

RESEARCH PAPER

Smaller but not Secondary: Evidence of Rodents in Archaeological Context in India

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The small site archaeology has a remarkable potential to contribute on many greater issues in archaeological studies. Similarly, micro dimensional data of any category should prove to be of great importance if studied judiciously. The present paper intends to point out this very fact with a special reference to skeletal remains of micromammals in the category of rodents as a special case. This topic has been specifically undertaken because it is largely observed that such skeletal material tends to be overlooked and sometimes even totally discarded as of no archaeological significance.

Rats and mice (muroids, Order: Rodentia) are one of the world's ubiquitous small rodents whose antiquity in India goes back to the Tertiary period. Its skeletal remains have been reported from several archaeological sites in India with temporal range of about 20 ka. Rodents have the potential to provide palaeoenvironmental information not attainable from other animal groups. The fact is well appreciated in palaeontology but unfortunately remains to be confronted in archaeological context so far. The present paper ventures to ponder upon the possibilities of palaeoenvironmental interpretations of rodent fauna in archaeological record. A sizable assemblage of microvertebrates excavated from an Early Historic site of Kopia, Dist. Sant Kabirnagar (Uttar Pradesh state of India) offers a case study of microfaunal interpretations. Evidence of murid's contribution to the diet of ancient human population is discussed with reference to several existing hunting gathering communities practicing small game and the *Musehars*, aborigines living in the interiors of Gangetic plains. It provides a ready database for the dietary inferences with regard to the rodent fauna that are interpreted from archaeological perspective. The paper demonstrates multifold implications of evidence of rats and mice in archaeological record that have significant bearing on the ecology, subsistence and behavioural archaeology.

Keywords: Rodents; small game; diet; ecology; subsistence; Indian archaeology

Introduction

Rodents are one of the most ubiquitous species of small mammals in the world. In the course of its evolutionary history, the rodents have diversified into various species, inhabiting every available space except the arctic region. Their distribution across the world is marked by a variety of habitats. The advantages of having wider range of potential microhabitats are facilitated by heterogeneity in the range of food types. Besides they are climate sensitive and their response to environmental change is rapid.

Muroids (rodents belonging to family muridae and cricetidae) are major representatives of Rodentia, which include more than 25 species from the geological past of India. Most of them are omnivorous. They have differential distribution eventually determined by variety of habitats, spread across the terrestrial length and breadth of the

world. Even though smaller in size, bearing extreme nuisance value both in the farms as well as habitational areas; rodents, especially in the category of rats and mice have left deep impressions on the human psyche. The resultant corpus of literature including fables and folklores offer a glimpse of animal behaviour and its particular status in Indian mythology. Eventually the study of rodents presents a wide range of issues including ecological, dietary, socio-economic and mythological that render them unique in the field of art and science of Indian Archaeozoology.

Relevance of Pleistocene Species

In India the first ever discovery of rodents amounting to five species was made by Richard Lydekker in 1886 in the deposits of Kurnool caves in Andhra Pradesh which is assigned to Terminal Pleistocene (Murty 1975, Prasad 1996). Hundred and twenty five years after, now we know of more than twenty five species of rodents known from Eocene to Pleistocene and Holocene sites in India (**Table 1** and **2**). The earliest record of rodents in India is available from Subathu Formation (Eocene) in NW India (Sahni and Srivastava 1973). The fossil rodent fauna

Table 1: Distribution of small rodent fauna in Geological Formations in India.

Taxon	SBTH	CHNJI	NGRI	DHK-PTH	TATROT	PNJR	KRWS	NMD	KRL	SON	Reference
Paramyidae											
<i>Birbalomys Woodi</i>	√	–	–	–	–	–	–	–	–	–	Sahni & Srivastava 1973
<i>Metkamys Blacki</i>	√	–	–	–	–	–	–	–	–	–	Sahni & Srivastava 1973
Rhizomidae											
<i>Rhizomyodes cf. R. Sivalensis</i>	–	–	–	√	√	–	–	–	–	–	Flynn 1982, Patnaik 1995a
<i>Rhizomyodes Nagri</i>	–	–	√	–	–	–	–	–	–	–	Flynn 1982
Muridae											
<i>Antemus chinjiensis</i>	–	√	–	–	–	–	–	–	–	–	Jacobs 1978
<i>Prognomys debruijni</i>	–	–	√?	√?	–	–	–	–	–	–	Jacobs 1978
<i>Mus auctor</i>	–	–	–	√	–	–	–	–	–	–	Jacobs 1978
<i>Mus flynni</i>	–	–	–	–	√	–	–	–	–	–	Patnaik 1995a
<i>Mus Platythrix</i>	–	–	–	–	–	–	–	–	√	–	Lydekker 1886
<i>Rattus sp.</i>	–	–	–	–	–	√	–	–	–	–	Gaur 1986
<i>Parapelomis robertsi</i>	–	–	–	–	√	–	–	–	–	–	Jacobs 1978, Patnaik 1995a
<i>Hydromys primitivus</i>	–	–	–	–	√	–	–	–	–	–	Patnaik 1995a
<i>Cremonmys cf. C. Cutchicus</i>	–	–	–	–	√	–	–	–	–	–	Patnaik 1995a
<i>Bandicota sivalensis</i>	–	–	–	–	√	–	–	–	–	–	Patnaik 1995a
<i>Bandicota cf. B. bengalensis</i>	–	–	–	–	–	–	–	√	√	–	Patnaik <i>et al.</i> 1995, Lydekker 1886
<i>Golunda killeri</i>	–	–	–	–	√	–	–	–	–	–	Jacobs 1978, Patnaik 1995a
<i>Golunda ellioti</i>	–	–	–	–	√	–	–	–	–	–	Lydekker 1886
<i>Apodemus tali</i>	–	–	–	–	–	–	√	–	–	–	Kotlia 1992
<i>Millardia cf. M. meltada</i>	–	–	–	–	–	–	–	–	√	√	Patnaik <i>et al.</i> 1995, Lydekker 1886
Cricetidae											
<i>Protatera cf. P. kabulense</i>	–	–	–	–	√	–	–	–	–	–	Patnaik 1995a
<i>Tatera cf. T. indica</i>	–	–	–	–	–	–	–	√	√	–	Patnaik <i>et al.</i> 1995, Lydekker 1886
<i>Gerbillus sp</i>	–	–	–	–	–	–	–	–	√	–	Patnaik <i>et al.</i> 1995
Nesomyidae											
<i>Nesokia cf. N. Hardwickki</i>	–	–	–	–	√	√	–	–	–	–	Raghavan 1992
Arvicolidae											
<i>Kilarcola indicus</i>	–	–	–	–	–	–	√	–	–	–	Kotlia & Koenigswald 1992
<i>K. indicus Sahnii</i>	–	–	–	–	–	–	√	–	–	–	Kotlia & Koenigswald 1992

Taxon	SBTH	CHNJI	NGRI	DHK-PTH	TATROT	PNJR	KRWS	NMD	KRL	SON	Reference
<i>K. kasmiriensis</i>	-	-	-	-	-	-	√	-	-	-	Kotlia & Koenigswald 1992
<i>Microtus deterrai</i>	-	-	-	-	-	-	√	-	-	√	Kotlia & Koenigswald 1992
<i>Microtus</i> sp.	-	-	-	-	-	-	-	-	-	√	Blumenschine & Chattopadhyaya 1983
<i>Pliopotamys</i>	-	-	-	-	-	-	√	-	-	-	Kotlia & Koenigswald 1992

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Subathu (Eocene).

Chinji (Lower Siwaliks, Upper Miocene).

Nagri and Dhokpathan (Middle Siwaliks, Lower to Middle Pliocene).

Tatrot and Pinjor (Upper Siwaliks, Upper Pliocene to Lower Pleistocene)).

Karewas (Plio-Pleistocene).

Narmada valley (Late-Mid Pleistocene to Late Pleistocene).

Kurnool caves (Terminal Pleistocene to Early Holocene).

Son Valley (Late to Terminal Pleistocene).

from the Neogene- Quaternary deposits of the NW India accounts for the major contribution to the study of Indian Rodentia with far greater palaeoecological implications (Patnaik 2003).

The palaeontological study of muroids has proved useful to the reconstruction of palaeoecology. Rodents spend their lifetime within a space confined only to a few kilometers hence facilitating reliable information with regard to biological environment of their distribution. On the other hand the large mammals whose long distance migrations for foraging render them unpredictable palaeoecological indicators. In the NW India there are six families of small rodents viz. paramyidae, muridae, cricetidae, rhyzomidae, nesomyidae and arvicolidae. Among them arvicolidae have been so far reliable chronological and climatic markers in South Asia. Arvicolidae (family Arvicolidae) are high altitude dwellers, presently distributed in Kashmir, Afghanistan, Indo-Pak Himalayan region and Nepal Himalayas. Their discovery in the Karewas of Kashmir revealed the evidence of climatic fluctuations in antiquity of over 2 myr. They appear 2.4 myr ago, the time which almost coincides with the age of first glaciation in the northern hemisphere (Repenning 1983). The Karewas experienced cool climate c. 2.4 myr ago. Between 2.4 to 2.2 myr the area witnessed cool to cold and glacial climate which again coincides with second appearance of arvicolidae during 0.3 to 0.4 myr when the Karewas again experienced the cold (Agrawal 1992). Murids and cricetids from the Late Pliocene to Lower Pleistocene deposits in the Siwaliks provide a precise record of the palaeocommunity of small rodents focusing on the ecological conditions of the particular region inhabited by them (Sahni and Kotlia 1985, Kotlia 1985, Kotlia 1985, Patnaik 1993 & 1995a, 2001, 2003).

The palaeoecological interpretations based on the record of muroids from the Narmada valley in central India (Patnaik 1995b, Patnaik *et al.* 1995, Kotlia and Joshi 2011) have been a significant contribution towards a reconstruction of local ecology. The explanations hitherto based on large vertebrates do not contribute to such extent of the

reconstruction of local ecology of a concentrated area since large mammals tend to move within larger areas. It has been largely observed that the large vertebrates thrive in near-bank and aquatic, and terrestrial ecological settings whereas rodents prefer sandy plains and grasslands with high sub-soil moisture. It implies a mosaic of diverse ecosystem providing sustenance to the fauna during the Late Pleistocene which also holds true for the Narmada valley (Patnaik 1995).

The faunal diversity at limestone cave deposits in Kurnool district in Andhra Pradesh provides an excellent record of palaeocommunity type during the Terminal Pleistocene and beginning of Holocene. The cave deposits have yielded faunal assemblages mostly in autochthonous situation. The bones show substantial evidence of bone modification (Patnaik *et al.* 2008). Agencies responsible for it may include human as well as carnivores and raptorial birds. The larger rodents like porcupines were active agents of bone modification.

Rats, mice and Archaeological Record

The temporal distribution of rats in archaeological context in India pushes it back to Late Pleistocene and the evidence of association with archaeological artefacts is available from Neolithic to the historic levels (**Table 2**). As mentioned earlier, the ossiferous gravels of the Narmada valley have yielded a large number of muroid remains of Late Pleistocene which however, do not have any association with Palaeolithic assemblages. On the other hand the rodent fauna from the Kurnool District of Andhra Pradesh is assigned to Terminal Pleistocene and Holocene levels respectively in association with Upper Palaeolithic, Mesolithic and Neolithic artefactual assemblages.

Faunal specialist is confronted with a major task of reconstruction of palaeoenvironment on the basis of the faunal record that is invariably inadequate and incomplete. The problem is further complicated when the taxonomic composition is poor and does not include the wide spectrum of faunal diversity in the faunal assemblage.

Table 2: Distribution and representation of Number of Identified Specimens (NISP) of muroids and Rhizomid? (Rodentia) from Archaeological sites in India

Culture	Sites	@	#	\$!	+	X	##	%	Reference	
Mesolithic	Bagor	*	*	–	–	–	–	–	–	Thomas 1975	
	Mahadaha	*	–	1	–	–	–	–	–	Alur 1980	
	Damdama	18	2	–	–	–	–	–	–	Thomas <i>et al.</i> 1995	
Neolithic	Gufkral	–	–	–	–	–	–	*	–	Sharma 1979–1980	
	Senuwar	2	–	–	–	–	–	1	–	Sathe & Badam 2004	
	Maski	4	–	–	–	–	–	*	–	Nath 1957	
	Sanganakallu	4	–	–	–	–	–	*	–	Alur 1969	
	Tekkalkota	*	–	–	–	–	–	*	–	Nagrajarao & Malhotra 1965	
	Kodekal	4	–	–	–	–	–	*	–	Shah 1973	
	Mohenjodaro	1	–	–	–	–	–	*	–	Sewell & Guha 1931	
Harappan	Harappa	9	*	*	2	–	–	–	–	Prashad 1936	
	Ropar	*	*	–	–	–	–	–	–	Nath 1968	
	Rakhigarhi	3	–	–	2	–	–	–	–	Uparathna 2011, Sathe (n.d.)	
	Bhirrana	*	–	–	–	–	–	–	–	Deshpande-Mukherjee (pers. Comm.)	
	Lothal	3	–	–	–	–	–	–	–	Nath & S. Rao 1985	
	Surkotada	*	–	–	–	–	–	–	–	Sharma 1990	
	Rojdi	*	–	–	–	–	–	–	–	Kane 1989	
	Babarkot	*	–	–	–	–	–	–	–	Ryan, <i>In press</i>	
	Kuntasi	*	–	–	–	–	–	–	–	Thomas <i>et al.</i> 1996	
	Kanmer	16	–	–	–	–	–	–	–	Goyal 2012	
	Shikarpur	4	–	–	–	–	–	–	–	Thomas <i>et al.</i> 1995	
	Padri	*	–	–	–	–	–	–	–	Joglekar 1996–97	
	Nageshwar	*	–	*	–	–	–	–	–	Shah and Bhan 1992	
	Pabumath	*	–	–	–	–	–	–	–	Misra 1988	
	Vagad	*	–	–	–	–	–	–	–	Misra 1988	
	Chalcolithic	Daimabad	*	–	–	–	–	–	–	–	Badam 1986
		Balathal	38	–	–	–	–	–	–	–	Tetso 2007
Nasik		1	–	–	–	–	–	–	–	George 1955	
Nevasa		8	3	–	–	1	4	–	–	Eapen 1960, Clason 1979	
Inamgaon		*	–	–	–	–	–	–	–	Thomas 1988	
Kaothe		4	–	–	–	–	–	–	–	Thomas & Joglekar 1990	
Walki		*	–	–	–	–	–	–	–	Joglekar 1992	
Tuljapur Garhi		1	–	–	–	–	–	–	–	Thomas 1992	
Megalithic and Early historic	Tekkalghat	2	–	–	–	–	–	–	–	Rao 1970	
	Bhokardan	*	–	–	–	–	–	–	–	Rao 1973	
	Nagara	–	7	–	–	–	–	–	–	Shah 1968	
	Jokha	3	–	–	–	–	–	–	–	Shah 1971	
	Dhatwa	–	*	–	–	–	–	–	–	Shah 1975	
	Yelleshwaram	8	–	–	–	–	–	–	–	Alur 1979	
	Peddabankur	1	–	–	–	–	–	–	–	Alur 1990	
	Nagarjunakonda	–	*	–	–	–	–	–	–	Nath 1963	
Kopia	–	–	–	–	–	–	–	4	Sathe 2013		

Muridae: @ *Rattus rattus* # *Bandicota indica* \$ *Bandicota bengalensis*

Cricetidae: ! *Tatera indica*

Rhizomidae: + cf. *Rhizomus sumatrensis* × *Mus* sp. ## *Muroid*. % *Millardia meltada*

*: The taxon is reported but the total NISP is not known.

Looking at the general nature of fossil record, there is no denying that taphonomic processes do create discrepancies between original species in living assemblages and fossil assemblages, and otherwise make faunal record difficult to interpret (Stahl 1996). Thus the fossil record cannot be accepted literally and that the samples cannot be treated as equivalent to the samples taken from modern ecosystems. Nevertheless, there is found original ecological information preserved in faunal assemblages, which is biased but interpretable.

The reconstruction of palaeoenvironment can be best attained especially when the assemblage is multi-species, reflecting the existence of a wider range of habitats. Since the mobility of microvertebrates is generally confined to restricted area during their entire life span and some of them are highly sensitive to climatic changes, their occurrence provides higher resolution in interpretations of palaeoenvironment and formation of palaeocommunities. In this light rodents present the potential to provide palaeoenvironmental information not attainable from other animal groups. The usefulness of rodents as a source of such information appears to have been overlooked in the context of Indian Archaeology. Even though exhaustive treatment has already been given to the topic of microvertebrate taphonomy and subsistence by several authors (e.g. Redding 1978, Morlan 1994, Stahl 1996 and references given therein), it is imperative that relevance of these 'guidelines' to small mammal archaeozoology in India is recognised to arrive at a comprehensive picture of faunal exploitation in prehistoric India. Against this backdrop a number of known premises are discussed in this paper in the context of recent researches in Indian archaeology.

Taxonomic Determination of Skeletal Remains of Smaller Rodents

Interpretations of behavioural biology and ecology of a species are based essentially on the correct identification. Muroids and cricetids have a very complex dental and skeletal morphology. Coupled with highly complex web of habitats, it requires a fine resolution to arrive at a precise taxonomic determination for meaningful deductions of palaeoecology. Black rat (*Rattus rattus*) is one of the species occasionally alluded to and identified in archaeofaunal assemblages followed by lesser bandicoot rat (*Bandicota bengalensis*), though known only from the few sites. Taking into consideration the close resemblance in dental and skeletal morphology among all the members of muroids, complete and larger reference collection of recent muroids is a prerequisite to arrive at accurate identification of small rodents. As regards postcranial elements, the problem of precise identification can be confronted with good results by using qualitative and quantitative methods of skeletal morphology (Graham and Saunders 1978). It would be worthwhile to re-examine the small mammal assemblages from archaeological sites and reassess the species components of rodent assemblages. Recent methodologies employed to discriminate between closely related large mammalian genera (Grine *et al.* 1986, Loreille *et al.* 1997, Sathe 2003, Cuijpers and Lauwerier

2008, Zedda *et al.* 2008, Sathe and Joshi 2013) offer a set of better guidelines for taxonomic determination of smaller rodents.

Taphonomy and Representation Bias of Small Rodent Collections

The skeletal remains of muroids from archaeological sites are represented by dentition and limb bones while the rest of skeletal elements are mostly absent. The count of bones (**Table 2**) points to several taphonomic factors which could have been responsible for absence of much of the skeletal elements. Following burial, pedogenic or soil induced modification could affect and alter all parts of the skeleton which is different from the corrosion produced by digestion. The breakage of bones would enhance in wet conditions but under dry conditions they are better preserved (Andrews 1990).

Perthotaxic, Taphic and Anataxic factors are major decisive attributes determining the 'future' of the death assemblage. However, before embarking on the discussion of later episodes of taphonomy it is necessary to view the mode of death for small rodents which proves to be the prime force setting the conditions for the subsequent mode of burial and fossilisation. Besides man there are three major non-human agencies viz. snakes, predatory birds, cats and monitor lizard. Python, Common Sand Boa, Rat snake, cobra, Krait and Russel's viper are swift rat killers. Rat snake also proven to be one of the most useful species to Indian farmers today in preventing their number from multiplying (Murthy 1993). Rat is one of the major items of prey for monitor lizards besides crab, insects and small vertebrates. However, snakes leave no record at all as they completely digest all parts of their prey animals (Murthy 1993). The degree of corrosion due to digestive enzymes in smaller vertebrates (Andrews 1990, 1995) has been a major guideline in identifying their consumer.

The forces causing death assemblage to disperse widely include sub-aerial weathering and trampling of bones in natural set ups. The severity of the process depends upon the duration of exposure. The skeletal elements would disintegrate to the extent that at its best only a few (mostly) dentition and incomplete postcranial elements will find its way to deposition and subsequent fossilisation. It is also true that the small mammal bones which pass through the digestive system of birds of prey and predatory animals and deposited the pellets and scats would certainly get disintegrated to a very large extent (Korth 1979, Saavedra *et al.* 1998, Lyman *et al.* 2003, Terry 2004).

Collection bias is one of the most influential factors in the life history of a fossil and more so when pertains to the smaller bones of microvertebrates. The careful recovery of the material is always solicited but flaws in sampling can create a bias in the very first step of faunal analysis (Stahl 1996). This is crucial for small rodents from archaeological sites especially when the general attitude towards rodent assemblages is to discard them as later intrusions. As a result the assemblages often appear chance collection rather than an outcome of systematic and intentional

sampling. Hence barely any data are available about the wider range of skeletal representation of smaller rodents and its stratigraphic relevance. Well-planned sampling, which also includes searching rodent bones from every single archaeological level with differential sieving, screening and flotation would be able to prevent differential loss of small as well as incomplete bones and is likely to yield diverse species of small mammals and microvertebrates. Needless to say that the larger the sample, the precise the conclusions would be holding key to better understanding of the role of rodents in archaeological perspective.

It is highly likely that the seemingly low count of identified specimens of rodents from archaeological sites may be ascribed to some sampling bias. The awareness that

the small mammals did contribute to the subsistence pattern of ancient human population is relatively of recent origin.

To ensure whether the Small Rodent Collection is really Intrusive or of the Same Date as the Other Assemblages

Rats and mice are predominantly fossorial. Extensive study has been carried out on this tendency of rats and mice by various zoologists in India which reveals an array of burrowing patterns (Arjunwadkar and Gadgil 1974, Barnett and Prakash 1975, George *et al.* 1982; please see **Table 3** for burrow patterns in living Indian muroids). This presents an apt analogy for detecting similar patterns

Table 3: The Habitat and Burrowing patterns of living muroids in India (After Barnett and Prakash 1975, Arjunwadkar and Gadgil 1974, George *et al.* 1982).

Species	Habitat	Burrowing Pattern
<i>Meriones hurrianae</i> Jerdon (Desert Gerbil)	Sandy soil, gravel plains and villages	Simple with 3 to 10 openings, brood chamber and a few bolt runs. Depth of brood chamber being 30 to 35 cm, horizontal profile dimension being 3 to 3.5 m. 1. Simple: 3 openings, 2.9 × 2 m of horizontal profile, total length of burrow system 4.94 m, burrow width 5–20 cm, depth of brood chamber 34 cm. 2. Elongated, extensive ramifying type: 6 openings, horizontal profile dimensions being 4.95 m, length of burrow system 20.3 m, burrow width 7–20 cm, depth of brood chamber 31 cm. 3. Superficial: upto 3 m long, 10 cm deep. 4. Shallow: its galleries range from 10 to 25 cm in depth. 5. Deep burrows: can be 1 m in depth
<i>Rattus rattus</i> Linnaeus (House Rat)	Commensal with man, crop fields nut groves in Kerala and Laksha Dweep	Lives in burrows, in thatched roofs and coconut groves
<i>Rattus meltada</i> Gray (Soft-furred rat)	Found mostly in irrigated fields, hedges and grasslands.	Burrows are simple, found often under bushes
<i>Rattus norvegicus</i> Berkenhout (Brown or Norway rat)	Sewers in cities, buildings: found in cellars than in attics	Powerful burrower but does not dig very deep burrows
<i>Mus musculus</i>	Buildings and the fields, houses, gardens, godowns, grain ware houses; Inhabits crop fields, commodity found in sugar cane fields.	fossorial but burrows are very shallow
<i>Mus booduga</i> Gray (Indian field Mouse)	Especially irrigated fields, found in association with <i>Rattus meltada</i> and <i>Tatera indica</i>	Its burrows are shallow with one or two openings, tends to store food grains in the burrows
<i>Mus cervicolor</i> Hodgson (Fawn-coloured Mouse)	Inhabits plains, fields and forests while <i>Mus platythrix</i> occurs in rocky and gravelly habitats (Fawn-coloured mouse)	Burrows are simple, not very long
<i>Nesokia indica</i> Gray (Short-tailed Mole Rat)	Inhabits cultivated fields, may occur in natural vegetation near crop fields. It burrows in the bunds in irrigated fields.	Specialized fossorial rat whose burrows are extensive. At each opening the Excavated soil is heaped into a pyramid.
<i>Bandicota bengalensis</i> Gray (Lesser bandicoot rat)	Exceptionally versatile, wide spread in irrigated fields, villages and towns.	Burrows go to a depth of 1m, with about 12 openings per burrow and are
<i>Bandicota indica</i> Bechstein	Inhabits habitational areas, gardens, food grain storage godowns.	Burrows found to be organized into colonies of 2 to 15 burrows, which are generally found next to a house or a grain storage godown. The total length of burrows may range between 44 to 520 cm. The maximum depth of burrows can be found between 23 to 115 cm

in archaeological context. Dwelling traces or 'Crotovinas' ('mole hills') as coined by Russian pedologists for fossil burrows (Gautier 1993) are one of the Trace Fossils which can be of immense use in identifying animal activity at the site. The evidence of such fossil burrows or 'Crotovinas' of rodents at an archaeological site helps in not only understanding its behavioural pattern but also throws light on the antiquity of rodents as well as the ecological conditions prevailing at the new site. With the help of Fluorine method it is possible to demonstrate the stratigraphical integrity of rodents at a given archaeological site giving a valid dimension to palaeoenvironmental reconstruction based on the presence of rodents.

The muroids and other small rodents are found in well documented Plio-Pleistocene deposits of the Northwest India thus establishing the validity of its geological provenance. However, their occurrence in Peninsular India is considered with great reservations. The Late Pleistocene ossiferous gravels generally lie at a depth of few meters from the top soil leading to the premise of their ancient origin while at archaeological sites they are found at the depth of few meters of total thickness. On this basis it is argued that they are of recent origin. Hence it is assumed that most of the muroid collection from archaeological sites is derived from rats died a short while ago inside the burrows. If the burrows are made by animals to live and not to die in (as appears to be so), contextual reference of their remains can best be confirmed by chemical analysis of bones and sediments. In order to examine the stratigraphic integrity of these remains and to ascertain that they are not mere contaminations from the recent levels, recently the Fluorine analysis of these bones was carried out which confirms the contemporaneity of muroids with other large animals found in several archaeological and Pleistocene sites in India (Sathe 2013, Sathe and Kshirsagar n.d., **Table 4**).

No Apparent Changes in the Habitat of Rodents in Prehistoric Times as observed at the Given Site

The comparison between community type from archaeological sites and the present faunal community type existing in the vicinity may be carried out to check whether the relative composition of the surroundings (available for exploitation to the species of rodents) has not changed since ancient times. This is needed to ascertain that the small rodent community has not changed since ancient times. When the continuation of the same rodent community is confirmed by monitoring palaeoenvironment with the help of living analogues, it provides an adequate picture of ecological setting of the area.

In the context of Indian muroids, taxonomical diversity is limited to a few species only which seems to be an outcome of discharge to the importance of small mammals in earlier stage of research in archaeozoology. However, **Table 3** helps to demonstrate the habitat and habits of living muroids and its cousins which can be used to understand the behavioural pattern in the past, following the principles of actualism. Oseologically the archaeological species of muroids do not differ from their living descendants and hence the present day habits and ecology of *Rattus rattus*, *Bandicota indica*, *B. bengalensis*, *Tatera*

indica, *Millardia meltada* and *Mus pp.* (**Tables 3 & 5**) provides meaningful insights into the ecological choice of their predecessors of early and late Quaternary. As the existence of small rodents is consistently associated with agricultural fields and storages its presence at an archaeological site also warrants presence of such activities in and around the settlement and statement regarding the ecological condition of the area.

In addition to the skeletal remains, evidence of coprolites and its quantitative representation might help to demonstrate the fluctuations in the number of muroids at the archaeological sites. However, no specific estimate has been worked out so far except the computation of rat coprolites from various cultural levels carried out for the first time by Kajale (1988) while screening for palaeobotanical remains at Inamgaon.

The Species should not be Domesticated or Managed

That the species found at an archaeological site is domesticated or managed for food resources loses its importance as a significant palaeoecological indicator does not imply in case of rats and mice since the question either of their domesticated or managing them does not arise at all throughout the history of animal domestication in India. Though indirect evidence points to their exploitation by humans in ancient time as source of food, ethnographic parallels reveal that rats are not subject to any deliberate management to enhance the food value.

Material Utilised for Palaeoenvironmental study must be drawn from the Local Environment

The species drawn from the archaeological site may owe its presence to i) being native to the site at the time of deposition or, ii) introduced by several biological factors e.g. the predatory birds which may have been roosting at the site or even by the carnivorous animals which killed them, colonisation attempted by rats, or man accidentally introducing them at the site. The study of surface taphonomy and skeletal and taxonomic computation of bones for their being part of pellets and/or scat may yield information of what species of predator could have consumed them (Sathe and Chakraborty 2014). Though no such factors could necessarily introduce them to the local environment, computing the ratio of bones of each species leading to estimate their actual number at the site, affording precise interpretations of palaeoenvironment.

Microvertebrates from Kopia: A Case Study in analysis of microvertebrate fauna from an archaeological site

The site of Kopia (26° 52' N: 83° 04' 50" E) is an Early Historic occupation representing Northern Polished Ware (NBP) culture to Kushana and Sunga period. It was excavated by Alok Kanungo and V. N. Misra for two seasons (2004 and 2005) and the material subject to present study comes from both seasons of excavations (Kanungo & Shinde 2004–05). The site is located nearly 12 km north of Khalilabad in District Sant Kabir Nagar, Uttar Pradesh. The temporal stretch of the occupation is of about five hundred years, beginning from the 5th–6th century B.C.

Table 4: Fluorine/Phosphate ratio in rodent bones at Kopia with reference to values on rodent bones from several Pleistocene –Holocene sites in India (Modified after Sathe and Kshirsagar n.d.).

No.	Site	Trench	Layer Period/Culture	%F	%P	%P ₂ O ₅	100F/ P ₂ O ₅	C 14 Dates
454	Recent		Holocene/Living	0.05	12.50	28.62	0.14	–
1	Kopia	AY ¹ /5039	3 Kushana/Early Historic	0.39	13.00	29.24	0.13	81881 ± 109
2	Kopia	AY ¹ /5031	4 Kushana/Early Historic	0.088	13.75	31.14	0.08	1683 ± 185
3	Kopia	AY ¹ /5039	3 Kushana/Early Historic	0.044	11.75	26.90	0.16	
4	Kopia	AY ¹ /5031	4 Kushana/Early Historic	0.014	13.75	31.48	0.04	
5	Kopia	AY ¹ /5038	4	0.017	12.87	29.48	0.05	
6	Kopia	AY ¹ /5042	4	0.030	12.24	28.05	0.10	
7	Kopia	AY ¹ /5037	4	0.025	12.12	27.76	0.09	
8	Kopia	AY ¹ /5042	4	0.025	13.12	30.06	0.08	
9	Kopia	AY ¹ /5039		0.030	12.12	27.76	0.10	
10	Kopia	AY ¹ /5038	4	0.025	13.12	30.05	0.08	
11	Kopia	AY ¹ /5037	4	0.043	14.37	32.91	0.13	
12	Kopia	AY ¹ /5031	4	0.05	11.25	25.70	0.19	
427	Balathal	D1	5 Holocene/Iron Age	0.04	9.37	21.46	0.186	c.500 B.C.–300 A.D.
464	Balathal	DE2	13 Holocene/Chalcolithic	0.061	10.75	26.62	0.22	2,*
461	Balathal	OE	15 Holocene/Chalcolithic	0.07	9.06	20.74	0.34	2350 – 1800 B.C.
462	Balathal	EY3	17 Holocene/Chalcolithic	0.073	11.75	26.91	0.27	
463	Balathal	FY1	17 Holocene/Chalcolithic	0.098	11.87	27.18	0.36	
								3,*
455	Daimabad	BZ'3	4 Holocene/Chalcolithic	0.076	11.87	27.18	0.28	1550 – 1035 B.C.
456	Daimabad	ZD60	7 Holocene/Chalcolithic	0.112	12.50	28.62	0.39	
								4,**
579	Kuntasi	K7	4 Holocene/Late Harappan	0.062	5.87	13.44	0.46	1900 – 1700 B.C.
580	Kuntasi	F1	8 Holocene/Mature Harappan	0.082	11.87	27.18	0.30	
581	Kuntasi	J8	8 Holocene/Mature Harappan	0.08	7.00	16.03	0.49	5,**
582	Kuntasi	G3	9 Holocene/Mature Harappan	0.107	8.12	18.59	0.57	2400 – 1900 B.C.
583	Kuntasi	12	13 Holocene/Mature Harappan	0.096	10.75	24.62	0.39	
584	Kuntasi	KC	20 Holocene/Mature Harappan	0.075	11.50	26.33	0.28	
523	Betamcherla	A2	Early Holocene	0.23	12.50	28.62	0.80	not available
524	Betamcherla	B3	Early Holocene	0.28	15.00	34.35	0.81	not available
521	Betamcherla	C3	Terminal Pleistocene	0.58	11.72	25.64	2.26	17,390 B.P. (TL Date) 6
525	Betamcherla	C7	Terminal Pleistocene	0.776	10.06	23.09	3.52	
522	Betamcherla	F	Terminal Pleistocene	0.83	8.19	18.75	4.42	not available
382	Narmada valley	GUGT	Late Pleistocene	1.646	11.62	26.61	6.185	31,750 B.P.

¹ Misra *et al.* 1995; ²Misra *et al.* 1995; ³Sali 1986; ⁴Dhavalikar *et al.* 1996; ⁵Dhavalikar *et al.* 1996; ⁶Murty and Nambi 1983; ⁷Agrawal and Kusumgar 1974; ⁸Kanungo *et al.* 2010.

* Dates for the corresponding rodent yielding layers are not available hence C14 dates of timeframe of Chalcolithic period are given.

** Very few C14 dates are available hence the dates given provide a general framework for mature and late Harappan period at the site.

to about 2nd–3rd century A.D. The microvertebrate record comes from a single trench AY1 located in the centre of the mound, providing lesser disturbance due to anthropogenic activities. The structural remains in the trench belong to Śunga-Kushana period, implying that the faunal assemblage can be assigned to a time frame of c. 1st century B.C. to about 2–3rd C. B.C.

The total collection comprises 2644 bones of which 2412 are the NISP, belonging to insectivores, muroids, fishes, small reptiles and birds (Fig. 1). The taxa include house shrew (*Suncus murinus*), field rat (*Millardia melitad*), blacknaped hare (*Lepus nigricollis*), and domestic fowl (*Gallus* sp.), indeterminate reptilian fauna and carp fish (cyprinids). The small mammal fauna may not belong to the muroids but offers first ever systematic study of microvertebrates and fish fauna from an archaeological site in India. The skeletal representation of small to very small-bodied taxa across the cultural phases demonstrates commendable efforts taken by the excavators while sampling the faunal record. Fairly good state of preservation, the absence of etching by gastric travel time in the abdomen of avifauna and completeness of the bones suggest that the accumulation owes its origin to natural death without any direct evidence of human predation. Even though the ribs and vertebrae as well as the long bone fragments are in plenty (232 nos., 8.77%), the assemblage does not show any evidence of post depositional

disturbance. Interestingly no bones bear any evidence of charring either (Sathe 2013).

How were the bones introduced in to the context that assigns them to early historic antiquity? Are the bones intrusive or the relics of ancient natural and anthropogenic activities? Good state of preservation, appearance of a naturally sorted collection and the total absence of vitrification of bones, unlike those of large animals within the site made it imperative that their stratigraphic relevance is examined to consider them truly ancient. In order to address these questions, the fluorine values were determined in twelve of the samples from the Śunga and Kushana levels. Interestingly, the receding values of fluorine from earliest (late-Mid Pleistocene) to the recent that have confirmed the relative antiquity of rodent bones (Sathe 2013; Joshi and Sathe 2007), also show the values for these specimens to be matching with the Early Historic period (Table 4). As regards the ecology and habitat of these microvertebrates, some are commensals in one way or the other and can be considered a strong pointer to the status and tenure of the settlement, agricultural association and supporting its archaeological affinity. Fish remains are indeed the food debris.

The present day distribution of murids associated with variety of crops in different parts of India (Table 3) helps us to understand their localised concentration. It shows that in most habitats, the various rodent species occupy

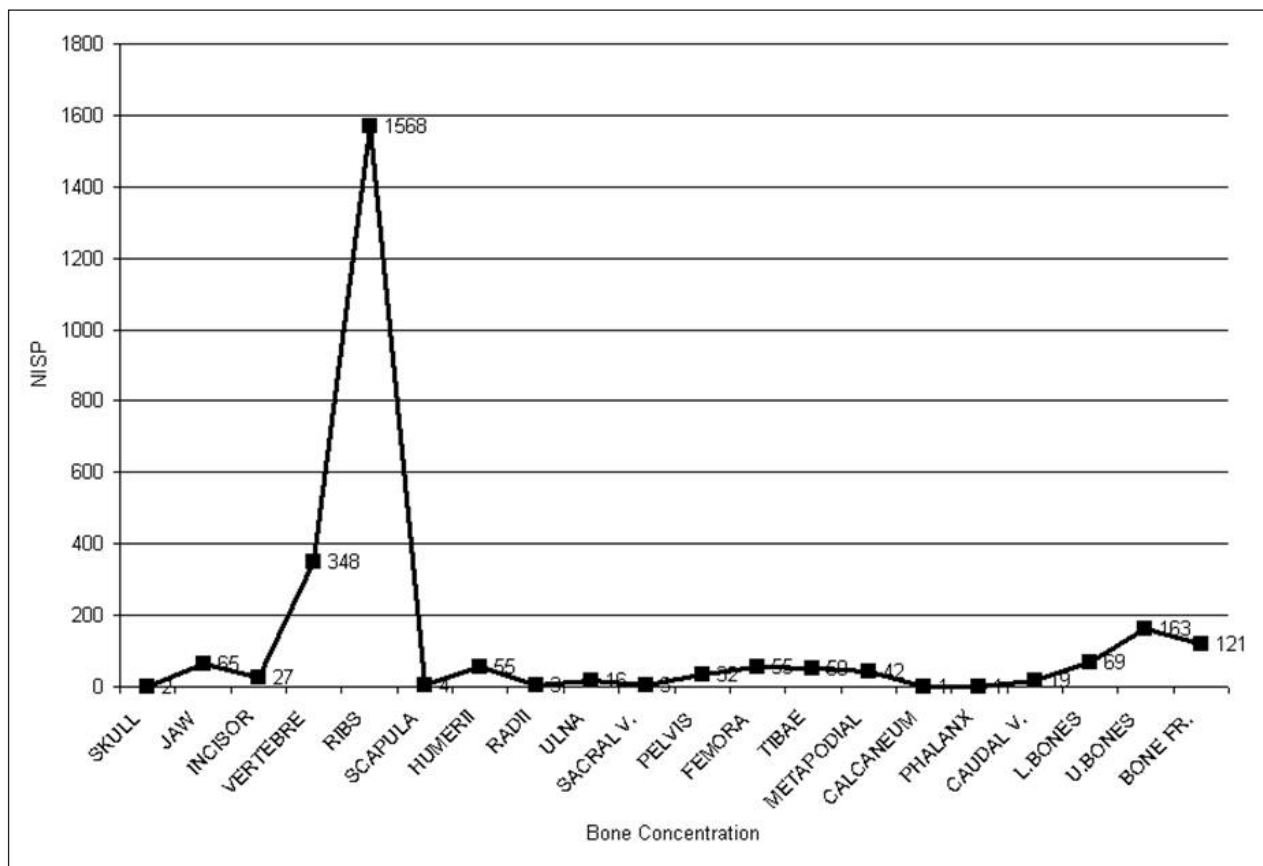


Figure 1: Representation of skeletal elements of microvertebrates (NISP) from the Early Historic site of Kopia, District Sant Kabir Nagar, U.P., India.

different situations which can be termed as sub-habitats, possibly helping to reduce the inter-species competition. Extensive work on the behavioural biology of pests in India by Barnett and Prakash (1975) provides some clues to this complex state of rodent ecology. In Indian wheat fields most of the *Bandicota bengalensis* are in the bunds; but *Millardia meltada* burrow in the fields while the mice (*Mus* spp.) live under bushes. In a village settlement *Rattus rattus* and *Mus musculus* would thrive in houses and cattle yards.

The presence of house shrew (*Suncus murinus*) points to its habitational association. These insectivores are a common domestic occurrence throughout India, Myanmar, Malaysia, southeastern China, Taiwan and Indonesia. They primarily subsist on insects including cockroaches (*Blattaria* spp.) and crickets (*Grillidae* spp.) and are found to be useful to man, especially in keeping the houses clear of cockroaches and even said to discourage rats from occupying houses (Roberts 1977). The house shrews can be tamed easily and it is not surprising that the reports of taming them have been useful to their masters (Crump 1912; Eates 1968). It is not surprising thus that in villages the shrews are symbols of wealth and are generally venerated. The house shrews have a life span of about one to one and a half years; they are prolific and can have a sizable population within spring and towards the monsoons with a litter size of 3 to 4. (Roberts 1977). Mongoose and snakes are the common predators. Due to the strong musky odour raptorial birds do not eat them and it is highly likely that even man has stayed away from them with respect to their dietary utility, also supported by the ethnographic data.

Millardia meltada (field rat) has a distribution confined to India, Nepal and Sri Lanka. Mostly found in irrigated fields, bunds, grasslands and hedges, it also inhabits gravelly soils. Weighing for 60 gm., it has a home range varying between 790–2200 square meters (Barnett and Prakash 1975). Short tailed mole rat (*Nesokia indica*) has a vast palaeartic distribution where parts of Uttar Pradesh have been its earlier range of distribution (Bennet and Prakash 1975). Body weight of an adult being 200gm. attracts the attention of hunting gathering communities for a better yield of meat in a single individual. Grasses, food crops and sugar cane consist their food. Commensals like the house rats (*Rattus rattus*) when adult weigh 150 to 200 gm., are a disease carrier and more common in villages than in towns for reasons of poor sanitary conditions. They breed throughout the year and twenty to fifty six individuals are born to every female (Barnett and Prakash 1975). Studies on *Rattus* distribution reveal the concentration going as high as 9.8 individuals per house or 1.3 per person in number of villages nearly 60 km east of New Delhi in Uttar Pradesh (Krishnamurty *et al.* 1967), and 83,000 (predominantly being *Rattus*) or 3.9 per house and 1.1 per person in Sidhpur Taluka in Gujarat, recorded over thirty years ago. It implies a consistently high population within the settlements where the total strength of the settlement may bring out a phenomenal presence of these pests in a given time. The field mouse or *Mus booduga* is truly a micromammal with a weight of about 8g. and have a wide

distribution mostly in irrigated fields. With a known home range of 1275 ± 52 per square meter, living in shallow burrows, with 3.3 individuals in each of them. With a litter size of one to five, they are one of the associational pests who share the habitats of *Rattus meltada* and *Tatera indica*. The study of spatial and temporal distribution of microvertebrates with reference to their individual share in understanding the local ecology highlights microvertebrates as useful micro eco indices of an ancient settlement especially here in context of the ancient site of Kopia.

Rats and Mice as Source of Food

As regards contribution of rodents to human diet, it is found that more than 71 genera and 89 species of rodents (though majority of them being hystricomorphs) comprise a substantial portion of edible wild game world over (Fiedler 1990). Rodents fill that dietary niche where in addition to being an easy availability, less expensive, require less efforts, and besides being a popular source of protein, rodent meat contains essential amino acids necessary in the human diet. High reproductive rates in rodent populations provide an undisruptive harvesting without depletion and it is also believed by some of the populations as an effective means of pest controlling strategy. The human consumption of rodents (guinea pigs) in the Americas goes back to more than 2500 B.C. (Lanning 1967), while the early Chinese reportedly ate common and bamboo rats. There are several references to methods of preparation and eating of newborn rats during the Tang dynasty in the AD 618–907 (Hendrickson 1983). To celebrate the building of the King's palace in Mesopotamia, ten-day feast was organised and in addition to thousands of oxen, sheep, lambs, deer, pigeons, fish and eggs; one thousand rodents (jerboa) were served (Flandrin and Montanari 1999). Romans popularised the edible dormouse by the 2nd century AD and several methods of preparation point to its being a delicacy (Brothwell and Brothwell 1969). The consumption of rats by the Maoris of New Zealand refers to exploiting family hunting territories to trap Polynesian rats, which they had introduced to Polynesia in the 16th century. Forty two diverse societies in North America are reported to be the consumers of rats today (Harris 1985). The taboo still prevails in several societies today that prohibit people from eating rats (Harris 1985) but that does not however, lessen the prospects of its being an important component of food economy in different parts of the world as a major supplement of proteins since ancient times.

Hunter gatherers 10,000 years ago certainly had a different 'diet chart' contrary to their modern counterparts containing substantial proportion of domesticated animals and plants. A number of publications have emerged over the past couple of decades, describing palaeolithic diet estimation of macronutrient composition, considered to validate the palaeolithic hunter gatherer's diet (Eaton and Konner 1985, Eaton *et al.* 1988, Eaton 1992 and Eaton *et al.* 1997). It is proposed that their diet consisted of 35% animal food by weight and 65% plant food. An array of values for micronutrients, electrolytes, carbohydrates, fat, proteins and fibre have been calculated and

comparisons drawn between the intake of micronutrients in Palaeolithic and the present day diet (Eaton *et al.* 1997). These values are of immense importance to understand the prehistory of food and evolutionary perspective of human diet through space and time (Jenike 2001). However, direct physical evidence of human consumption of small mammals has been most elusive in palaeontological record. In this context, cut marks on the mandibles of fossil hedgehog (*Erinaceous broomei*) from early hominin site of Olduvai George Bed I are perhaps the first ever report of human activity on small mammals indicating its contribution to the human subsistence (Farnandez-Jalvo *et al.* 1999).

While looking at the contribution of animal foods in the diet of aborigine populations, the easy availability of small game, minimum efforts and consistently high ratio of edible meat to total weight are found to favour small game over large ones, albeit a supplementary component. Eventually it adds to the intake of animal foods that are invariably high in protein (Eaton n.d. 1998). The dietary perspective of present day hunter-gatherers reveals a story where shifts induced by resourcefulness of small game especially in the category of variety of rodents becomes a ready reference while looking at the prehistory of small

game and food processing. The data pertaining to the pattern of exploitation, carcass processing and consumption are a useful point of reference to understand the contributions microvertebrates or micromammals may have made to the diet of ancient human population.

The skeletal material of rats and mice from archaeological sites in India does not bear any signs of charring or butchering. This has led to conclude that humans did not consume the small rodents. However, the prehistoric rock paintings provide a positive evidence of its being hunted and collected along with larger game, which includes rats as a regular part of the diet of prehistoric man. The paintings showing a series of three different episodes of rat hunting were found on the rock shelters at the site of Jaora near Bhimbetka in Central India and have been dated to Mesolithic period (Neumayer 1983). It is a living tradition and the painted faunal record provides insights into the past human behaviour. One of them shows a hunter with a bow and arrows, walking with a basket or net carrying carcasses of a cow, deer, monkey, a small ruminant, monitor lizard and one big and four small-size rats as part of his hunt. The picture symbolises hunter's wish of catching all the animals as his day's hunt (**Fig. 2**). Another painting is a portray of a man carrying a basket

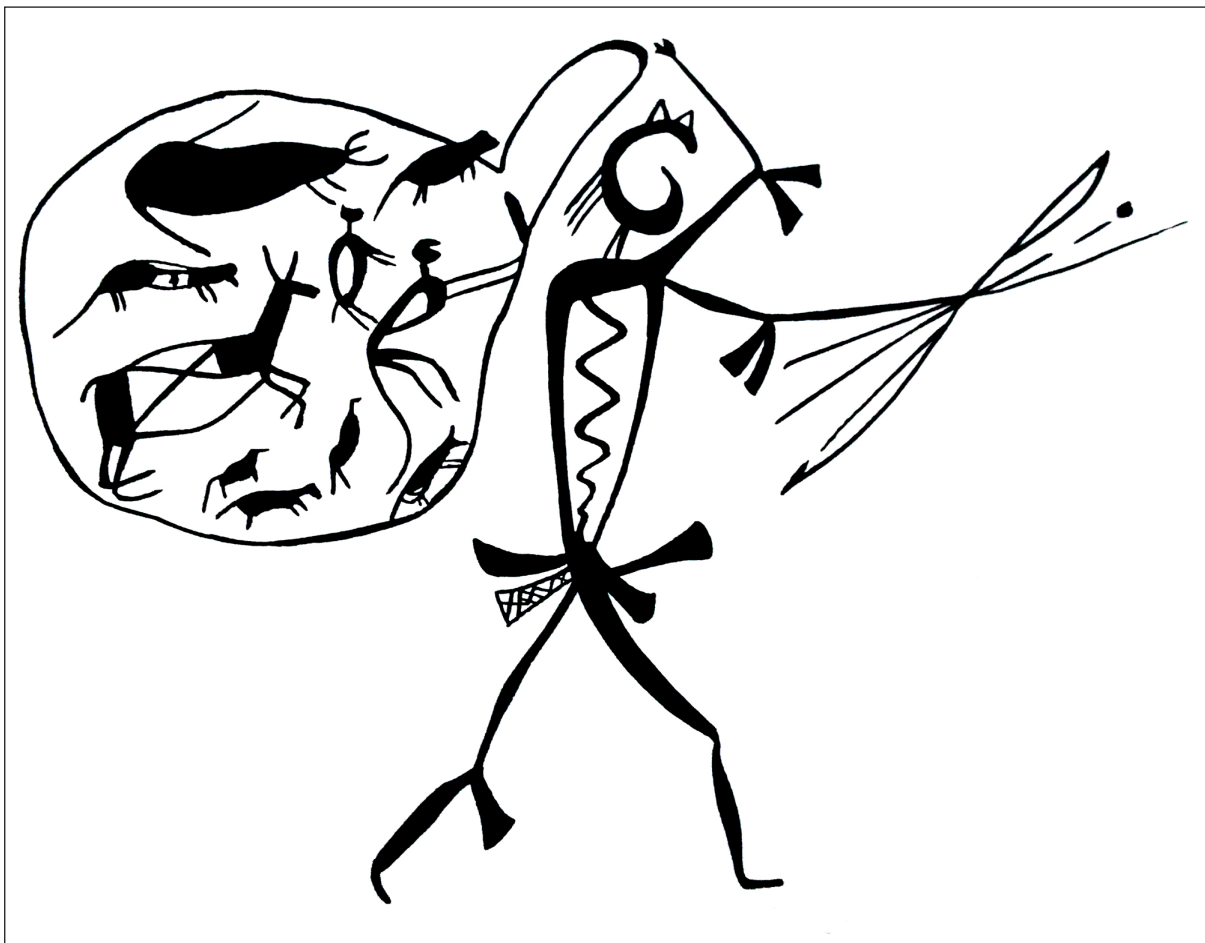


Figure 2: Mesolithic rock painting symbolizing hunter's wish to catch all the depicted animals which besides the larger game include one big and four small-size rats as part of his hunt.

Note: Painted record of small game: Evidence from the Rock Art at Bhimbetka, Dist. Raisen, M.P., India.

balanced with the help of a cord on his head. The basket is covered with a lid and contains a total of 9 rats; few of them being caught live (**Fig. 3**). One more with human figures depicts several activities together. A man is engaged in digging out a rat burrow with the help of a stick. Three rats are already extracted and killed which lie next to him. To the right of the burrow is a poorly preserved painting of a man trying to grip a rat which is about to escape. Two women are busy digging with the help of a pointed stick. Four v-shaped baskets and a few digging sticks are also painted. Interestingly the shape of rat hole greatly resembles the burrow pattern of present day muroids (**Fig. 4**).

The ethnographic parallels reveal that bandicoot rat, field rat and common rat form part of the diet of many tribal communities in India today (**Fig. 4**). *Katkaris*, *Varalis* and *Vadaris* (from hilly and forested regions of

Maharashtra, Karnatak and Gujarat) do hunt smaller animals like rats and their close relatives. To supplement the supply of food grains and other food items these tribes look upon rats as food reserve, which they hunt by digging rat holes. The rat hunt has an additional dimension as tribes also hunt for the food storage built up by these animals (Bombay Presidency Gazetteer 1885). Hunting rats is a collective exercise carried out by the entire community. Rats are driven out of their holes and all other possible places of their hiding in and around the habitational area and then killed. After having harvested a sufficient yield the rats are distributed to every household. Rats are roasted and whole of it are consumed in a manner that even the bones are not spared. For *Katkaris* it is a much desired delicacy besides being considered as having medicinal property in curing people of tuberculosis and arthritis (Tribhuvan and Peters 1992).



Figure 3: A man carrying a basket balanced with the help of a cord on his head. The basket is covered with a lid and contains a total nine rats, few of them being caught alive.

Note: Painted record of small game: Evidence from the Rock Art at Bhimbetka, Dist. Raisen, M.P., India.



Figure 4: Portrayal of several activities together reveals a man engaged in digging out a rat burrow with the help of a stick. Three rats are already extracted and killed which lie next to him. To the right of the burrow is a poorly preserved paintings of a man trying to grip a rat which is about to escape. Two women are busy digging with the help of a pointed stick. Four v-shaped baskets and a few digging sticks are also painted.

Note: Painted record of small game: Evidence from the Rock Art at Bhimbetka, Dist. Raisen, M.P., India.

The *Irulas*, indigenous people of Tamil Nadu are distributed over nine districts viz. Chinglepet, South and North Arcot, Coimbtore, Nilgiris, Salem, Thiruchirapally, Tanjore and Kanya Kumari. Originally expert hunters of the larger game, *Irulas* in recent years have been forced to resort to the smaller game due to ever depleting wildlife as a result of forest cutting and expanding sheets of cultivation. Eventually they have turned towards rat catching as a highly successful means of obtaining animal meat and have developed special liking for the rat meat. The practice of rat hunting has equipped them with excellent skills of catching snakes, thereby playing a big role in venom industry (Dharmarajan 2007). Having absolute familiarity with the burrowing patterns the *Irulas* have developed excellent skills of hunting rats, thereby providing most effective natural solution to the population control of rats. A day's hunt can yield as many as hundred rats without putting any special efforts to accomplish the exercise. Local farmers employ them for catching rats and nearly for over a couple of decades these *Irulas* operate as part of the Co-operate society (known as 'RATS' or Rats and Termite Squad) engaged in killing them for food, and in the process providing tough majors in controlling its population explosion. One such episode refers to rats control in paddy fields by inviting *Irulas* from the '*Irula Snake Catchers Industrial Co-operative Society Limited*' in Chennai which turned out to be mutually beneficial as dividends and good riddance (*CIKS Quarterly News Letter*, 2007)!

Kuchapuri Yerukulas are semi-nomadic hunting gathering community living in the interiors of Nandyal basin of

Kurnool district of Andhra Pradesh. They are well known for expertise in hunting avifauna, which forms a major part of their diet. However, they occasionally hunt bandicoot rat and gerbil along with other small size animals such as monitor lizard, turtle and mongoose (Murty 1981).

Bhumias, one of the aboriginal tribes of the southern Madhya Pradesh occasionally eat field rats and mice in addition to other wild animals. However, small millet and rice is their staple food while meat forms an additional source of food (Fuchs 1968). Bandicoot is one of the food items of people of *Mandia* tribe living in neighbouring districts of Chandrapur and Bhamraghar in Maharashtra.

The *Kanjars* are a hunting gathering community of the Ganga valley, Uttar Pradesh who are according to 1971 Census spread in almost all parts of the state. They subsist predominantly on the meat of wild animals and exhibit omnivorous tendencies. In addition to hunting large game they do hunt and eat bandicoot rat, field rat in addition to mongoose, monitor lizard and snakes (Nesfield 1883, Nagar and Misra 1990).

Living traditions of small game as source of food: Musehars, a case study

To test the hypothesis that the archaeological record also includes the food debris of rodent bones, regardless whether they bear any direct evidence for it should be based on multiple lines of evidence. These include ethnographic record of trapping, preparation and consumption of rodents; knowledge of burrowing patterns and their behavioural biology;

Table 5: Predominant rodent species in croplands in various states in India (After Arjunwadkar and Gadgil 1974, George et al. 1982).

States	Predominant rodent species
Andhra Pradesh	<i>Bandicota bengalensis</i> – <i>Tatera indica</i> – <i>Millardia meltada</i> – <i>Mus</i> spp.
Assam	Bomboo rats?
Bihar	<i>Bandicota bengalensis</i> – <i>Tatera indica</i>
Chhatisgarh	Data not available
Gujarat	<i>Meriones hurrinae</i> – <i>Tatera indica</i> – <i>Rattus rattus</i>
Haryana	<i>Millardia meltada</i> – <i>Nesokia indica</i> – <i>Tatera indica</i>
Jammu & Kashmir	Data not available
Karnataka	<i>Tatera indica</i> – <i>Bandicota bengalensis</i> – <i>Millardia meltada</i> – <i>Mus platythrix</i>
Kerala	Data not available
Madhya Pradesh	<i>Tatera indica</i> – <i>Bandicota bengalensis</i> – <i>Millardia meltada</i>
Maharashtra	<i>Bandicota bengalensis</i> – <i>Mus</i> spp.
Manipur	<i>Bandicota bengalensis</i> – <i>Rattus rattus bullock</i>
Meghalaya	<i>Bandicota bengalensis</i> – <i>Rattus rattus bullock</i>
Nagaland	<i>Bandicota bengalensis</i> – <i>Rattus rattus bullock</i>
Orissa	<i>Bandicota bengalensis</i> – <i>Millardia meltada</i> – <i>Mus</i> spp.
Punjab	<i>Tatera indica</i> – <i>Millardia meltada</i> – <i>Nesokia indica</i> – <i>Mus</i> spp.
Rajasthan	<i>Meriones hurrinae</i> – <i>Tatera indica</i> – <i>Millardia meltada</i>
Sikkim	Data not available
Tamil Nadu	<i>Tatera indica</i> – <i>Millardia meltada</i> – <i>Mus</i> spp.
Telangana state	Data not available
Tripura	Data not available
Uttar Pradesh	<i>Millardia meltada</i> – <i>Tatera indica</i> – <i>Bandicota bengalensis</i> – <i>Mus</i> spp.
Uttaranchal	Data not available
West Bengal	<i>Bandicota bengalensis</i> – <i>Mus</i> spp.

and actualistic work of looking for their present day distribution at an archaeological site (Szuter 1988). Survey of ethnographic literature has so far amply demonstrated that the consumption of rodents in most of the scheduled tribes of India is practiced even today and rodent fauna supplements the diet on a regular basis.

To assess the dietary contribution of these rodents and search for the factors responsible for the information loss of the skeletal data after the consumption and burial; an actualistic study was undertaken in one of the well known rat consuming communities viz. *Musehars* living in the anterior of the Gangetic plains in the District of Allahabad, U.P. in north India. '*Musehars*', a hunting gathering community is spread over eastern Uttar Pradesh, western Bihar and are a well known rat catchers whose traditional economic activities involved the collection and sale of herbs, medicinal plants, roots, honey, resins, working as field labourers and helping over the brick kilns, rearing silk worms and making leaf plates and bowls (Crooke 1896) which continues to be widely practiced even today (Ansari 1999). Their occupations have

continued with minor additions like rearing pigs for obvious benefits in the face of perpetual poverty (Singh 1993). These *Musehars* are also known as *Banmanus*, *Banraja*, *Monr*, *Mushera* and *Musaha*, denoting their historic association with rats and mice primarily as a predator and they are highly skilled at catching them for food. They are equally skilled at other animals like tortoise, monitor lizard, squirrel and a number of game birds that supply towards animal foods in their diet. Author carried out a detailed ethnographic study along with the members of the tribal community and entire exercise from the time of trapping the rats to their consumption was documented and the live meat and edible meat ratios were also computed. The discarded bones were carefully sampled and studied for any taphonomic signatures caused by human consumption. Site documentation included useful narratives regarding the frequency of small game including rodents, as food as well as its utility as medicine that the *Musehars* consumed regularly.

The number of rats in a single kill could include as many as ten to twenty individuals and food processing

would follow immediately. The peak of such activities would coincide during and after the harvest and thrashing grains. Harvesting twice a year provides a maximum yield of sometimes running into hundred rats a day for the group. Most common species of prey included *Tatera indica*, *Rattus meltada*, Bandicoot rat and occasionally the moles (*Nisokia indica*), besides other animals such as turtle, monitor lizard and several other birds of prey. Survival potential of bones, types of bones that survived last and the degree of burning marks and their location on bones were found to be useful markers for archaeological interpretations. At times the rodents were roasted whole and bones eaten away, leaving no evidence that could have been of any consequence. Sometimes the sizeable number of rats was pulverized along with the bones after cooking and the meat taken to the settlement, once again leaving no scope for its direct archaeological evidence. The application of immunological analyses of the archaeological materials like grinding stones and ceramics using analogy from the living aborigine populations should help in shedding important light on the patterns of food preparation and diet perspective (Yohe II *et al.* 1991, Barnard *et al.* 2007, Solazzo *et al.* 2008, Barker 2010). On site consumption involved overwhelming participation of younger age groups in addition to the teenage hunters. The bones that leave signatures of burning include caudal vertebrae and phalanges for the fact that these are most susceptible to burning due to least flesh cover. Skull, rib cage, mandibles, femora, humeri and metapodial are invariably found and bear no trace of burning. The dogs as pets consume the remainder but they are carefully kept away from the kill site throughout the entire procedure. However, an interesting example comes from yet an adjacent hamlet where nearly all the bones of several field rats were completely wiped away by scavenging dogs, leaving behind no signatures of human intervention. The differential burning of the skeletal elements is often owing to the roasting whole of the animal but it is the postmortem procedures that decide the fate of these bones in getting into the archaeological record. However, the absence of burning in the assemblage at an Early Historic site of Kopia once again makes it a unilateral statement that even based on ethnographic examples it can be logically deduced that the rodent fauna provided nutritional value.

The exploitation of rodents for food does not seem to restrict to the aborigines. In a Sanskrit treatise of

12th century A.D., viz. '*Abhilaasitarth Cintamani* or *Maanasollasa*,' written by the King Someswar IIIrd of the Chalukya Dynasty of Western India, a chapter titled '*Annabhoga*' refers to recipes prepared from the meat of rodents especially caught from the cultivated fields which are healthy and possess more of meaty portions (Gokhale 2010). One of the methods is to barbeque the whole of rat which even continues to be practiced among the aborigines today.

As can be evidenced from these examples the animal is roasted and consumed whole of it or the bones discarded may not essentially reach the archaeological record and hence dampens any efforts in hypothesis building with any scientific precision. Based on this analogy it can be established that either the absence of bones of these small rodents or the traces of human activity of new available bones does not necessarily rule out their inclusion in the diet of prehistoric man. This is also supported by the fact that owing to the high ratio of edible meat versus the live weight (**Table 6**) and easy availability of smaller game (especially rats and mice) in close proximity to human settlements afforded an easy source of food for the ancient human populations.

Discussion and Conclusion

The evidence of muroids in archaeological context demonstrates multifold implications with respect to ecological, subsistence and behavioural archaeology. The Fluorine analysis confirms the antiquity of its bones. Added to careful sampling of its bones this helps in understanding the ecological diversity of the area. Besides, identification of eco-niche of individual taxon, it makes a welcome addition to the data already available for other mammals. Systematic screening of sediments for the presence of rodents with respect to context of the micro settlement pattern should help to designate their role. The observations on the faunal materials from early historic site of Kopia reveal two strong possibilities i.e. majority of the assemblage has escaped avifaunal predation and it is a mix of naturally sorted as well as the food debris accumulated over the period of four to five hundred years of habitational history. Present day analogy with regard to the site certainly points to small mammal (rodent) fauna as a regular supplement to the diet. For indeterminate assemblage it could have been either a mere co-existence as crop robbers or the victims of predation by carnivorous birds, and cats need

Table 6: Carcass weight and edible meat of the rodents consumed by the Musehars (Calculations After Whyte 1953, Stahl 1982, Eaton *et al.* 1997).

Carcass weight And percentage	<i>Rattus rattus</i>	<i>Bandicota bengalensis</i>	<i>Millardia meltada</i>	<i>Tatera indica</i>
Live weight	100 g	150 g	65 g	60 g
Bone	10 g	10 g	3 g	4g
Viscera	20 g	30 g	10 g	9 g
Skin	35 g	30 g	20 g	15 g
Edible meat	120 g	120 g	32 g	32 g

to be confirmed. However, the review strongly recommends for the systematic collection of rat bones from individual archaeological units and computation of minimum number of individuals (MNI) to explain the factors helped maintaining rodent populations, e.g. prosperous or famine resulted agricultural phases, durations of settlements, site abandonment, and presence or absence of savannah grassland with subsoil moisture congenial to proliferation of rodent population.

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Competing Interests

The author has no competing interests to declare.

References

- Agrawal, D P** 1992 *Man and Environment in India Through Age*. New Delhi: Books & Books.
- Agrawal, D P and Kusumgar, S** 1974 Prehistoric Chronology and Radiocarbon Dating in India, New Delhi.
- Alur, K R** 1969 Animal Remains from Sanganakallu. In: Ansari, Z D and Nagarajrao, M S (Eds.), *Excavations at Sanganakallu 1964–65*. Pune: Deccan College. pp. 29–38.
- Alur, K R** 1979 Animal Remains from Yelleswaram. *The Andhra Pradesh Journal of Archaeology*, 1(2): 63–66.
- Alur, K R** 1980 Faunal Remains from Vindhyas and the Ganga valley. In: Sharma, G R, Misra, V D and Pal, J N (Eds.), *Excavations at Mahadaha 1977–78*. Allahabad: University of Allahabad, pp. 89–115.
- Alur, K R** 1990 *Studies in Archaeology and Palaeontology*. Dharwad: Dharwadi Shrihari Prakashan.
- Andrews, P** 1990 *Owls, Caves and Fossils*. London: British Museum (Natural History).
- Andrews, P** 1995 Experiments in Taphonomy. *Journal of Archaeological Science*, 22: 147–153. DOI: <https://doi.org/10.1006/jasc.1995.0016>
- Ansari, S** 1999–2000 Small game hunting Musahars: an ethnoarchaeological approach. *Purattatva*, 30: 142–149.
- Arjunwadkar, A V and Gadgil, M** 1974 Burrowing Habits of the Greater Bandicoot Rat (*Bandicota indica*). *Journal of Bombay Natural History Society*, 71(1): 138–140.
- Badam, G L** 1986 Preliminary Report on the Faunal Remains from Chalcolithic Daimabad, Maharashtra. *Archaeological Studies*, 93–100.
- Barker, A** 2010 Archaeological Protein Residues: New Data for Conservation Science. *Ethnobiology Letters*, 1: 58–65. DOI: <https://doi.org/10.14237/ebl.1.2010.60>
- Barnard, H, Ambrose, S H, Beehr, D E, Forster, M D, Lanehart, R E, Malainey, M E, Parr, R E, Rider, M, Solazzo, C and Yohe, R M** 2007 Mixed results of seven methods for organic residue analysis applied to one vessel with the residue of a known foodstuff. *Journal of Archaeological Science*, 34: 28–37. DOI: <https://doi.org/10.1016/j.jas.2006.03.010>
- Barnett, S A and Prakash, I** 1975 *Rodents of Economic Importance in India*. New Delhi: Arnold-Heinemann.
- Blumenschine, R J and Chattopadhyaya, U C** 1983 A Preliminary Report on the Terminal Pleistocene Fauna of the Middle Son Valley. In: Sharma, G R and Clark, J D (Eds.), *Prehistory in the middle Son valley*. Allahabad: University of Allahabad, pp. 281–284.
- Brothwell, D R and Brothwell, P** 1969 *Food in Antiquity: A Survey of the diet of early Peoples*. London: Thames and Hudson.
- Clason, A T** 1979 *Wild and Domestic Animals in Prehistoric and Early Historic India*. Lucknow: Ethnographic and Folk Culture Society.
- Crooke, W** 1896 *The Tribes and Castes of North Western Province and Oudh*. Vol. II, Calcutta: Government of India.
- Crump, C A** 1912 Mammal Survey of Kutch. 'Food Habits of Musk Shrew', Report No. 3, *Journal of Bombay Natural History Society*, 21(3): 843.
- Cuijpers, S and Lauwerier, R C G M** 2008 Differentiating between bone fragments from horses and cattle: a histological identification method for archaeology. *Environmental Archaeology*, 13: 165–79. DOI: <https://doi.org/10.1179/174963108X343281>
- Dharmarajan, S** 2007 Irula Tribe, Ecology and Business Innovation – A Case Study. *Proceedings of the Conference on Global and Competitiveness of Indian Corporate*, Chennai. pp. 595–606.
- Dhavalikar, M K, Rawal, M R and Chitalwala, Y M** (Eds.) 1996 *Kuntasi: A Harappan Emporium on West Coast*, Pune: Deccan College.
- Eapen, J** 1960 A Report on the Animal Remains of Nevasa Excavations. In: Sankalia, H D, Deo, S B, Ansari, Z D and Erhardt, S (Eds.) *From History to Prehistory at Nevasa (1954–56)*. Pune: Deccan College, pp. 531–536.
- Eates, K R** 1968 An introduction to the Vertebrate Fauna of Sind and Khairpur State, Written in 1952 and published in *West Pakistan Gazetteer – Sind Region, Government of West Pakistan*. Chapter III.
- Eaton, S B** 1992 Human, lipids and evolution. *Lipids*, 27: 814–820. DOI: <https://doi.org/10.1007/BF02535856>
- Eaton, S B, Eaton, S B and Konner, M J** 1997 Palaeolithic nutrition revisited: A twelve-year retrospective on its nature and implications: Review. *European Journal of Clinical Nutrition*, 51: 207–216. DOI: <https://doi.org/10.1038/sj.ejcn.1600389>

- Eaton, S B and Konner, M** 1985 Palaeolithic nutrition. A Consideration of its nature and current implications. *New England Journal of Medicine*, 312: 283–289. DOI: <https://doi.org/10.1056/NEJM198501313120505>
- Eaton, S B, Konner, M and Shostak, M** 1988 Stone Agers in the fast lane: Chronic degenerative diseases in evolutionary perspective. *American Journal of Medicine*, 84: 739–749. DOI: [https://doi.org/10.1016/0002-9343\(88\)90113-1](https://doi.org/10.1016/0002-9343(88)90113-1)
- Fernandez-jalvo, Y, Andrews, P and Denys, C** 1999 Cut Marks on small mammals at Olduvai Gorge Bed – I. *Journal of Human Evolution*, 36: 587–589. DOI: <https://doi.org/10.1006/jhev.1999.0292>
- Fiedler, L R** 1990 Rodents as food source. In: Davis, L R and Marsh, R E (Eds.) *Proceedings of 14th Vertebrate Pest Conference*. Davis: University of California, pp. 149–155.
- Flandrin, J L and Montanari, M** (Eds.) 1999 *Food: A Culinary History from Antiquity to the present*. New York: Columbia University Press.
- Flynn, L J** 1982 Systematic Revision of Siwalik Rhizomyidae (Rodentia). *Geobios*, 15: 327–389. DOI: [https://doi.org/10.1016/S0016-6995\(82\)80084-3](https://doi.org/10.1016/S0016-6995(82)80084-3)
- Fuchs, S** 1968 *The Gond and Bhumia of Eastern India*, Bombay: New Literature Publishing Company.
- Gaur, R** 1986 First report on a Rattus (Murinae, Rodentia) from the Pinjor Formation of Upper Siwaliks of North West India. *Current Science*, 55(II): 542–544.
- Gautier, A** 1993 Trace Fossils in Archaeozoology, *Journal of Archaeological Science*, 20: 511–523. DOI: <https://doi.org/10.1006/jasc.1993.1032>
- George, C M, Joy, P J and Abraham, C C** 1982 Distribution Feeding Habits and Burrowing Patterns of *Tatera indica* Cuveiri (Watehouse). *Journal of Bombay Natural History Society*, 79: 296–301.
- George, J C** 1955 Identification of Bones. In: Sankalia, H D and Deo, S B (Eds.) *Report on the Excavations at Nasik and Jorwe 1950–51*. Pune: Deccan College, pp. 142–146.
- Gokhale, S** 2010 *Abhilashitarth Chintamani arthaat Mansollasa: ya granthateel sanskruti Darsan* (in Marathi). Pune: Bhartiya Itihas Samshodhak Mandal, p. 60.
- Goyal, P** 2012 *Investigations into animal-based subsistence of the Harappan culture in Gujarat with special reference to Kanmer*. Unpublished Ph.D. Thesis. Pune: Deccan College Postgraduate and Research Institute.
- Graham, I and Saunders, A** 1978 A Multivariate Statistical Analysis of Small Mammal Bones. In: Brothwell, D R, Thomas, K D and Clutton-Brock, J, (Eds.) *Research Problems in Zooarchaeology*. London: Institute of Archaeology Occasional Publication No.3, pp. 59–67.
- Grine, F E, Fosse, G, Krause, D W and Jungers, W L** 1986 Analysis of individual, intraspecific and interspecific variability in quantitative parameters of caprine tooth enamel structure. *Acta Odontologica Scandinavica*, 45: 1–23. DOI: <https://doi.org/10.3109/00016358709094349>
- Harris, M** 1985 *Good to eat: Riddles of food and Culture*. New York: Simon and Schuster.
- Hendrickson, R** 1983 *More cunning than man: A social history of rats and man*. New York: Dorset Press.
- Jacobs, L L** 1978 Fossil Rodents (Rhizomyidae and Muridae) from Neogene Siwalik deposits, Pakistan, *Museum of Northern Arizona Press, Flagstaff, Bulletin*, Ser. 52: 1–103.
- Janike, M R** 2001 Nutritional ecology: diet, physical activity and body size. In: Panter-Brick, C, Layton, R H and Rowley-Conwy, P (Eds.) *Hunter-Gatherers: An Interdisciplinary Perspective*. Cambridge: Cambridge University Press, pp. 205–238
- Joglekar, P P** 1992 *A Biometric Approach to the Faunal Remains of Walki and Kaothe*, Unpublished Ph.D. Dissertation, Pune: University of Poona.
- Joglekar, P P** 1996–97 Faunal Remains from Padri: Second Preliminary Report, *Bulletin of the Deccan College PGRI*, 56–57: 55–68.
- Joshi, S V and Sathe, V** 2007 Fluorine Dating of the Pleistocene Vertebrate Fossils from the Manjra valley, Maharashtra, *Man and Environment*, 32(1): 33–38.
- Kajale, M D** 1988 Flora. In: Dhavalikar, M K, Sankalia, H D and Ansari, Z D (Eds.) *Excavations at Inamgaon*. Pune: Deccan College, pp. 727–822.
- Kane, V S** 1989 Animal Remains from Rojdi. In: Possehl, G L and Rawal, M K, (Eds.) *Harappan Civilization and Rojdi*. New Delhi: Oxford and IBH, pp. 182–184
- Kanungo, A, Misra, V N, Dutta, R, Prasad, G V, Yadava, M G and Hodgins, G W L** 2010 The radiocarbon chronology of Kopia, an early glass manufacturing centre in India. *Archaeometry*, 52(5): 899–918. DOI: <https://doi.org/10.1111/j.1475-4754.2009.00497.x>
- Kanungo, A K and Vasant, S** 2004–2005 Excavations at Kopia 2005: A Preliminary Report. *Purattatva*, 35: 126–134.
- Kirshnamurty, K, Uniyal, V, Rao, M and Pingale, S V** 1967 Studies on rodents and their control, Pt. I. Studies on rat population losses of food grains (75, 77, 109, 110). *Bulletin of Grain Technology*, 5: 147–153.
- Korth, W W** 1979 Taphonomy of microvertebrate fossil assemblages. *Annals of Carnegie Museum*, 48(Art. 15): 235–285.
- Kotlia, B S** 1985 Pliocene Murid (Rodentia, Mammalia) from Kashmir Basin, Northwestern India. *N. Jb.Geol. Palaeontol*, 184(3): 339–357.
- Kotlia, B S** 1985 Quaternary Rodent fauna of the Kashmir Valley, North-Western India: Systematics, Biochronology and Palaeoecology, *Journal of Palaeontological Society of India*, 30: 81–91.
- Kotlia, B S and Joshi, M** 2011 Taphonomy of Late Pleistocene micromammalian fauna of Narmada valley, Central India. *Palaeoworld*, 20: 84–91. DOI: <https://doi.org/10.1016/j.palwor.2010.09.017>
- Kotlia, B S and Koenigswald, W V** 1992 Plio-Pleistocene Arviculids (Rodentia, Mammalia) from Kashmir Intermontane Basin, Northwestern India. *Palaeontographica*, 223: 103–135.
- Lanning, E** 1967 *Peru before the Incas*. New Jersey: Prentice hall.

- Loreille, D, Vigne, J-D, Hardy, C, Callou, C, Treinen-Claustre, F, Dennebouy, N and Monnerot, M** 1997 First distinction of sheep and goat archaeological bones by the means of their fossil mtDNA. *Journal of Archaeological Science*, 24: 33–37. DOI: <https://doi.org/10.1006/jasc.1995.0094>
- Lydkker, R** 1886 The Fauna of Kurnool caves. *Palaeontologia Indica*, Series C 4(2): 23–58.
- Lyman, R L, Power, E and Lyman, R J** 2003 Quantification and sampling of faunal remains in owl pellets. *Journal of Taphonomy*, 1(1): 3–14.
- Misra, V N** 1988 Significance of Vertebrate Remains from Archaeological Sites in the Arid and Semi-arid Zones of Northwest India. In: Ghosh, P K and Prakash, I (Eds.) *Ecophysiology of desert vertebrates*. Jodhpur: Scientific Publishers. pp. 35–57.
- Misra, V N, Shinde, V, Mohanty, R K, Dalal, K, Mishra, A, Pandey, L and Kharakwal, J** 1995 Excavations at Balathal: Their contribution to the Chalcolithic and Iron Age Cultures of Mewar, Rajasthan. *Man and Environment*, 20(1): 57–80.
- Morlan, R E** 1994 Rodent bones in archaeological sites. *Canadian Journal of Archaeology*, 18: 136–143.
- Murty, M L K** 1975 Late Pleistocene fauna of Kurnool Caves, South India. In: Clason, A T (Ed.) *Archaeozoological Studies*. North Holland: Amsterdam, pp. 132–138.
- Murty, M L K** 1981 Symbiosis and traditional behaviour in the subsistence economics of the Kunchapuri Yerukulas of South India: A predictive model. *Puratattva*, 10: 50–61.
- Murty, T N S** 1993 *Illustrated Encyclopaedia of the Reptiles of India*. Delhi: B.R. Publishing Corporation.
- Nagar, M and Misra, V N** 1990 The Kanjaras- A Hunting-Gathering Community of the Ganga valley, Uttar Pradesh. *Man and Environment*, 15(2): 70–88.
- Nagrarajao, M S and Malhotra, K C** 1965 *The Stone Age hill dwellers of Tekkalkota*, Pune: Deccan College.
- Nambi K S V and Murty M L K** 1983 An Upper Palaeolithic Fireplace in Kurnool caves, South India. *Bulletin of the Deccan College Research Institute*, 42: 110–16.
- Nath, B** 1957 Animal Remains from Maski. *Ancient India*, 13: 111–120.
- Nath, B** 1963 Advances in the Study of Prehistoric and Ancient Animal remains in India: A review. *Records of the Zoological Survey of India*, 61: 1–63.
- Nath, B** 1968 Animal Remains from Rupar and Bara sites, Ambala Dist. of East Punjab, India. *Bulletin of the Indian Museum*, 3(1–2): 69–116.
- Nath, B and Rao, S** 1985 Animal Remains from Lothal Excavations. In: Rao, S R (Ed.) *Lothal: A Harappan Port town (1955–62)*. New Delhi: Archaeological Survey of India, pp. 636–650
- Nesfield, J C** 1883 The Kanjars of Upper India. *Calcutta Review*, 77: 368–398.
- Neumayer, E** 1983 *Prehistoric Indian Rock Paintings*. Mumbai: Oxford University Press.
- Patnaik, R** 1993 *Micropaleontology, Biostratigraphy and Palaeoenvironmental Analysis of the Siwalik Sequences in the Saketi-Nahan area (Himachal Pradesh)*, Unpublished Ph.D., Dissertation. Chandigarh: Panjab University.
- Patnaik, R** 1995a Micromammal-Based Palaeoenvironment of Upper Siwaliks Exposed Near Village Saketi, H.P. *Journal of Geological Society of India*, 46: 429–437.
- Patnaik, R** 1995b Narmada valley Microvertebrates: Systematics, Taphonomy and Palaeoecology. *Man and Environment*, 20(2): 75–90.
- Patnaik, R** 2001 Late Pliocene Micromammals from Tatrot Formation (Upper Siwaliks) exposed near village Saketi, Himachal Pradesh, India. *Palaeontographica*, 261: 55–81.
- Patnaik, R** 2003 Reconstruction of Upper Siwalik Palaeoecology and Palaeoclimatology using microfossil palaeocommunities. *Palaeogeography, palaeoclimatology, palaeoecology*, 197: 133–150. DOI: [https://doi.org/10.1016/S0031-0182\(03\)00390-0](https://doi.org/10.1016/S0031-0182(03)00390-0)
- Patnaik, R, Badam, G L and Murty, M L K** 2008 *Quaternary International*.
- Patnaik, R, Badam, G L and Sathe, V** 1995 Discovery of Microvertebrates from the Pleistocene Deposits of the Central Narmada valley, India. *Current Science*, 68(8): 828–830.
- Prasad, K N** 1996 Pleistocene cave fauna from Peninsular India. *Journal of Caves and Karst Studies*, 58(1): 30–34.
- Prashad, B** 1936 Animal Remains from Harappa, *Memoirs of Archaeological Survey India*, 51.
- Raghavan, P** 1993 New Records of Microfossil Assemblages from the Basal Pinjor Formation at Panchkula, Haryana, India, *Bulletin of the Indian Geologists Association*, 23(1): 29–37.
- Rao, V V** 1970 Skeletal Remains from Takalghat and Khapa Excavations. In: Deo, S B (Ed.) *Excavations at Takalghat and Khapa (1968–69)*. Nagpur: Nagpur University, pp. 225–233.
- Rao, V V** 1973 Bone remains from Bhokardan Excavations. In: Deo, S B D (Ed.) *Excavations at Bhokardhan (Bhogvardhana)*. Nagpur, pp. 225–233
- Redding, R W** 1978 Rodents and the Archaeological Palaeoenvironment: Considerations, Problems, and the Future. In: Meadow, R H and Zeder, M A (Eds.) *Approaches to Faunal Analysis in the Middle East*. Harvard University: Peabody Museum Bulletin 2. Cambridge Mass.: Peabody Museum of Archaeology and Ethnology, pp. 63–68.
- Repenning, C A** 1983 *Pitymys Meadensis* hibbard from the valley of Mexico and the Classification of North American species of *Pitymys* (Rodentia: Cricetidae), *Journal of Vertebrate Palaeontology*, 2(4): 471–482. DOI: <https://doi.org/10.1080/02724634.1983.10011947>
- Roberts, T J** 1977 *The Mammals of Pakistan*. London & Tonbridge: Ernest Bess Limited, 361.
- Ryan, K** *In press* Faunal analysis. In: Possehl, G L and Rawal, M H (Eds.) *Report on the Excavations at Babarkot: 1990–91*, New Delhi: Archaeological Survey of India.
- Saavedra, B and Simonetti, J A** 1998 Small mammal taphonomy: intraspecific bone assemblage comparison between South and North American Barn Owl, *Tyto alba*, population. *Journal of Archaeological Science*, 25: 165–170. DOI: <https://doi.org/10.1006/jasc.1997.0211>
- Sahni, A and Kotlia, B S** 1985 Karewa Microvertebrates: Biostratigraphical and Palaeoecological Implications.

- In: Agrawal, D P, Kusumgar, S and Krishnamurthy, R V (Eds.) *Current Trends in Geology Vol. 6 (Climate and Geology of Kashmir)*. New Delhi: Today's & Tomorrow's Printers and Publishers, pp. 29–43.
- Sahni, A and Srivastava, V C** 1973 Additional Eocene Mammals from the Subathu Formation of Jammu and Kashmir. *Journal of Palaeontological Society of India*, 17: 31–49.
- Sali, S A** 1986 *Daimabad, 1976–79*. New Delhi: Archaeological Survey Of India, Government of India.
- Sathe, V** 2003 Tooth enamel ultrastructure in cattle and buffaloes: Taxonomic interpretations. *Archives of Comparative Biology of Tooth Enamel*, 8: 28–34.
- Sathe, V** 2013 Microvertebrate Assemblage from Kopia. In: Kanungo, A (Ed.) *Glass in Ancient India Excavations at Kopia*. Thiruvananthapuram: Kerala Council for Historical research, pp. 241–253.
- Sathe, V and Badam, G L** 2004 Faunal remains. In: Singh, B P (Ed.) *Early Farming Communities of the Kaimur Volume II (Appendix III)*. Jaipur: Publication Scheme. pp. 536–584
- Sathe, V and Chakraborty, P** 2014 Microvertebrate taphonomy in the pellets of *Tyto alba* (Barn Owl). Abstract Book, pp. Paper presented at 12th International Conference of International Council of Archaeozoology (ICAZ), held at San Rafael City, Mendoza Province, Argentina from 22nd to 27th September 2014.
- Sathe, V and Joshi, S** 2013 An X-ray Diffraction Investigation of bones from Archaeological sites in India: a Taxonomic Discrimination method for Archaeozoology. *Bulletin of the Deccan College Postgraduate and Research Institute*, 72–73.
- Sathe, V and Kshirsagar, A** n.d. The Antiquity of Rodents (murids and cricetids) as Tested by Fluorine from Quaternary Deposits in India: Myth and Reality.
- Sewell, R B S and Guha, B S** 1931 Zoological Remains In: Marshall, Sir John ed. *Mohenjodaro and The Indus Civilization Vol II*. London: Anthen Probsthain, pp. 647–673.
- Shah, D R** 1968 Bones and Shells. In: Mehta, R N and Shah, D R (Eds.) *Excavations at Nagara*. Baroda: M.S. University, pp. 152–163.
- Shah, D R** 1971 Faunal Remains from excavations at Jokha. In: Mehta, R N, Choudhary, S N, Hegde, K T M and Shah, D R (Eds.) *Excavations at Jokha*. Baroda: M.S. University, pp. 70–74.
- Shah, D R** 1973 Animal Remains from Kodekal excavations. In: Paddayya, K (Ed.) *Investigations into the Neolithic Culture of the Shorapur doab, South India*. Leiden: E.J. Brill, pp. 92–95.
- Shah, D R** 1975 Animal Remains. In: Mehta, R N and Choudhary, S N (Eds.) *Excavations at Dhatwa*. Baroda: M.S. University, pp. 57–60.
- Shah, D R and Bhan, K K** 1992 Faunal Remains. In: Hegde, K T M, Bhan, K K, Sonawane, V H, Krishnan, K and Shah, D R (Eds.) *Excavations at Nageswar, Gujarat: A Harappan Shell working site on the gulf of Kutch*. Baroda: M.S. University, pp. 145–147.
- Sharma, A K** 1979–80 Excavations at Gufkral. *Puratattva*, 11: 16–25.
- Sharma, A K** 1990 Animal Bone Remains. In: Joshi, J P (Ed.) *Excavations at Surkotada 1971–72 and Explorations in Kutch. Memoirs of Archaeological Survey of India* 87, pp. 372–383.
- Singh, S K** 1993 *The Scheduled Castes*. Vol.II, New Delhi: Oxford University Press.
- Solazzo, C, Fitzhugh, M, William W, Ronaldo, C and Tokarski, C** 2008 Identification of Protein remains in Archaeological potsherds by Proteomics. *Anal. Chem.* 80, 4590–4597. DOI: <https://doi.org/10.1021/ac800515v>
- Stahl, P** 1982 On Small mammal remains in Archaeological Context. *American Antiquity*, 47(4): 822–829. DOI: <https://doi.org/10.2307/280287>
- Stahl, P W** 1996 The recovery and interpretation of microvertebrate bone assemblages from archaeological contexts. *Journal of Archaeological method and Theory*, 3(1): 31–75. DOI: <https://doi.org/10.1007/BF02228930>
- Szuter, C** 1988 Small mammal exploitation among desert horticulturists in North America. *Archaeozoologia*, 2(1.2): 191–200.
- Terry, R C** 2004 Owl pallet taphonomy: A preliminary study of the post-regurgitation taphonomic history of pallets in a temperate forest. *Palaios*, 19: 497–506. DOI: [https://doi.org/10.1669/0883-1351\(2004\)019<0497:OPTAPS>2.0.CO;2](https://doi.org/10.1669/0883-1351(2004)019<0497:OPTAPS>2.0.CO;2)
- Tetso, D** 2007 *Archaeozoological aspects of the Ahar culture of Rajasthan with special reference to Balathal, District Udaipur, Rajasthan*. Unpublished Ph.D. Thesis. Pune: Deccan College Postgraduate and Research Institute.
- Thomas, P K** 1975 Role of Animals in the Food Economy of the Mesolithic Culture of Western and Central India In: Clason, A T ed. *Archaeozoological Studies*. North Holland: Amsterdam, pp. 322–328.
- Thomas, P K** 1988 Faunal Remains. In: Dhavalikar, M K, Sankalia, H D and Ansari, Z D (Eds.) *Excavations at Inamgaon*. Pune: Deccan College, pp. 823–953.
- Thomas, P K** 1992 Faunal Assemblage and Subsistence Strategies at Tuljapur Garhi. *Man and Environment*, 17(2): 71–74.
- Thomas, P K and Joglekar, P P** 1990 Faunal Remains. In: Dhavalikar, M K, Shinde, V and Atre, S (Eds.) *Excavations at Kaothe*. Pune: Deccan College, pp. 233–264.
- Thomas, P K, Joglekar, P P, Mishra, V D, Pandey, J N and Pal, J N** 1995 A Preliminary Report of the Faunal Remains from Damdama. *Man and Environment*, 20(1): 29–36.
- Thomas, P K, Joglekar, P P, Mukherjee-Deshpande, A and Pawankar, S J** 1995 Harappan Subsistence Patterns with Special Reference to Shikarpur, a Harappan site in Gujrat, *Man and Environment*, 20(2): 33–41.
- Thomas, P K, Matsushima, Y and Deshpande, A** 1996 Faunal Remains In: Dhavalikar, M K, Rawal, M R and Chitalwala, Y M (Eds.) *Kuntasi: A Harappan Emporium on West Coast*. Pune: Deccan College, pp. 298–347.
- Tribhuvan, R D and Peters, P** 1992 Medico-ethnobiology of the Katarkis and Thakurs, *Tribal Research Bulletin* (Tribal Research and Training Institute, Pune), 24(1): 20–24.
- Uparathna, U R** 2011 *Animal based subsistence of Early Harappans during earliest levels of RGR 6 at Rakhi-*

garhi, Dist. Hissar, Haryana. M.A. Dissertation, Pune: Deccan College.

Whyte, T R 1953 A method of calculating the Dietary percentage of various food animals utilised by aboriginal peoples. *American Antiquity*, 4: 396–398. DOI: <https://doi.org/10.2307/277116>

Yohe, Il, Robert, M, Margaret, E N and Schneider, J S 1991 Immunological identification of small – mammal

proteins on aboriginal milling equipment. *American Antiquity*, 56(4): 659–666. DOI: <https://doi.org/10.2307/281543>

Zedda, M, Lepore, G, Manca, P, Chisu, V and Farina, V 2008 Comparative bone histology of adult horses (*Equus caballus*) and cows (*Bos taurus*). *Anatomia Histologia Embryologia*, 37: 442–445. DOI: <https://doi.org/10.1111/j.1439-0264.2008.00878.x>

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