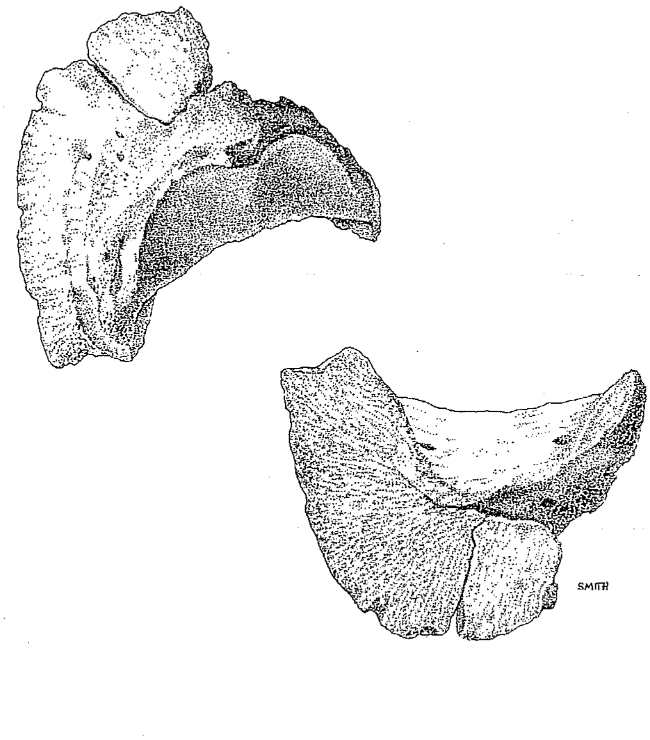
ARCHAEOZOOLOGY OF THE NEAR EAST III

Proceedings of the third international symposium on the archaeozoology of southwestern Asia and adjacent areas

edited by

H. Buitenhuis, L. Bartosiewicz and A.M. Choyke



ARC - Publicaties 18
Groningen, The Netherlands, 1998

Cover illustration: Dorsal and palmar aspects of a
Bronze Age horse phalanx from Arslantepe, Turkey,
identified by Sándor Bökönyi.
Courtesy by the artist, Patricia Smith (Reduction: 64%).

Printing: RCG -Groningen

Information: Centre for Archeologicl Research and Consultancy
Poststraat 6, 9712 ER Groningen, The Netherlands

ISBN 903670791-9
NUGI 644/821/835

Preface

This publication is the result of the third international symposium on archaeozoology of southwestern Asia and adjacent areas, held in Budapest, Hungary from 2 - 5 September 1996. The editors would like to thank all colleagues of the Working Group who helped with the translation of abstracts. Financial support for the publication was given by the Acker Stratingh Stichting, Groningen, The Netherlands.

Participants of the 3rd ASWA Conference, Budapest 1996
(Photo: Péter Komjáthy, Aquincum Museum)

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Contents

THE EXPLOITATION OF WILD AND DOMESTIC WATER BUFFALO IN PREHISTORIC NORTHWESTERN SOUTH ASIA

Ajita K. Patel[1] and Richard H. Meadow[2]

Résumé

L'exploitation pré- et protohistorique du buffle indien, sauvage (*Bubalus arnee*) ou domestique (*Bubalus bubalis*), n'est pas bien connu. Le Nordouest de l'Asie Sud est partie de la zone original de la forme sauvage et était peut-etre une areal de la domesticaton locale. Cette article commence avec la présentation d'informations iconographiques de la présence de buffle dans cette région au 3ême millenaire BC. Apres, une discussion sur le probleme d' identification de buffle en le materiel archaeozoologique suive. Le discours se passe au site préhistorique de Santhli au Nord Gujarat, ou les restes d'un minimum de huit individus de buffle sauvage se sont trouvé. Détails de ces materiaux se sont présenté et comparé avec les restes de buffle provenant de sites de la région de Mehrgahr, Pakistan Balochostan, de 7ême- 4ême millenaire BC) et de Dholavira de la région de Kutch (période Harappien, second part du 3ême millenaire BC). Data métriques de buffle moderne de la région Pakistan Punjab se sont usé pour des raisons comparatives. Le discussion de ces materiaux est le premier chance pour comprendre mieux l'exploitation préhistorique du buffle sauvage, et le processs de sa domestication , et l'exploitation de la forme domestique.

Introduction

The water buffalo is an animal whose past is little known. In 1963, Zeuner noted that the "*archaeological evidence for their history as domestic beasts is curiously scanty*" (Zeuner, 1963: 249), and the situation is no better for the wild form. During the early Holocene the distribution of the wild *Bubalus arnee* (Kerr, 1792) probably covered much of tropical Asia from perhaps as far west as Mesopotamia to perhaps as far east as the coast of southern China and throughout much of South and Southeast Asia. Today the wild form is considered endangered, with small populations remaining in parts of eastern India, Nepal, and northern Southeast Asia. The domestic form, *Bubalus bubalis* (Linnaeus, 1758), however, has been taken by humans well beyond the presumed range of its wild ancestor to Italy and southeastern Europe, to Africa, and even to the Americas. In addition, domestic buffalo have gone feral in Sri Lanka and parts of India and Southeast Asia (Mason, 1974; Cockrill, 1984; Wilson and Reeder, 1993: 402).

Evidence for the broad prehistoric distribution of water buffalo comes from archaeology and paleontology, with bone remains or representations identified from Mesopotamia and North Syria (Zeuner, 1963; Brentjes, 1969; Boehmer, 1975; Uerpmann, 1982; Potts, 1997) and China (e.g., Han Defen, 1988; Olsen, 1993) as well as from Southeast Asia (Higham *et al.*, 1981) and South Asia (Pilgrim, 1939; Zeuner, 1963; Badam, 1979). Since the 1920s depictions of water buffalo have been known from third millennium BC Indus Valley civilization sites of northwestern South Asia, and thus some have thought that water buffalo was first domesticated in that area. In the text of his book, Zeuner (1963: 249) was cautious in this regard, noting: "*Whether the Indus Valley civilization had them in the domesticated state is not certain, though they were known as is shown by the seals (Fig. 9: 6) and they were used somehow, as bones were recovered at Mohenjo-Daro.*" In the caption of the cited figure, however, Zeuner was more direct: "*Seal impression ... from Mohenjo-Daro, c. 2500 BC, showing that the water buffalo was already domesticated in north-west India at that date.*"

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Figure 1. Map of northwestern South Asia, southern Central Asia, and eastern West Asia, showing locations of sites mentioned in the text.

Similar claims (e.g., Cockrill, 1984) have been made for Mesopotamia on the basis of late third millennium (Akkadian period) depictions, Boehmer (1975), however, has argued that water buffalo were imported to Mesopotamia from northwestern South Asia perhaps as gifts or tribute to Mesopotamian rulers and disappeared from the region after only a short period, not to be introduced again until much later. Farther east, finds of water buffalo bones in sites with the remains of rice in the Lower Yangzi Valley have led some scholars to assume the presence of the domestic animal as early as the sixth millennium BC in eastern China (e.g., Chang, 1986), an area for which there is also some paleontological evidence from at least the Early Pleistocene (Zeuner, 1963: 251; Olsen, 1993). Some years ago, Charles Higham suggested that the use of the domestic water buffalo came into Southeast Asia together with the plow from China in the second millennium BC (Higham *et al.* 1981). This is a position he no longer holds (personal communication 27 November 1997). In light of this we would argue that all water buffalo finds from prehistoric deposits throughout East and Southeast Asia need to be re-evaluated, with the operating assumption being that they come from wild animals unless it is demonstrated otherwise.

Our primary concern in this paper is not water buffalo in general, but specifically its exploitation in parts of northwestern South Asia (Fig. 1). We begin by noting some iconographic evidence for water buffalo in this region followed by discussing some of the difficulties of identifying water buffalo from zooarchaeological evidence. We then pass to the site of Santhli in North Gujarat where the bone remains of at least eight wild water buffalo individuals have been recovered. We present details of the Santhli material and compare it with water buffalo remains from the sites of Mehrgarh (Balochistan) and Dholavira (Kutch). For comparative purposes we also use data recorded from modern specimens of Pakistani Punjab. In discussing this material we provide a first step toward a better understanding of the prehistoric exploitation of the wild form, of the process leading to its domestication, and of the exploitation of the domestic form.

Iconographic evidence

As noted, prehistoric and early historic exploitation of the water buffalo in South Asia and Mesopotamia was first suggested based on depictions of the animal. Iconographic representations are particularly common from sites of the Harappan period (c. 2600-1900 BC) in northwestern South Asia where they occur as terra-cotta figurines as well as on terra-cotta and faience tablets and steatite seals. These representations are identified as water buffalo on the basis of the long backward sweeping horns that often have the horn sheath grooves depicted as transverse incisions or notches or, on figurines, sometimes as painted lines. Such a horn morphology is characteristic of the wild water buffalo and of the "Swamp" domestic form now found mostly in East and Southeast Asia (Mason, 1974; Cockrill, 1984). The domestic buffalo with short and tightly curled horns is called the "River" form and is today common as the milk producing variety of South Asia. Cockrill (1984: 55) has noted that a Harappan period "*steatite seal in the Lahore Museum shows a male Swamp-type buffalo at a feeding trough which surely indicates domestication.*" While the animal does have the long backward sweeping horns, the fact that its head is above what is said to be a feeding trough is not enough to identify it as domestic because there are depictions on Harappan seals of elephants, rhinoceros, and tigers also with their heads above similar troughs (Shah and Parpola, 1991).

Indeed some of the most graphic scenes of water buffalo in Harappan iconography show a human combating or spearing the animal. An example is provided here as Figure 2 from the site of Harappa itself. This terra-cotta tablet, impressed from a master mold from which multiple copies were made, depicts a human (probably a male) spearing a water buffalo in the context of other typically Harappan iconographic elements including the gharial and a squatting, anthropomorphic figure with a horned headdress. The man holds an upraised spear in one hand with one foot on the animal's head, while the other hand appears to pushing on the right horn.

Interpretation of scenes such as these is difficult. The animal shown in Figure 2 could be wild with a hunting scene being depicted, or it could be domestic with a form of ritual human--animal combat being presented. Similar interpretative problems occur with terra-cotta figurines. While there are many examples that clearly depict water buffalo, the domestic or wild status of these animals remains unclear. In the absence of water buffalo shown in clearly domestic pursuits such as being milked or pulling a plow, we perhaps have a better chance of characterizing their exploitation if we turn to the bone remains of these animals, although this approach has its own problems as well.

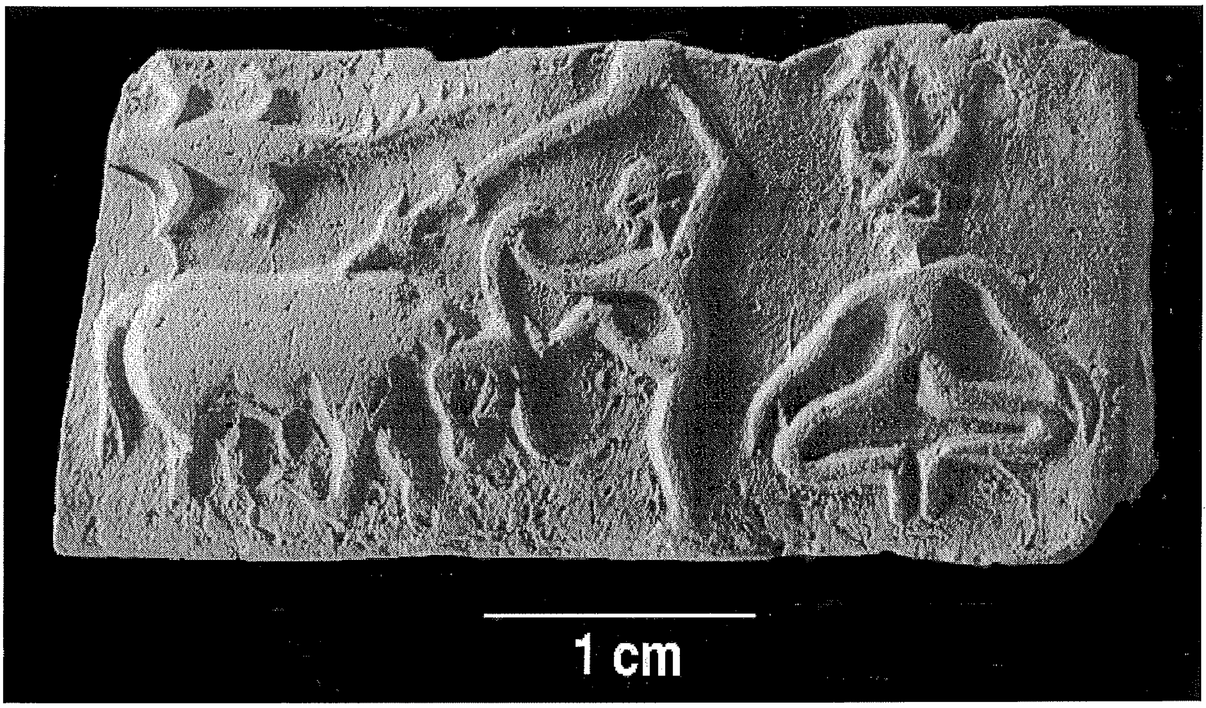

Figure 2. Reverse of a terra-cotta moulded tablet from Harappa, Harappan period. Specimen no. H95-2486/4651-01. A number of examples of this impression have been found at Harappa, all made from the same mould. In the upper left is the depiction of a gharial (*Gavialis gangeticus*) situated above the water buffalo being speared by a man while to the right is a horned human figure in feet-together "yogic" position. Photograph by Richard Meadow, courtesy of the Harappa Archaeological Research Project.

Faunal remains

Identifications of water buffalo based on bone remains were published from the Harappan period site of Mohenjo-daro by Sewell and Guha (1931) and from Harappa by Prashad (1936). These determinations were made by comparing the ancient remains with modern specimens available in the collections of the Zoological Survey of India. The reports, however, do not present details of the procedures used for making the identifications. This is unfortunate because we do not know if these investigators defined specific features that can be reliably used to differentiate water buffalo bones from those of other bovines. In our experience identifying to genus the bones of the different large bovids such as cattle (*Bos indicus* and *Bos taurus*), water buffalo, and nilgai (*Boselaphus tragocamelus*) present difficulties akin to those involved in differentiating from one another the bones of small bovids such as sheep (*Ovis* sp.), goat (*Capra* sp.), gazelle (*Gazella* sp.), and blackbuck (*Antilope cervicapra*).

To date, the most detailed publication of post-cranial differences between water buffalo and cattle is that by Higham (1975a, 1975b), who also included the gaur (*Bos gaurus*) in his study of modern and prehistoric material collected from central Thailand. Higham focused on the carpals, tarsals, metapodials, and first and third phalanges in his study, but notes characters of the tibia, humerus, radius, ulna, and lower second premolar as well (Higham, 1975a). His analysis follows on the earlier studies of Hooijer (1958) and Pilgrim (1939) who dealt with paleontological remains from South and Southeast Asia. These works - specifically the criteria for the lower third molar and lower limb bones - formed the basis for identification and publication by the second author (Meadow, 1981) of water buffalo from seventh millennium aceramic Neolithic levels at the site of Mehrgarh on the western margin of the Indus Valley. Suggested differences between the second phalanges of cattle and water buffalo were also published in that article.

More recently, the second author began a collection of modern water buffalo and zebu skeletons from the area of Harappa in Pakistani Punjab. Elaborating on the works mentioned above he documented several morphological and metrical differences between the two species, particularly with respect to the carpals and tarsals. Additional modern comparative collections have since been prepared at Harappa by Laura J. Miller (New York University) who is continuing the study in an attempt to better characterize ancient bovine exploitation at that site. In India carcasses of water buffalo and zebu were collected by the first author from dumping grounds of villages in North Gujarat and Kutch. Morphological criteria, worked out by the second author on modern collections from Pakistani Punjab, were checked for consistency and effectiveness on the material from the different populations of India by the first author. In addition, more characters were also identified on the Indian material as additional skeletons were prepared and accessioned. These newly worked out and tested criteria (publication in preparation) have served as the basis for identifying significant numbers of water buffalo bones in the large faunal assemblages from the Harappan period urban site of Dholavira located on an island in the Great Rann of Kutch (Patel, 1997). They also served to confirm identification of at least seven water buffalo uncovered at the site of Santhli, east of the Little Rann of Kutch in North Gujarat.

Climate and geography

The Ranns of Kutch are unique geographic features. Today they are low lying, flat, largely saline tracts of land that are seasonally inundated by water from the monsoon rains that fall directly on the Ranns or that flows from the many rivers that drain into the Ranns from North Gujarat to the East and Saurashtra to the South. The resultant flooding creates marshy areas, along the margins of which grow stands of vegetation that provide grazing resources for both wild and domestic animals. Elevated areas in both the Great and Little Rann today form islands that are used by humans as pastures for their animals and also for settlement. Whether these islands were ever connected to the mainland during the prehistoric period is unknown, although the presence of archaeological sites does attest to their habitation. The most noteworthy example of this is the Harappan period urban site of Dholavira on the island called Khadir Bet in the Great Rann of Kutch. To the east of the marshy zones of the Ranns is the alluvial plain of North Gujarat. Elevated zones in this plain have been identified as stabilized sand dunes on top of which a number of archaeological sites have been found (including Loteshwar and Santhli, see below).

Today in the North Gujarat and Kutch regions, raising domestic bovids (sheep, goat, cattle, water buffalo),together with crop growing on the limited arable land, are important means of livelihood. Both forms of subsistence depend upon rainfall which can vary greatly across the landscape and between years. In good years, people have historically brought their animals from as far away as Sindh and Rajasthan for grazing while a series of poor rains can turn much of the area into virtual desert. Wild animal populations are also sensitive to these fluctuations in moisture availability, with large forms such as blackbuck (*Antilope cervicapra*), gazelle (*Gazella bennetti*), nilgai (*Boselaphus tragocamelus*), and wild ass (*Equus hemionus*) being especially affected.

Santhli

Santhli is situated north of river Banas and east of Little Rann of Kutch in the Banaskantha district of Gujarat. Parts of the site were excavated during the 1993-94 field campaign by a team, that include the first author, from the Department of Archaeology and Ancient History, M.S. University of Baroda. On the surface, an area of 120 by 90 m was found to be covered by discrete concentrations of

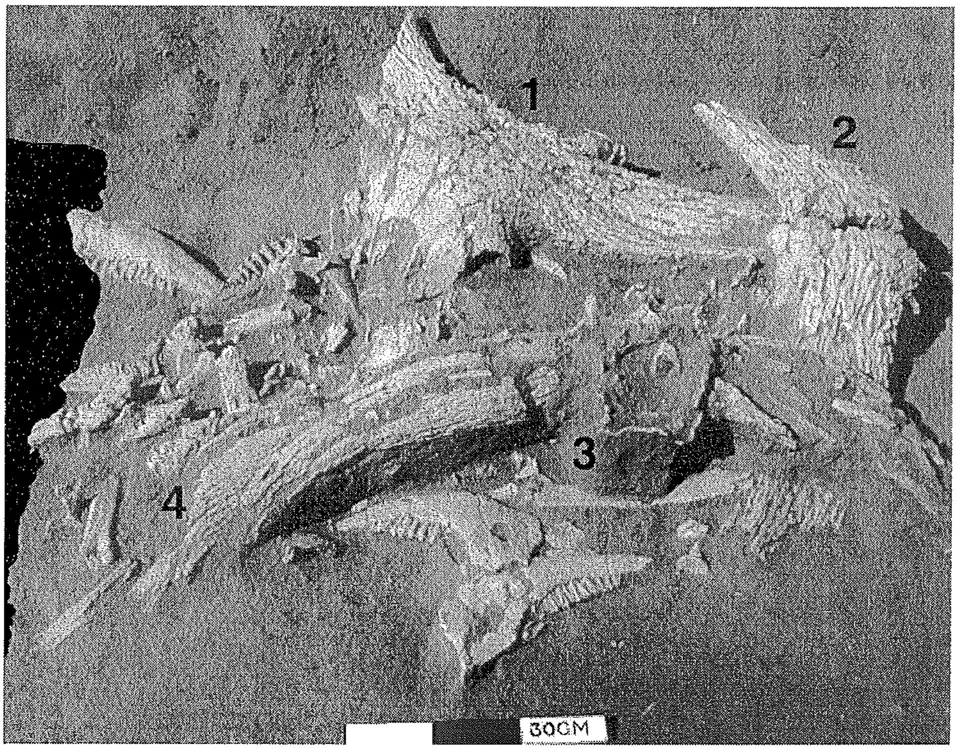

Figure 3. Santhli bone deposit, eastern extension of Trench IV (EEAC1). Photograph shows overall view from the east, of the remains of at least four water buffalo. Cranium 1 was deposited before Cranium 2 which, in turn, was deposited before Cranium 3; Cranium 4 was also deposited before Cranium 3, the facial portion of which in missing. Also illustrated are five half-mandibles and various post-cranial elements including the articulated tarsals and metatarsal shown in greater detail in Figure 4. Photograph by Ajita Patel, courtesy of the Department of Archaeology and Ancient History, M.S. University of Baroda.

artifacts. Total habitation deposits amounted to just 40 cm with no evidence of any structural features. Two periods of occupation were identified: Periods I and II.

Period I at Santhli is an Aceramic deposit with both geometric and non-geometric microlithic tools. These include lunates, triangles, trapezes, borers, backed blades, points and other varieties. The tools are made from siliceous materials including chalcedony, chert, jasper and agate. There are also a number of small pieces of sandstone called "palette stones" and tool manufacturing debitage (blade-cores, flake-cores and flakes). Of particular significance in this deposit at Santhli are clusters of bones of large mammals including skulls of at least eight bovines together with post-cranial remains. Based on their skull morphology and size we have identified these as having come from wild water buffalo (*Bubalus arnee*). Other faunal remains from these deposits come exclusively from wild animals including especially the blackbuck (*Antilope cervicapra*).

Period II is a Ceramic deposit of about 10-15 cm thickness. It is patchy with a few pottery sherds and shell beads and bangles. Important features of this occupation are two extended inhumation burials. One of these is a joint/double burial of two adult individuals with five ceramic vessels of different shapes. These vessels are similar to the pottery found in the burials at Nagwada, a site situated close to the eastern margin of the Little Rann of Kutch (Sonawane and Ajithprasad,1994). The second burial is that of a child; like the first it was furnished with ceramic vessels but no other grave goods. Both in their shape and decoration the "Burial pottery" is said to resemble the pottery found at the pre-Harappan levels of Kot Diji, Amri in Sindh and Balakot in southeastern Balochistan. On this basis a late fourth and early third millennium date is assigned to the Burial pottery (Ajithprasad and Sonawane, 1994).

As far as absolute dates are concerned, North Gujarat sites including Santhli face a problem of preservation of datable organic material. Charcoal is not preserved at all and bones are leached or concreted. This is due to the soil conditions and the continuous leaching of calcium salts creating calcium carbonate concretions in the sediment which become encrusted on the archaeological material. Organic matter that is impregnated with these salts has a very low probability of having any datable material being preserved.

One site where it has been possible to obtain radiocarbon determinations is Loteshwar located on the margin of a salty waste depression north of river Rupen in Mehsana district of North Gujarat. As at Santhli, the site has two components: Aceramic (Microlithic) and Ceramic (Chalcolithic). Samples of charcoal found in pits with Chalcolithic ceramics have given conventional calibrated dates of 2921 and 3698 BC (PRL-1564, PRL-1565: Sonawane and Ajithprasad, 1994; Possehl, 1994). Most of the deposit at Loteshwar, however, is Aceramic from which no charcoal has been recovered. As at Santhli, these levels are characterized by the presence of faunal remains exclusively from wild animals. One burned humerus of blackbuck has provided an AMS date of 6630 ± 160 bp (CAMS-35362) which can be calibrated to approximately 5550 BC. This determination is what is termed a "total organic carbon bone date" and as such provides a minimum age for the specimen (Ajita Patel, paper in preparation). Given the broadly similar nature of the archaeological remains at Loteshwar and Santhli, it is possible that the Aceramic (Period I) at Santhli could also date to the sixth millennium BC, but this remains to be established through future investigations.

Element	Eastern Exten.	Trench IV	Total	Expected [MNI=8]	% of Expected	MNI by element	% of Max. MNI
Cranium	7	1	8	8	100.0%	8	100.0%
Mandible	6	1	7	16	43.8%	6	75.0%
Atlas	2	1	3	8	37.5%	3	37.5%
Axis	1	0	1	8	12.5%	1	12.5%
Cervical V.	22	1	23	40	57.5%		
Thoracic V.	7	1	8	96	8.3%		
Lumbar V.	1	0	1	48	2.1%		
Sacrum	1	1	2	8	25.0%	2	25.0%
Rib	12	8	20	192	10.4%		
Scapula	0	0	0	16	0.0%	0	
Humerus	3	1	4	16	25.0%	3	37.5%
Radius	5	1	6	16	37.5%	5	62.5%
Carpals	12	2	14	96	14.6%	3	37.5%
McIII+IV	6	0	6	16	37.5%	4	50.0%
McV	1	1	2	16	12.5%	2	25.0%
Innominates	2	1	3	16	18.8%	2	25.0%
Femur	3	1	4	16	25.0%	4	50.0%
Patella	1	0	1	16	6.3%	1	12.5%
Tibia	1	2	3	16	18.8%	2	25.0%
Tarsals	11	0	11	96	11.5%	3	37.5%
MtIII+IV	2	0	2	16	12.5%	1	12.5%
Sesamoids	3	3	6	192	3.1%		
Ph 1	6	2	8	64	12.5%		
Ph 2	6	1	7	64	10.9%		
Ph 3	1	1	2	64	3.1%		

Notes for Table 1: in the Eastern Extension, one atlas, one axis, and five cervical vertebrae were found articulated; one distal radius and one proximal metacarpal were found with four articulating carpals each; one distal tibia was found with articulating Os malleolare, calcaneum, and talus; a complete set of tarsals was found with a metatarsal; a Phalanx 1, Phalanx 2, and Phalanx 3 were uncovered together.

Table 1. Skeletal part distributions of *Bubalus* sp. from Santhli.

The water buffalo of Santhli

As noted, the Aceramic (microlithic) deposits at Santhli included clusters of bones of large mammals with skulls from at least eight bovines. The greatest concentration of bones was in a five meter square, Trench IV, and in an approximately two meter square eastern extension of this trench (Fig. 3). A single skull and some post-cranial remains were found in the western portion of Trench IV, but the bulk of the specimens were clustered in the extension. All of the faunal material was uncovered within 40 cm of the modern ground surface and much was even more shallowly buried. Because of the way the bones had been deposited it was not possible to link cranial with post-cranial parts in the eastern extension with any degree of certainty. Most specimens, especially on their upward facing surfaces, displayed severe cracking (Behrensmeyer, 1978: Stage 4 and even 5) and were bleached white. Many teeth, however, were found in a generally good state of preservation, an apparent anomaly also observed by Behrensmeyer (1978: 153) who noted during her work in the Amboseli Basin (Kenya) that "*the weathering characteristics of teeth could not be related in any consistent way to the bone [weathering] stages.*" Because of the condition of the specimens and because they appear at least partially fossilized, it is likely that they were exposed for some time before being buried deeply enough to permit leaching and some mineralization. It is also possible that the concentration was exposed and buried more than once as sediments eroded and were redeposited in this dunal area. The excavated bone beds of Santhli were dominated by crania. One was found in the western part of Trench IV and seven in the eastern extension. Four of the latter can be seen in Figure 3 where Crania 1 and 2 are lying frontal up and Crania 3 and 4 are lying frontal down. The remaining three crania were found in deposits just below the upper four. Most post-cranial skeletal elements were also rep-

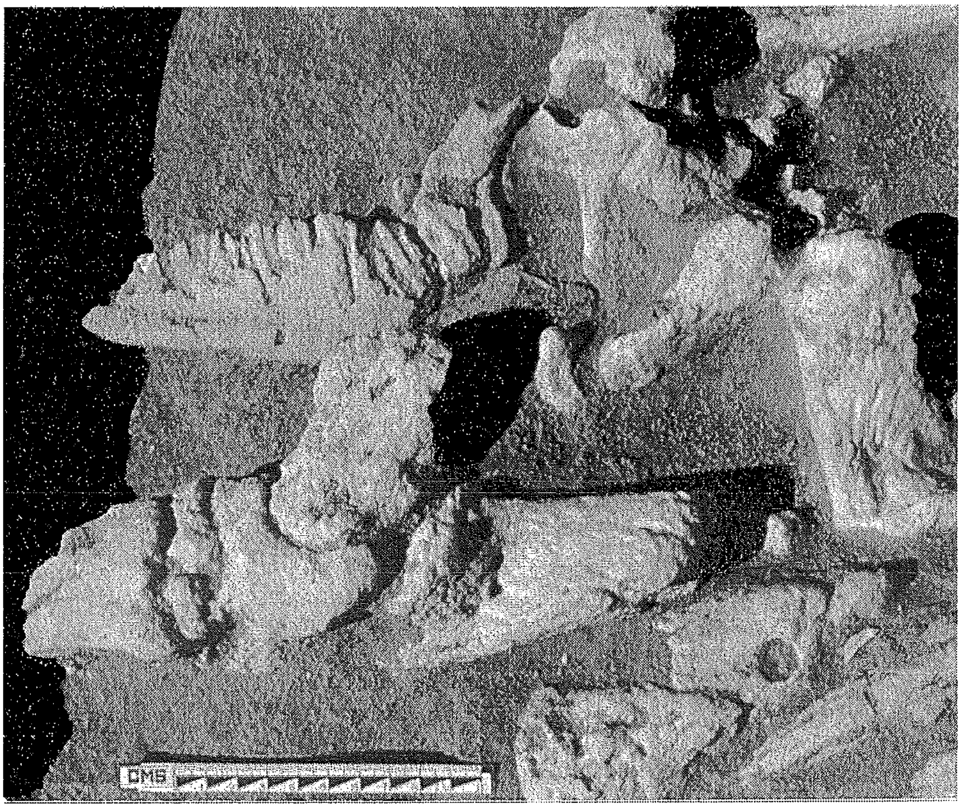

Figure 4. Santhli bone deposit, eastern extension of trench IV (EEAC1). Photograph shows articulated tarsals and metatarsal of the right hind legof a subadult water buffalo (proximal calcaneum unfused) together with the right half-mandible from a young water buffalo (M1 just erupting) and a thoracic vertebra. Photograph by Ajita Patel, courtesy of the Department of Archaeology and Ancient History, M.S. University of Baroda.

resented, but in reduced numbers compared to what would be expected given the eight skulls (Table 1 and graphically in Fig. 6). The scapula and proximal humerus are notable by their absence. Some of the post-cranial bones were found articulated including one set of seven cervical vertebrae that are likely to have belonged to Cranium 1 (partly shown in Figure 5), distal radius and carpals, distal tibia and tarsals, tarsals and metatarsal (Fig. 4), and an extremity (Fig. 5).

The Santhli crania lack intact maxillary dentition because their face portions had been destroyed. However, associated with the seven crania in the eastern extension are six half-mandibles, all six of which come from different individuals (five are shown in Fig. 3). Judging from the state of tooth eruption and wear of those mandibles preserved well enough to characterize (Table 2), the oldest animal represented is a young adult with the third molar just coming into wear. The youngest animal is an infant with its first molar just erupting (Fig. 4).

Locus	Man#	Side	dP2	dP3	dP4	M1	M2	M3
STL EEAC1	1	L	worn flat	heavy wear	Grant-g	Grant-g	Grant-f	Grant-b
	2	R	worn flat	fully in wear	Grant-f/g	Grant-d	Grant-a	
	3	R	in wear	fully in wear	Grant-f/g	Grant-d	Grant-a	
	4	L			crown broken	crown broken	crown broken	
	5	L	n.d.	crown broken	Grant-g	Grant-g	Grant-b	Grant-a
	6	R	n.d.	n.d.	n.d.	erupting		

Note for Table 2: wear stages follow Grant (1982: figure 1).

Table 2: Tooth eruption and wear of Santhli *Bubalus* mandibles

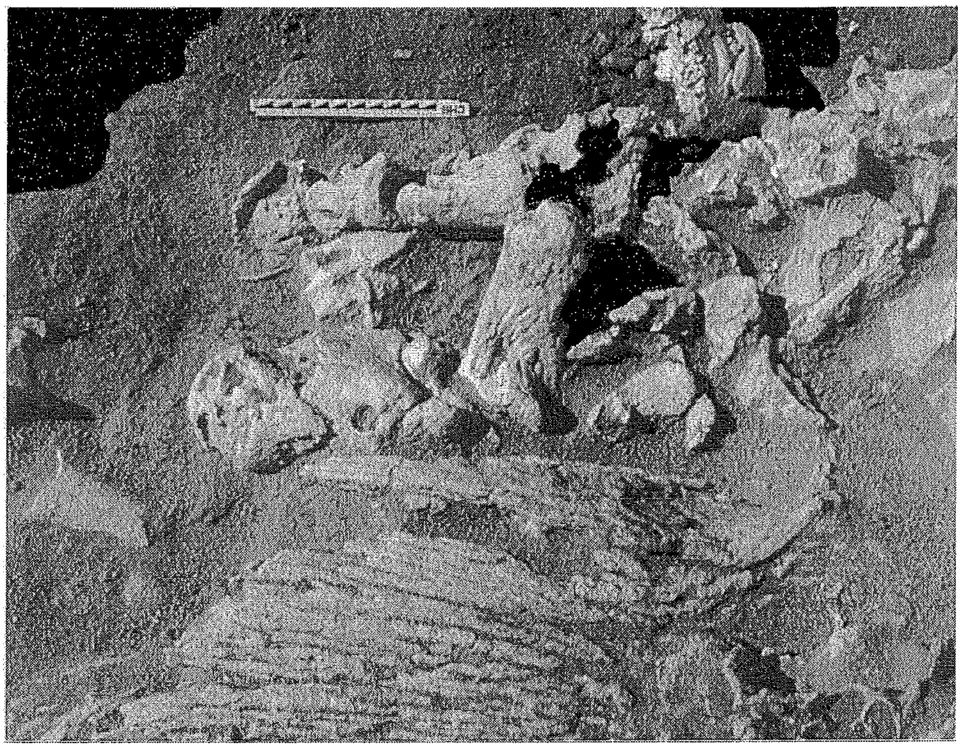

Figure 5. Santhli bone deposit, eastern extension of trench IV (EEAC1). The articulated extremity, the distal metapodial, and the articulated cervical vertebrae were found underneath the specimens noted in the caption to Fig. 4. The articulating distal tibia, talus, and particularly the vertically standing calcaneum next to the horncore of cranium 4 in the cnter of this figure also can be seen in Fig. 4 (lower right). Photograph by Ajita Patel, courtesy of the Department of Archaeology and Ancient History, M.S. University of Baroda.

Locus	Bone#	Element	Def. M1	M1	Def. M2	M2	Def. M3	M3	Def. M4	M4	Def. M5	M5	Def. M6	M6
EEAC1	116	M/3	occ. L.	39.0	GB	19.5	Cr.H	69.0						
EEAC1	60	Axis	BFcr	*106.0*	Bdens	*47.0*								
EEAC1	6	Humerus	Bd	*91.0*	Dd	*95.0*	GLmt	57.5	SLm/ct	*41.5*				
EEAC1	1	Radius	Bd	*98.0*										
EEAC1	4	Radius	Bd	98.0	BFd	98.0								
EEAC1	33	O.c. inter	L	39.0	B	*36.0*								
EEAC1	36	O.c. inter	L	37.5	B	36.0								
EEAC1	32	O.c. uln	L1	*38.0*	L2	*55.0*								
EEAC1	37	O.c. uln	L1	36.5	L2	*43.0*	D	*46.0*						
EEAC1	40	O.c. uln	L1	*34.5*										
EEAC1	41	O.c. uln	L1	*37.0*			D	*48.0*						
EEAC1	42	O.c. uln	L1	*41.0*	L2	*51.0*	D	*48.5*						
EEAC1	34	O.c. I+III	D	55.0	B	49.0	L	*28.0*						
EEAC1	35	O.c. IV	B	48.0	D	*46.5*	L	*36.5*						
EEAC1	39	O.c. IV	B	42.5										
EEAC1	7	McII+IV	Bp	88.8	Dp	*53.0*	BFII+III	*52.0*	DFII+III	45.0	DFp	49.5		
EEAC1	51	McIII+IV	Bp	*77.0*	Dp	*44.5*	BFII+III	*45.0*	DFII+III	*42.0*	DFp	*42.5*		
EEAC1	11	McIII+IV	BFd	86.0	Bd	76.0	BFmd	40.5	BFld	39.0	DFmtd	27.0		
EEAC1	11	McIII+IV	BFd	86.0	DFltd	25.0	DFmd	*41.0*	DFld	*40.0*	DD	32.5		
EEAC1	12	McIII+IV	BFd	85.0			BFmd	40.5	BFld	40.0	DFmtd	29.0		
EEAC1	12	McIII+IV	BFd	85.0	DFltd	28.5	DFmd	*40.0*	DFld	*44.0*				
EEAC1	9	Pelvis	LA	*85.0*										
EEAC1	14	Femur	DC	*56.5*										
EEAC1	15	Femur	DC	65.0										
EEAC1	13	Patella	GL	*71.0*										
EEAC1	21	Tibia	Bd	73.0	Dd	55.5								
EEAC1	24	O.M.	GL	*35.5*										
EEAC1	20	Talus	GLl	89.5	GLm	*85.5*			Bd	*62.0*				
EEAC1	23	Talus	GLl	83.5			Dl	42.5	Bd	*50.0*				
EEAC1	22	Calcan.	GL	161.0	Bd	50.0	Dd	66.7	LTc	101.0				
EEAC1	48	O.t. c+IV	GB	*75.0*										
EEAC1	49	O.t.II+III	D	*49.0*	B	31.0	L	16.5						
EEAC1	43	Ph 1							SD	*40.0*				
EEAC1	27	Ph 1 pst.			Bp	36.2							Dp	41.4
EEAC1	28	Ph 2 pst.	GL	*57.5*			Bd	34.5	SD	33.0	Dd	38.5		
EEAC1	30	Ph 2 pst.	GL	51.5	Bp	34.0			SD	28.0			DFp	33.3
EEAC1	Cran.	Occipital	vdD 30	151.5										
EEAC1	Cran.	Frontal	vdD 32	280.0										
EEAC1	Cran.	HC - Rt	vdD 45	176.5										
EEAC1	Cran.	HC - Lft	vdD 45	166.0										
TRIV	Cran.	Cranium	vdD 30	*135.0*	vdD 32	*224.0*	vdD 33	233.0						
TRIV	Cran.	HC - Rt	vdD 45	105.0										
TRIV	Cran.	HC - Lft	vdD 45	114.0	out cur	540.0	in curv	580.0	line	530.0				
EEAC1	Man-1	Mand - L	vdD 3	115.0	vdD 5	282.0	vdD 6	*360.0*	vdD 7	180.0	vdD 8	109.0	vdD 9	71.0
EEAC1	Man-1	Mand - L	vdD 12	*189.0*	vdD 13	168.0	vdD 14	247.5	vdD15a	97.5	vdD15b	67.5	vdD15c	52.5
EEAC1	Man-2	Mand - R									vdD15b	*54.5*	vdD 9	70.0
EEAC1	Man-3	Mand - R									vdD15b	*59*	vdD 9	67.5
EEAC1	Man-5	Mand - L									vdD15b	*63*	vdD 9	*73.0*
EEAC1	Man-1	Mand - L	occL dp2	14.2	occL dp3	21.0	occL dp4	35.0	occL M1	33.0	occL M2	35.5	occL M3	35.5
EEAC1	Man-2	Mand - R	occL dp2	8.2	occL dp3	*19.0*	occL dp4	40.0	occL M1	35.0				
EEAC1	Man-3	Mand - R	occL dp2	*8.0*	occL dp3	21.5	occL dp4	*33.5*	occL M1	*34.0*				
EEAC1	Man-5	Mand - L					occL dp4	36.5	occL M1	33.5	occL M2	39.5		

Notes 3: All specimens are *Bubalus* sp., probably *Bubalus arnee.* from Santhli. Note that because of the weathering and cracking of the Santhli specimens, many measurements are estimates; these are printed in italics. EEAC1 = Trench IV eastern extension; TRIV = Trench IV. Measurement definitions follow Von den Driesch (1976) [=vdD] and, for carpals, Stampfli (1963) [i.e., L1, L2]. Definitions for post-cranial dimensions use the same abbreviations as Von den Driesch (L=Length, B=Breadth, D=Depth (but SD=Smallest Diameter and DC=Diameter of the Caput [head]), G=Greatest, S=Smallest (Least); F=Facies articularis, l=lateral, m=medial, p=proximal, d=distal, t=trochlea, etc.). Other dimensions include: for teeth: occ.L=occlusal length; for the M/3: Cr.H=crown height of enamel taken on the lingual side from the occlusal "valley" to the apical "valley"; for the Humerus: GLmt=Greatest Length of the trochlea on the medial side and SLm/ct=Smallest Length of the trochlea in the valley between the medial trochlea and the one located more centrally in the element; for the metacarpal: II+III=articular area for the Os carpale II+III; for horncores: out cur=preserved length of outer curvature; in curv=preserved length of inner curvature; line=shortest distance from preserved distal end of the core to the base of the core.

Table 3: Measurements (in mm) of *Bubalus* bones from Santhli

Although the state of epiphyseal fusion of the post-cranial remains is in apparent agreement with the dental data, confirmation of this and any assignment of specific ages to tooth eruption and bone fusion stages must await study of these characters in modern animals.

As noted above, identification of water buffalo at Santhli was made on the basis of specific morphological features of the skeleton, particularly the skull, carpals, tarsals, and extremities. Given the large size of these identified elements, they more likely come from wild than from domestic animals (measurements in Table 3). We have documented this by comparing the Santhli specimens with modern and archaeological specimens from both Pakistan and India. The archaeological materials come from the aceramic Neolithic (c. 6500-5500 BC) and Chalcolithic (c. 4500-3500 BC) levels at Mehrgarh (District Kachi, Balochistan, Pakistan: Meadow 1981) and from Harappan (c. 2600-2200 BC) levels at Dholavira (District Kutch, Gujarat, India: Patel 1997; see Fig. 1 for locations of these sites).

For the skulls, it was possible to measure the greatest basal dimension (diameter) of horncores from two of the crania. Compared to a nearly complete water buffalo horncore from Chalcolithic Mehrgarh (basal diameter of 130 mm) one of the specimens from Santhli is larger with measurements of 175 for the right side and 166 mm for the left side. The second specimen from Santhli is smaller with dimensions of 105 mm (right) and 114 mm (left). Even so, these dimensions are large compared to modern domestic water buffalo. For example, two modern specimens of a domestic "River" breed from Harappa have provided the following diameters: 79 mm (right) and 77.5 mm (left); 53.5 mm (right) and 51.5 (left). These are about half the size of the specimens from Santhli which, however, are configured in the backward sweeping arc typical of modern "Swamp" breeds as well as of wild *Bubalus arnee*. The differences in basal horncore diameters thus might be attributed

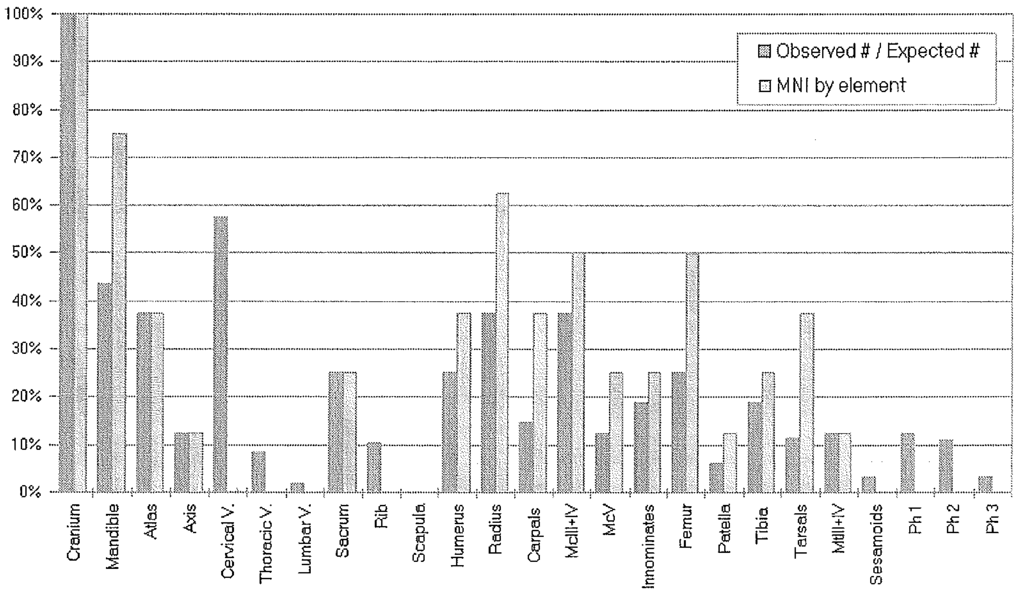

Figure 6. Santhli: percentages of expected skeletal parts. Based on the data in Table 1, this figure uses two different algorithms to illustrate skeletal part distributions for the Santhli water buffalo. The darker bars represent proportions calculated directly from the counts of different elements without any attempt to evaluate specimen symmetry, state of epiphyseal union, or other individualizing features. Thus, for each archaeological element the raw frequency ("Observed #") is divided by the number of that element found in the living animal ("Expected #"). The lighter bars represent the minimum number (and in some cases the actual number) of individuals calculated on an element by element basis using all available information (Symmetry, state of epiphyseal union, etc.). Vertebrae, ribs, sesamoids, and phalanges were not evaluated using this second technique.

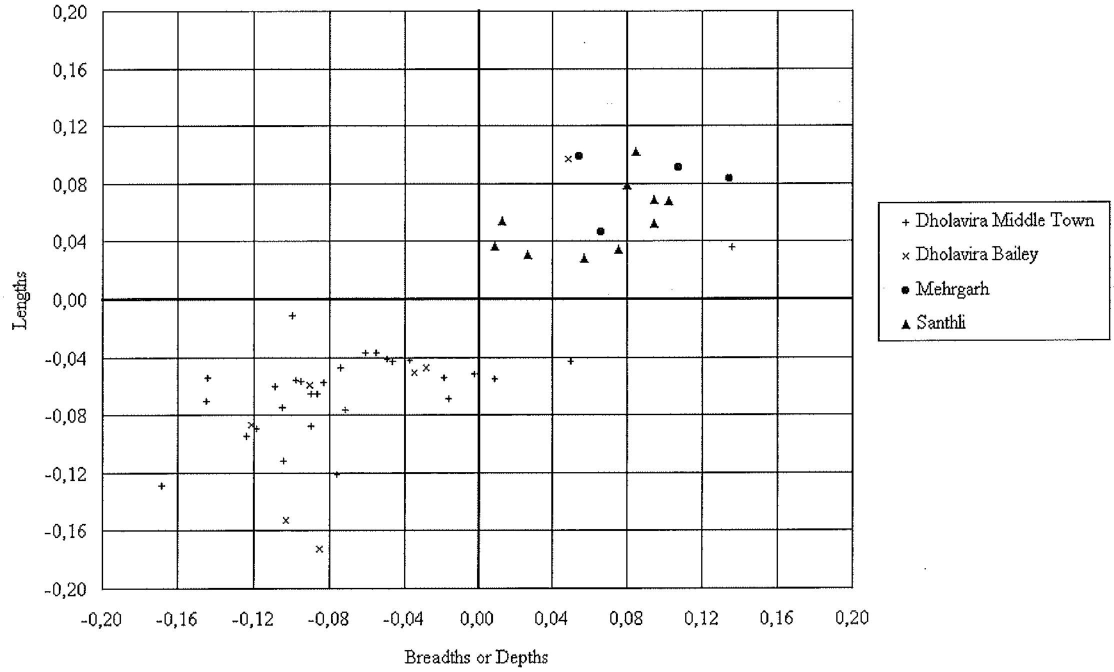

Figure 7. Scatter plot of log differences for 50 water buffalo bones from Santhli, Dholavira and Mehrgarh, when compared to a modern standard. See the text for explication of the technique and Tables 3 and 4 for the data. Since breadth and depth dimensions reflect the weight of the animal and length dimesions the height of the animal, the two are provided with different axes. On the x-axis, the breadth dimesnsion for a specimen was used when available; otherwise a depth dimension was used. The "Bailey" and "Middle Town" are two sectors of Dholavira (see Patel, 1997).

to breed difference except for the fact that this difference in size between the Santhli and modern skulls is confirmed by dimensions of least occipital breadth and least frontal breadth and also by post-cranial measurements (Table 3).

Post-cranial measurements are plotted in Figures 7 and 8 using the difference of logarithm technique that was first employed by Meadow (1981) for documenting the size diminution that accompanied animal domestication. This technique involves subtracting the log (base 10) of a "standard dimension" from the log of the comparably measured dimension of an archaeological specimen. The dimensions used as standards for water buffalo are presented in Table 4. They are averages of measurements taken on a number of modern domestic water buffalo from Pakistani Punjab (District Sahiwal, near Harappa). The coefficients of variation show that there is minimal variability in this collection, which is from a population of subadult to old females of the "River" type that were kept for their milk. In Figure 7 the log differences are displayed in a scatter plot of length dimensions versus breadth or depth dimensions, whichever was possible to measure on a specific specimen. Points in the upper right quadrant are larger than the standard along both axes; those in the lower left are smaller along both axes. Points in the lower right quadrant are larger than the standard in breadth or depth, but smaller in length. In Figure 8, the number of specimens with log differences of breadth dimensions falling into specific ranges are presented as a series of bars. This serves to highlight similarities and differences between the different assemblages and permits the inclusion of specimens for which only a single dimension could be measured.

Specimens used to plot Figures 7 and 8 come from Santhli, aceramic Neolithic Mehrgarh, and Dholavira. All dimensions from Mehrgarh and Santhli water buffalo are larger than the standard in both length and breadth or depth. The Dholavira dimensions are smaller than the standard with only

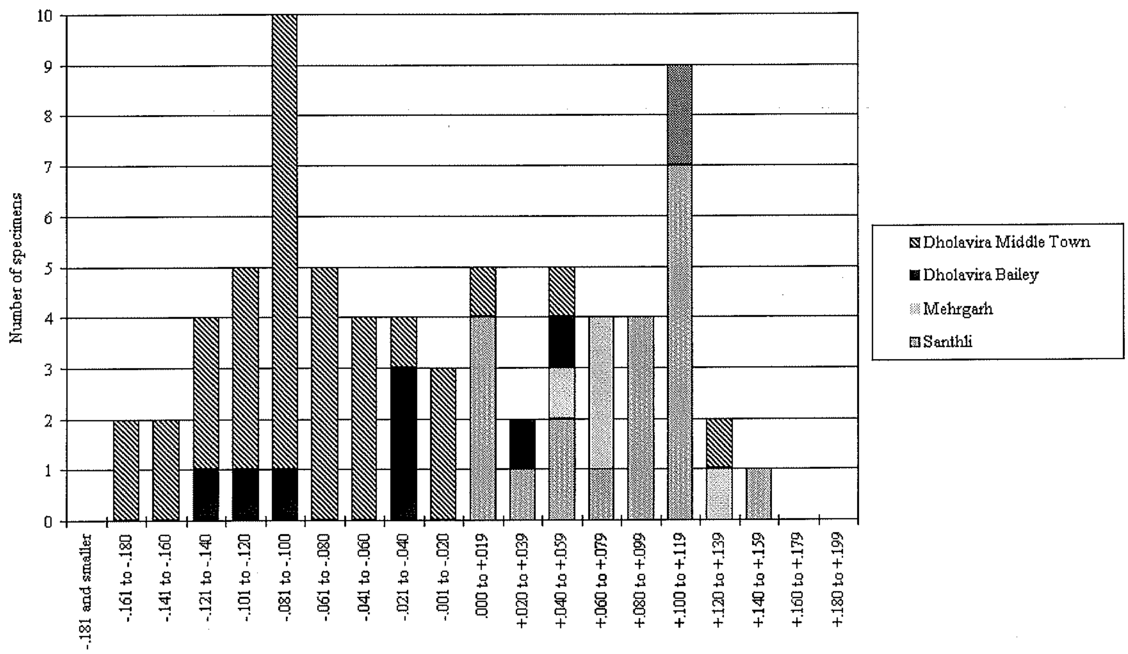

Figure 8. Bar chart showing distribution of log differences for breadth measurements of 71 water buffalo bones from Santhli, Dholavira and Mehrgahr. see text for explanation of the technique and Tables 3 and 4 for the data.

four exceptions, two each in the upper right and lower right quadrants of Figure 7. These distributions confirm the large size of the Santhli specimens as noted for the skulls and show that they are of a size comparable to those from Mehrgarh located at the foot of the Balochistan mountains far to the northwest. They also indicate that the Dholavira water buffalo were generally much smaller than those from Santhli and Mehrgarh, although there are the exceptional larger and/or heavier animals represented in the bone remains.

As noted, most and perhaps all of the water buffalo remains from Santhli appear to have come from infant to young adult animals. Cranial dimensions suggest that both males and females may be represented in the collection, although definitive determinations have not been possible in the absence of sexable portions of pelves and of a larger collection of post-cranial remains.

Discussion

Although direct evidence for human exploitation of the Santhli water buffalo is lacking, it seems likely that humans were involved in creating the deposit. Given the often cracked and sometimes eroded condition of the surfaces of the bones, it was not possible to determine if any specimens bore cut marks or other signs of butchery. Nevertheless the presence of microlithic tools along with the bones does suggest human activity associated with the deposit. Whether this activity is the scavenging of carcasses of animals killed by another agency or the killing and butchering of animals by a hunting party is also not possible to determine unequivocally. A hunting scenario is supported by the fact that the water buffalo were neither extremely young nor very old; these are not animals one would expect to be easily predated by wild carnivores. The deposits are also not in an environment where one would expect that prime animals would be susceptible to death by natural agents such as floods. Drought conditions, however, could have contributed to the water buffalo becoming concentrated in wetter low-lying areas where they would be more exposed to human predation.

As far as skeletal part distributions and articulations are concerned, the assemblage is both highly ravaged and partially intact. Thus there are no scapula or proximal humeri represented and the face portions and ends of horncores of all skulls are largely destroyed (although to what extent this may have been post-depositional destruction is unclear). Yet there are some fully articulated joints and parts of limbs from lower legs, both front and rear, and crania are the most frequently represented part of the skeleton. In the eastern extension crania are piled up one on top of the other as if they had been thrown into a depression, with other material - including the articulated joints and limbs - tossed on top. Such a bone pile is not what one would expect from a carnivore ravaged assemblage. Instead one can argue that a number of animals were killed and butchered near the area of the bone pile, and that unwanted, less meaty, or unmanageable portions of the carcass and skeleton were left behind. The presence of articulated joints and lower limbs is consistent with there being a surfeit of meatier areas of the skeleton with consequently less attention needing to be paid to the less meaty parts.

That the Santhli water buffalo were wild is suggested by the large size of their bones. The bone dimensions are generally larger than those of "improved" modern domestic "Swamp" animals of the Punjab and considerably larger that the small domestic water buffalo characteristic of North Gujarat today. They are of a size comparable to specimens identified as water buffalo from what are likely to be contemporary or perhaps somewhat earlier levels at the site of Mehrgarh on the eastern margins of Balochistan. They are also of a size comparable to a few specimens from the site of Dholavira in neighboring area of Kutch. Much of the Dholavira material that has been identified as water buffalo, however, is much smaller than that from Santhli. This indicates that considerable size diminution had taken place by the middle of the third millennium BC and that the animals from Dholavira are domestic.

The water buffalo bones from Santhli thus provide a unique standard against which other South Asian water buffalo material can be compared. They give us essential metrical and morphological data for a poorly known animal that was native to a large area of Asia. For this reason, further excavations at Santhli and at nearby sites that may have similar bone concentrations is required. Once a large corpus of data has been accumulated we will have a solid baseline against which subsequent developments in the exploitation of this animal can be evaluated. For this study we have used a collection of modern water buffalo of the "River" breed for our standard. In fact, the history of the development or introduction of this very breed, and of the production of dairy products that are integral to its exploitation, needs to be investigated, because all evidence to date from Santhli and Mehrgarh suggests that the aboriginal water buffalo of northwestern South Asia were not of the "River" but of the "Swamp" type.

To date there is one piece of evidence that Harappan water buffalo were also of "Swamp" type. This evidence is in the form of a horncore reported by the second author (Meadow, 1979) from the Harappan levels at Balakot, a small site located near the Arabian Sea coast northwest of Karachi (Fig. 1). The greatest basal diameter of this core is no more than 80 mm (it is broken at the base), which makes it similar in size to the modern Punjab "River" specimens noted above. As stated in the original publication, however, (pg. 302): "*Its small dimensions and thin walls suggest that it comes from a young animal. Enough of the frontal remains to show that the horn projected laterally in the plane of the forehead before curving gently back, still in the same plane. These features are characteristic of the Swamp form of water buffalo now supplanted in much of South Asia by the River breeds distinguishable by their rather tightly curled horns which, along with milk production, were traits apparently selected for over a long period.*"

No post-cranial remains of water buffalo were identified at Balakot. The situation is quite different at Dholavira where comparative osteological investigations have permitted the first author to identify significant numbers of water buffalo post-cranial specimens (for details see Patel, 1997). It is of particular interest that Figures 7 and 8 suggest that both wild and domestic forms are represented in the collection. That there were water buffalo to be hunted indicates the presence of natural habitats suitable for their survival. These could have been relatively close to the site along the margins of the

Great Rann of Kutch which may have been less filled with silted four thousand years ago than it is today and which also may have received fresh-water inflow from an eastern course of the Indus River that no longer exists today. But the water of the Rann was still probably quite saline and not suitable for either agriculture or human consumption. Thus huge efforts were expended at Dholavira to capture and store water from run-off in enormous reservoirs in what is today an area that receives little reliable rainfall (e.g., Bisht, 1994). These reservoirs could have served to water domestic stock as well as agricultural fields and the human population.

Keeping and raising water buffalo is different is some ways from husbanding other domestic bovids. While sheep, goat, and cattle can be herded extensively and moved to new grazing areas as needed, water buffalo are dependent upon better quality forage and water for soaking their hides. During the third millennium BC, they are likely to have been kept within the city itself where the reservoirs of Dholavira would have provided a reliable source of water for daily bathing. It is thus not so surprising that domestic water buffalo remains are found at Dholavira, although their presence in considerable numbers does beg the question of what they were being used for.

Today water buffalo are kept primarily for their secondary products, traction and especially milk, although their meat is also consumed and their hides are used for leather. Phillipe Gouin (1990, 1992) has suggested that milk products were important during the Harappan period, and the considerable presence of water buffalo at Dholavira lends support to this hypothesis. What needs to be investigated is how such exploitative practices are reflected in the archaeological record and, specifically, in the faunal remains. This in turn would help in characterizing the nature and extent of water buffalo exploitation in the past. Efforts have been and are being made to determine if extensive milking or traction is reflected in the nature of bone structure and bone pathology (e.g., Horwitz and Smith, 1990; Bartosiewicz *et al.*, 1993; Laura J. Miller, work in progress). The extent to which such studies carried out on modern animals can be effectively and reliably applied to archaeological bovine remains in the South Asian context, however, remains to be determined. Their application to cattle and water buffalo will surely be complicated by problems of preservation, diagenesis, and identification, the same problems that bedevil the zooarchaeologist who is trying to separately characterize the exploitation of sheep and goat.

As far as the beginnings of water buffalo domestication are concerned, with the information at hand with respect to body size diminution, it seems clear that we must look earlier than the Harappan period for evidence of this process. Thus it is essential to retrieve and study large collections of bovine bones from archaeological deposits of the fourth and first half of the third millennium BC. Furthermore, it is likely that the key time for the elaboration of water buffalo exploitation was the early part of the Harappan period in the middle of the third millennium, when the Harappan phenomenon swept across large parts of northwestern South Asia. This was a time of major social and economic changes in South Asian prehistory, but it is also a time that remains poorly known in many ways despite nearly eight decades of research. We need a better understanding of the early phase of the Harappan period in all of its aspects, including faunal exploitation. Once these needs are recognized and research projects developed to address issues such as those elaborated in this paper, we can expect to make significant progress in our understanding of the history of social and economic developments in northwestern South Asia, including the exploitation of water buffalo and its integration into the urban economy.

Looking farther afield, the careful study of water buffalo remains needs to be extended to East Asia, where this animal is considered essential to a system of rice agriculture that some believe started at least as early as the sixth millennium BC (Glover and Higham, 1996). But as yet, there are no detailed analyses of water buffalo remains from archaeological sites in China. We have thus barely begun to document and understand the complex history of an animal little appreciated in the West but essential to agricultural or dairy production throughout all of the southern part of Asia.

Acknowledgments

We wish to thank the directors and personnel of the various archaeological projects under whose auspices the faunal materials discussed in this paper were collected. These include: 1) the Santhli excavations of the Department of Archaeology and Ancient History, Faculty of Arts, M.S. University of Baroda, under the overall direction of Prof. V.S. Parekh, Head; 2) the Dholavira excavations of the Archaeological Survey of India, Government of India, under the field direction of Shri Ravindra Singh Bisht; 3) the Harappa Archaeological Research Project first under the direction of the late Prof. George F. Dales, Jr., and currently directed by the second author together with Prof. Jonathan Mark Kenoyer, and Prof. Rita P. Wright; and 4) the French Archaeological Mission to Pakistan directed by Dr. Jean-François Jarrige. The first author wishes to acknowledge the indispensible assistance of Jaimal Rasan and Ghani Usman in processing the Dholavira faunal materials. The second author for the same purpose at Harappa acknowledges Jay Knight and Tonya Largy and, at Mehrgarh, Nerissa Russell and Jay Knight.

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Table 4: Post-cranial skeletal measurements (in mm) of modern *Bubalus bubalis* from the area around Harappa District Sahiwal, Punjab, Pakistan.

Scapula	Meas.	SLC	GLP	LG	BG	HC	HS	Lp
	n	8	8	8	8	8	8	6
	mean	62.7	82.7	64.1	52.0	64.7	363.4	219.6
	s.d.	4.3	3.3	4.2	2.1	4.7	14.5	13.5
	V	6.9	4.0	6.5	4.1	7.2	4.0	6.1

Humerus	Meas.	Bd	BT	SD	Bp	Dp	GLC	GL	Dd	GLmt	SLm/ct
	n	10	11	10	8	9	9	6	10	10	10
	mean	89.3	79.3	41.5	98.1	118.3	278.0	311.3	85.4	50.4	35.9
	s.d.	5.1	4.1	2.6	3.3	4.5	10.9	11.9	3.7	2.1	1.4
	V	5.7	5.2	6.3	3.4	3.8	3.9	3.8	4.4	4.2	4.0

Radius	Meas.	Bp	BFp	SD	Bd	BFd	GL	Dp
	n	11	11	11	11	11	11	10
	mean	85.5	77.4	43.0	76.6	76.3	309.5	44.8
	s.d.	3.2	4.4	1.8	4.7	3.8	9.7	2.5
	V	3.7	5.7	4.3	6.1	5.0	3.1	5.6

Ulna	Meas.	BPC	DPA	SDO	GL	LO
	n	9	9	10	8	9
	mean	51.4	72.1	52.0	380.7	108.3
	s.d.	1.9	3.5	4.0	17.8	5.1
	V	3.7	4.9	7.8	4.7	4.7

Os carpi radiale	Meas.	L	B
	n	11	11
	mean	34.6	31.4
	s.d.	1.7	2.0
	V	5.0	6.3

O.c. intermedium.	Meas.	L	B
	n	11.0	11.0
	mean	33.3	29.0
	s.d.	1.1	1.7
	V	3.5	5.9

O.c. ulnare	Meas.	L1	L2	B
	n	11	11	11
	mean	34.2	41.0	40.4
	s.d.	1.4	2.5	1.2
	V	4.0	6.0	2.9

O.c.II+III	Meas.	D	B	L
	n	11	11	11
	mean	38.8	37.6	19.1
	s.d.	1.3	1.0	0.9
	V	3.3	2.6	4.9

O.c. IV	Meas.	B	D	L
	n	10	10	10
	mean	34.1	32.1	28.2
	s.d.	1.7	2.0	1.3
	V	5.0	6.3	4.6

Metacarpal	Meas.	Bp	Dp	SD	Bd	Dd(ep)	GL	DD
	n	11	11	11	11	11	11	11
	mean	67.7	41.0	40.0	71.7	37.9	191.7	23.8
	s.d.	3.0	1.2	2.7	3.9	1.6	7.3	2.5
	V	4.4	3.0	6.8	5.4	4.2	3.8	10.6

Pelvis	Meas.	LA/LAR	SH	SB	LFO	GBA	SBI
	n	12	12	12	11	4	4
	mean	75.5	46.9	33.2	93.5	277.9	195.9
	s.d.	4.0	2.1	3.2	7.5	20.2	19.5
	V	5.3	4.6	9.6	8.0	7.3	10.0

Femur	Meas.	Bp	DC	SD	Bd	BTP	GLC	GL	Dd
	n	3	16	16	15	8	16	4	8
	mean	129.9	50.7	39.8	107.8	57.0	371.4	379.5	136.1
	s.d.	0.7	2.4	2.0	2.9	1.9	12.2	9.9	3.5
	V	0.5	4.8	4.9	2.7	3.4	3.3	2.6	2.6

Tibia	Meas.	Bp	SD	Bd	Dd	GL	Dp
	n	14	16	16	16	16	15
	mean	110.0	42.1	71.6	53.6	357.3	98.0
	s.d.	4.4	2.5	3.1	2.1	13.2	4.4
	V	4.0	5.9	4.4	3.9	3.7	4.5

Os malleolares	Meas.	L	D
	n	15	15
	mean	29.1	37.9
	s.d.	1.9	2.0
	V	6.5	5.1

Talus	Meas.	GLl	GLm	Dl	Bd	Bp
	n	16	16	16	16	16
	mean	76.6	71.9	42.0	49.0	46.9
	s.d.	2.1	1.9	1.5	2.0	1.6
	V	2.7	2.6	3.5	4.1	3.3

Calcaneum	Meas.	GL	D	DTuber	GB	LTuber
	n	14	16	15	15	14
	mean	147.0	62.8	37.4	55.5	94.1
	s.d.	5.4	2.1	1.9	3.2	3.4
	V	3.7	3.3	5.1	5.7	3.6

Os tarsus c.+IV	Meas.	B	D
	n	16	16
	mean	63.9	57.3
	s.d.	3.2	2.8
	V	5.0	4.8

O.t. II+III	Meas.	D	B	L
	n	16	16	16
	mean	41.4	24.5	13.6
	s.d.	1.5	1.6	1.9
	V	3.7	6.3	13.7

Metatarsal	Meas.	Bp(true)	Bp	Dp	SD	Bd	Dd(ep)	GLwoPp	GL	DD
	n	16	16	16	16	16	16	16	16	16
	mean	57.2	55.4	50.6	34.3	65.5	38.5	223.4	230.7	29.5
	s.d.	2.6	2.5	3.2	2.9	2.9	1.5	8.8	8.7	1.8
	V	4.5	4.6	6.2	8.6	4.4	3.8	3.9	3.8	5.9

Phalanx 1	ant.	Meas.	GLpe	Bp	Bd	SD	Dp	PL
		n	22	22	22	22	22	22
		mean	63.9	37.7	34.0	32.6	35.0	58.3
		s.d.	2.0	1.4	2.4	2.2	1.9	2.1
		V	3.1	3.8	7.0	6.9	5.5	3.7

Phalanx 1	post.	Meas.	GLpe	Bp	Bd	SD	Dp	PL
		n	32	32	32	32	32	32
		mean	66.6	34.7	31.7	29.1	37.5	61.1
		s.d.	2.5	1.3	1.9	2.2	1.8	2.3
		V	3.8	3.8	5.9	7.5	4.9	3.8
Phalanx 1	ant. & post.	Meas.	GLpe	Bp	Bd	SD	Dp	PL
		n	54	54	54	54	54	54
		mean	65.5	35.9	32.7	30.6	36.5	59.9
		s.d.	2.7	2.0	2.4	2.8	2.2	2.6
		V	4.1	5.5	7.3	9.2	6.1	4.4
Phalanx 2	ant.	Meas.	GL	Bp	Bd	SD	Dp	PL
		n	22	22	22	22	22	22
		mean	44.5	36.0	30.8	28.3	33.5	39.9
		s.d.	1.8	1.9	2.3	2.3	1.2	1.5
		V	4.1	5.3	7.6	8.3	3.5	3.7
Phalanx 2	post.	Meas.	GL	Bp	Bd	SD	Dp	PL
		n	30	31	30	30	30	30
		mean	46.3	34.2	28.1	26.1	34.1	42.8
		s.d.	1.7	1.6	1.8	1.4	1.2	1.7
		V	3.6	4.6	6.4	5.3	3.5	3.9
Phalanx 2	ant. & post.	Meas.	GL	Bp	Bd	SD	Dp	PL
		n	52	53	52	52	52	52
		mean	45.6	35.0	29.2	27.0	33.9	41.6
		s.d.	1.9	1.9	2.4	2.1	1.2	2.1
		V	4.2	5.5	8.3	7.9	3.6	5.1
Phalanx 3	ant.	Meas.	GL	Ld	MBS	BFp	HFp	
		n	22	22	22	22	22	
		mean	81.2	61.7	27.8	27.8	34.2	
		s.d.	4.0	3.5	1.5	1.7	2.4	
		V	4.9	5.7	5.5	6.2	7.1	
Phalanx 3	post.	Meas.	GL	Ld	MBS	BFp	HFp	
		n	30	31	31	31	31	
		mean	78.5	63.3	25.5	27.2	33.3	
		s.d.	6.1	5.8	1.5	1.7	1.9	
		V	7.7	9.1	6.1	6.4	5.8	
Phalanx 3	ant. & post.	Meas.	GL	Ld	MBS	BFp	HFp	
		n	52	53	53	53	53	
		mean	79.6	62.6	26.4	27.4	33.7	
		s.d.	5.4	5.0	1.9	1.7	2.2	
		V	6.8	7.9	7.2	6.3	6.5	

Notes for Table 4: Generally low coefficients of variation (V) indicate a rather homogeneous population. Measurement definitions follow von den Driesch (1976) [=vdD] and, for carpals, Stampfli (1963) [i.e., L1, L2]. For further information see notes to Table 2.