions. Although hominin-modified fossil bones have yet to be scientifically reported, early hominins in India must have availed themselves of this faunal diversity. For example, Badam and Prakash (1992) describe a large array of mammalian and other fauna portrayed at the prehistoric rock art sites in the Upper Chambal valley (Agrawal and Kharakwal, 2002; Datta et al., 2003). Such data has been integrated in the past to reveal the presence of fluvial floodplains, perennial water bodies, seasonal streams, and ancient terrestrial surfaces (see Misra, 1997, 2001). Likewise, broad palaeoenvironmental reconstructions can also be carried out at a regional level, often partially supported by pollen assemblages, isotope studies, and invertebrate and micromammal fossil assemblages (e.g., Patnaik, 1995). In that respect, large-scale landscape-specific observations (e.g., Blumenschine, 1986; Tappen, 1995) would prove instructive in understanding potential land-use by early humans and their behavioral and ecological relationships (i.e., hunting/scavenging strategies) with the regional faunal communities in the Indian subcontinent. Additional examples of methods that can be applied to South Asian faunal assemblages include more rigourous systematics, regional biochronological correlations, ecomorphological analyses, isotopic signatures, dental histology, dental mesowear studies, biomolecular studies, preliminary DNA extraction attempts, absolute dating of key type-specimens, more detailed taphonomic investigations, and systematic examinations for bone-modification by hominids on vertebrate fossils associated with stone tool assemblages. It has also been demonstrated by other researchers working in the Indian subcontinent that ethnoarchaeology of certain tribal groups can also provide valuable insights on hunting and meat-processing behaviors of Pleistocene *Homo*. Existing fossil collections and additional surveys and excavations can further provide Old World palaeoanthropologists with rewarding opportunities to study South Asian faunal dynamics and associated hominin adaptations within this unique region.

Acknowledgements

I am thankful to Rajeev Patnaik for permission to include unpublished information from the Narmada Basin Palaeoanthropology Project, which is funded by the National Geographic Society (awarded to R. Patnaik), Mr. Pat Sarma (through Sheela Athreya), and the Wenner-Gren Foundation for Anthropological Research (awarded to the author). Vijay Sathe, Avinash Nanda, Robin Dennell and an anonymous reviewer provided numerous critical suggestions and important references; V. Sathe also kindly provided a photograph for the Manjra evidence. Miriam Belmaker particularly helped improve the structure and content of the paper, for which I am thankful. Finally, I thank Nicholas Toth and Kathy Schick, co-directors of the Stone Age Institute & CRAFT research Center (Indiana University, USA) for institutional support and general encouragement in my research. Any errors and misinterpretations are entirely my own.

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