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Stable Isotope and Trace Element Analysis of Animal and Human Remains from Garhwal Himalaya: Palaeodietary Reconstruction

S. Kumar Juyal, V. Nautiyal, R.H. Tykot, T. O'Connell & K. Privat

ABSTRACT

Paleodietary studies based on bone chemistry have caught attention in India in recent years. However, it has not been carried out extensively as elsewhere, because of the unavailability and inaccessibility of the scientific facilities required to carry out such studies in the country. We have been trying to develop the analytical facilities to conduct work in these new emerging areas of paleodietary studies during the last few years. The present paper reports the results of the trace elements and carbon and nitrogen isotopic analyses of modern and archaeological specimens of human and animal bones from different sites of Uttaranchal. Based on these results it may be said that the high altitude animals particularly, jhuppu[1] (datable to 100 B.C.), had subsisted mainly on C_3 plants and this dietary practice continued till present time. On the other hand, the human population mainly subsisted on C_4 plants, but also consumed a high proportion of animal flesh in its diet. In the Alaknanda valley the domesticated animals largely subsisted on the C_4 rich diet, however this practice during the present time shifted towards the C_3 based diet.

The bones of modern cattle and goat at different altitudes (i.e. high altitude, river valleys and foothill) also provide significant difference in the trace element levels. The trace element concentration of Sr, Zn, K, Mg, Mn, Cu, Fe, Na and Ca in the animal bones shows a changing pattern at different altitudes, suggesting that the concentration of trace elements is directly proportional to the dietary intake with the altitudinal changes.

Introduction

In recent years, the studies on prehistoric subsistence and food practices have attained a worldwide attention as the focus of the archaeologist has also shifted from the conventional issues and problems. In India various archaeologists in collaboration with anthropologists have been using the tools of skeletal biology, dental palaeopathology and anthrophometry to shed light on the nutritional and status of health of individuals of prehistoric and protohistoric communities belonging to different cultural phases of Indian archaeology. In recent years the advances in bone chemistry have allowed archaeologists to exploit the analytical tools of isotopes and trace elements to investigate the diet of ancient human and animal groups, which otherwise is not discernible through conventional methods. In a wider perspective the palaeodietary studies have become a new paradigm in multidisciplinary archaeological and anthropological research.

The Problem

The archaeology of mid-central Himalaya or Uttaranchal is now fairly well understood (Nautiyal & Khanduri 1977, 1979, 1986, 1991; Nautiyal et al. 1979, 1991; Joshi 1986). Based upon the archaeological excavations in mid-central Himalaya a more precise chrono-cultural sequence is available to us, and the cultural manifestations of these early communities is clearly reflected through the different structures, artifacts, pottery traditions, metallurgy, art etc. However, there are still many problems related to the adaptive behavior and exploitation patterns of different food resources of these early communities who settled in high altitudes and riverine valleys, following their long distance migrations as well as those of the animals domesticated by these settlers. Therefore, we are totally skeptical about the subsistence behaviour and food habits of some of the sedentary and transhumant communities belonging to different cultures and their animals in different ecological or vegetation zones. In this context no work related to the food habits has ever been attempted. Therefore this was the most virgin field for the authors to undertake. Since the reconstruction of the palaeodiet based on the bone chemistry is a new attempt in India, therefore we have given some background about the concepts of the bone chemistry as well as an account of the work being done elsewhere in the world, and the results of our work on the bones from Garhwal Himalaya.

Bone Chemistry: Dietary Signals

The human skeleton is a structural framework for supporting our bodies. The oesteometric analysis of bones provides valuable information about the status of health, nutrition, growth and disease of individuals. The nature and type of diet taken by individuals influence the growth and development of the bones and based on the earlier studies it was found that the chemical and biochemical signatures of the bones influenced to a great extent by the dietary intake (Price 1989; Sillen & Kavanagh 1982; Price et al. 1985). Such dietary signatures are reflected in the trace elements and isotopic ratios of the bones (Price 1989). These signals remain in the bone even after the death of an individual, which can be retrieved, for use in the reconstruction of past human diets. This observation has been validated by experimental studies on the laboratory animals (Lambert & Homeyer 1993), and modern populations of human beings (O'Connell & Hedges 1999), and therefore forms the basis of the palaeodietary studies.

Review of Literature

A review of literature suggests that a large number of studies have been carried out worldwide and therefore, it may be important to provide a brief reference to the work being done elsewhere. The isotopic analysis of dietary carbon and nitrogen has been used to make dietary inferences (Van der Merwe 1982; DeNiro 1987; Schoeninger 1989; Schwarcz & Schoeninger 1991; Ambrose 1993; Schoeninger & DeNiro 1984; Vogel 1978), and used to discriminate marine vs. terrestrial components in diet (Chisholm et. al. 1982, 1983; Hayden et. al. 1987; Schoeninger et. al. 1983; Schoeninger & DeNiro 1984; Sealy & Van der Merwe 1985; Tauber 1979, 1981). However, the trace element analysis has been used by many researchers in order to understand the dietary behaviour of ancient populations (Schoeninger 1982; Bisel 1988). Trace elements are analyzed as a specific palaeodietary indicator; barium (Ba) and strontium (Sr), for example, have been considered as strong vegetable intake indicators (Comar et. al. 1957; Parker & Toots 1980; Lambert et. al. 1984; Lambert & Weydert-Homeyer 1993), while copper (Cu) and zinc (Zn) are discriminators of meat consumption (Underwood 1977; Klepinger 1984; Buikstra et. al. 1989; Lambert & Weydert-Homeyer 1993).

Over the years with the advances in bone chemistry and understanding of the various fundamental issues and problems related to diet, nutrition, metabolism, and the effect of digenesis (post-mortem changes), as well as of the applications of different analytical techniques, have led to the various scientific studies on reconstructing palaeodiets and palaeonutrition of the prehistoric communities in different parts of the world (DeNiro & Schoeninger 1985; Katzenberg & Schwarcz 1986; Price & Kavanagh 1982; Richards et. al. 1998; Privat et. al. 2002; Richards et. al. 2003). As a result of these advances, a new light into the food habits have been thrown which has complemented the evidence based on archaeobotanical remains as well as helped to reconstruct the diet of the communities where no palaeobotanical materials have been found preserved.

It is in this framework, the present study has been conceived for investigating the chemical signatures on the bones of human and animal remains belonging to different cultural phases excavated from different archaeological sites of mid-central Himalaya so that their food habits could be reconstructed.

Material and Methods

For the present study the cortical bone samples were collected from a wide range of animals. The skeletal or bone remains have been taken from the different archaeological sites which have been excavated over the last two decades (Nautiyal & Khanduri 1977, 1979, 1986; Nautiyal et al. 1979, 1991) (Table 1), while the bones of modern animals were collected from different altitudes. The bone samples of modern domestic animals belongs to Cattle, Dog, Pig, Buffallo and Goat (Table 2), however the bones of wild animals collected from the foothill belong to Deer, Languor, Chousingha, Elephant, Cat, and Tiger (Table 3).

Before taking up the bones for elemental analysis, the samples of the bones were also submitted to CDRI, Lucknow for estimating the C/N ratios in the bone.

The pretreatment and sample preparation of the bone samples for the analysis was adopted from the earlier work of Farswan and Nautiyal (1997).

All the extraneous materials were removed from the bone samples. In the modern bone samples, the cartilage or flesh were removed by the boiling of bone in de-ionized water and then by the scraping the remaining portion with glass edge. The archaeological samples were also cleaned in the same fashion.

In case of complete bone samples, it was broken to expose the medullar cavity and the exposed surface was then abraded with abrasion sheet to remove the contaminations. Similarly the outermost portions of the surface of the archaeological samples were also cleaned, since this part is highly exposed to contamination.

The clean samples were further broken into small pieces and placed in different vials, which were rinsed with de-ionized water, covered again with de-ionized water and cleaned in ultrasonic bath for thirty minutes. The liquid was then drained. The process of sonification was repeated to perfectly clean the samples.

After sonification, the small vial containing the samples were covered with 1M or 1N acetic acid and allowed to settle at room temperature, and kept for overnight. This method was used to remove the post-depositional carbonate contamination. The samples were checked after at an interval of half an hour to ensure that it had dissolved the carbonate contamination completely. The acid washed bones were then rinsed with de-ionized water and dried in an oven overnight at 80-90^{0}C.

After drying of the samples, one gram of each sample was weighed into a labeled porcelain crucible. The crucibles were heated in a muffle furnace at 725^{0}C for 7-8 hours. After the crucibles were cooled, these were again weighed with their ash contents to determine the percent of weight loss, an indication of the amount of organic material in the bone.

For each sample approximately 200mg of bone ash were weighed into a disposable Pyrex test tube. About 10ml of concentrated nitric acid was added to each test tube and heated up to 100-120^{0}C for one hour. The insoluble residue, cloudiness and colour in the solution were noticed after an hour as an indicator of contamination. After heating for one hour the samples were removed from the hot plate, allowed to cool down, and diluted up to 100ml with the help of de-ionized water. The sample solution was then shaken to ensure that the sample was mixed well. Each sample was then introduced into plastic bottle and tightly covered with cork. Finally the samples were introduced into the Atomic Absorption Spectrophotometer for elemental analysis. Before the samples are subjected for the analysis the AAS was calibrated by running the standard solution of the known concentration. In the present study we have analyzed the samples in our archaeometric laboratory for the trace elements of Sr, Zn, Ba, Mg, Cu, Ca, Na and Mn.

Isotopic Analysis

For the isotopic analysis of carbon and nitrogen the samples were submitted at the Research Laboratory for Art and Archaeology, University of Oxford, UK and Department of Anthropology, University of South Florida, USA. The samples were analyzed by Dr. Tamsin O'Connell and Karen Privat at Oxford, UK and Dr. Robert Tykot in Florida, USA.

Samples were prepared following the method described in Richards and Hedges (1999) and adopted by O'Connell and Karen Privat. As per the method approximately 0.5-1.0g were obtained from each individual sample using a handsaw, which was cleaned before each sample was taken. The surfaces of the bone pieces were then cleaned by shot blasting and demineralised in 0.5M aq. HCl at 4°C. The samples were rinsed with distilled water and then gelatinised in acidic solution (pH3) at 75-83°C for 48 hrs. The liquid fraction containing the gelatinised protein was isolated by filtration, evaporated to dryness, rehydrated, frozen, and lyophilised to produce the final 'collagen' product. 2.5-4.0mg portions of this 'collagen' were used for each analysis.

The samples were processed in an automated carbon and nitrogen analyser (Carlo Erba carbon and nitrogen elemental analyser) coupled with a continuous-flow isotope ratio-monitoring mass spectrometer (Europa Geo 20/20 mass spectrometer). The samples were run in triplicate. δ^{13}C values were measured relative to the VPDB standard, and δ^{15}N values were measured relative to the AIR standard reference. The analytical error (1σ) for all samples is ±0.2‰ for both δ^{13}C and δ^{15}N.

Further, the trace elemental data were examined through the various statistical tests like descriptive analysis, student (t-test), analysis of variance (ANOVA) (f-test), and Pearson and Spearman correlation through the SPSS package. The Descriptive Statistics analysis tool generates a report of univariate statistics for data in the input range, providing information about the central tendency and variability of the data.

The independent sample t-test procedure compares means for two groups of cases, however the ANOVA procedure produces an analysis of variance for a quantitative dependent variable. The analysis of variance (f-test) is used to test the hypothesis that several means are equals. This technique is an extension of the two mean comparisons, such as the t-test. The student t-test is used for examining the difference in two categories of samples and ANOVA (f-test) is used for examining the difference in more than two categories of samples. The Correlation analysis tool measures the relationship between two data sets that are scaled to be independent of the unit of measurement. The correlation analysis tool is used to determine whether two ranges of data move together, i.e. whether large values of one set are associated with large values of the other (positive correlation), whether small values of one set are associated with large values of the other (negative correlation), or whether values in both sets are unrelated (correlation near zero). The Pearson and Spearman correlation have been taken for statistically testing the relationship between different trace elements.

Results

The results trace element analysis of archaeological, modern domestic and wild, samples are summarized in Tables 4–6 and Figures 1–3, respectively. The trace element concentration is reported in ppm (‰) (parts per million) except sodium (Na) and calcium (Ca), which are shown in percentage (%). The isotopic analysis results are indicated in Tables 7 & 8. The C/N ratios of the samples are summarized in Table 9. The significance of variation {both student (t-test) and analysis of variance (f-test)} is indicated in Tables 10–17.

The results of the C/N ratio definitely confirm that the bone samples taken for the present study are well preserved in nature and, therefore, have not gone any diagenetic alteration.

The bone samples of goat were collected from foothills, river valley and high altitude. The value of zinc (Zn) has been found to be highest in the high altitude samples (116‰), intermediate in the foothills samples (104‰) and lowest in the river valley samples (71‰). The analysis of variance (ANOVA) shows a significant variation at different altitudes ($f = 6.480$ & $p = 0.003$). The concentration of strontium (Sr) is 639‰, 293‰ and 365‰ in foothill, river valley and high altitude bone samples, respectively. The concentrations of strontium of goat at different altitudes are statistically significant ($f = 43.297$ & $p = 0.000$). The concentration of potassium (K) is 1525‰, 885‰ and 825‰ for foothill, high altitude and river valley samples, respectively. The concentration of trace element (potassium) of goat at different altitudes are statistically significant ($f = 64.021$ & $p = 0.000$), however the concentration of magnesium (Mg) is highest in high altitude (7880‰), intermediate in river valley (7604‰) and lowest in foothill (6832‰). The concentrations of copper

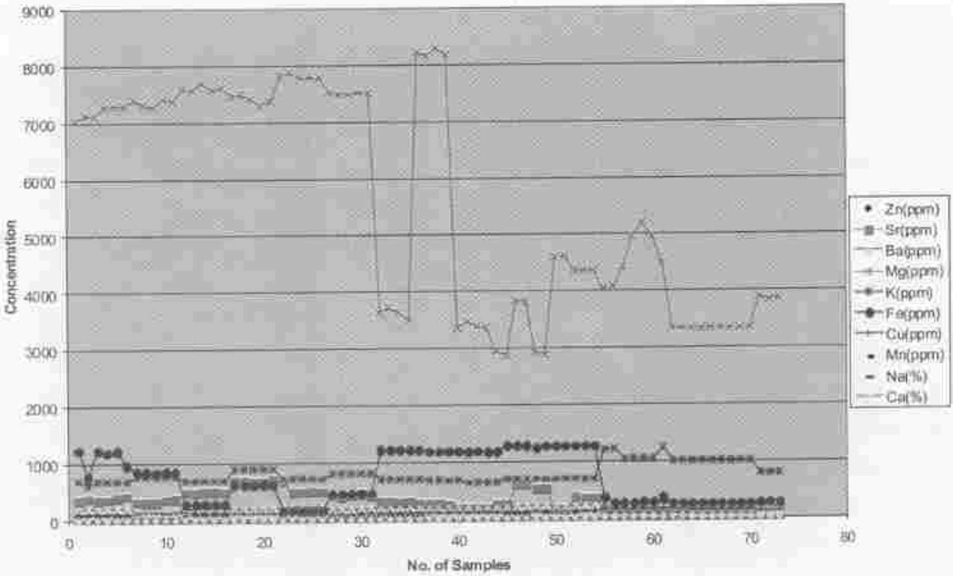


Figure 1. Trace elements concentration in archaeological samples

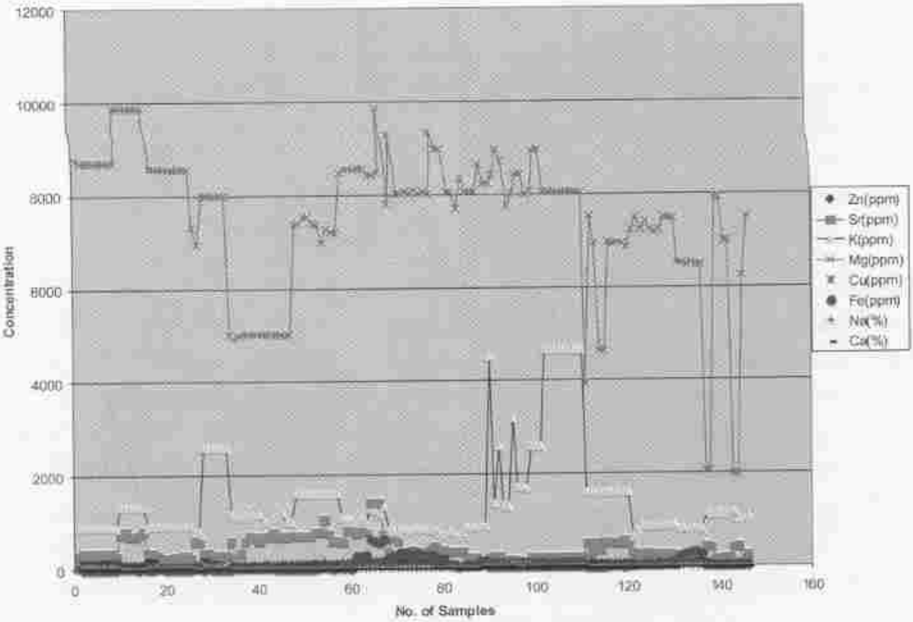


Figure 2. Trace elements concentration in modern domestic samples

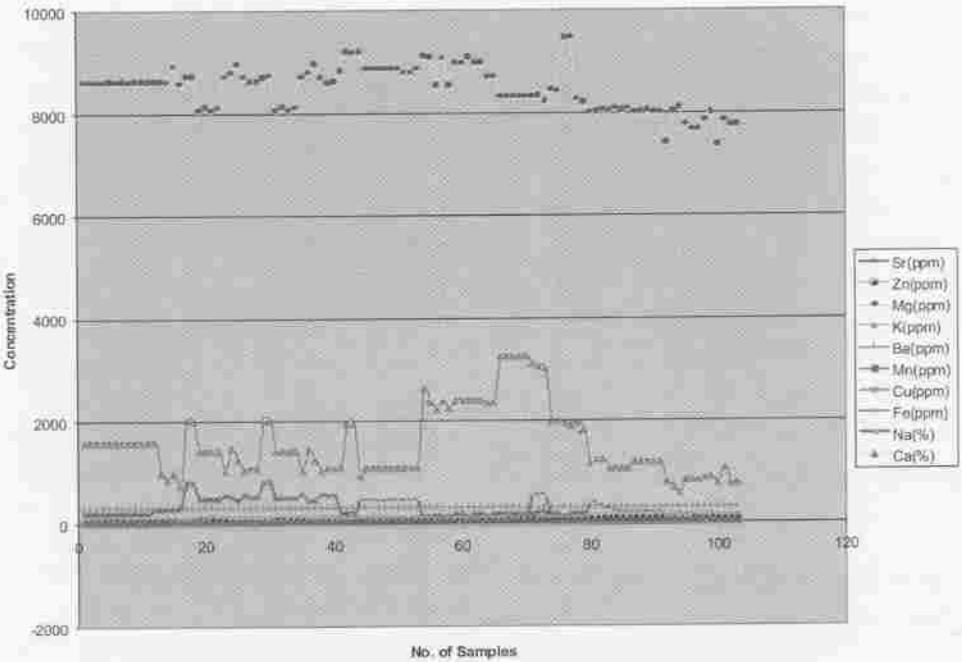


Figure 3. Trace elements concentration in modern wild samples

(Cu) and iron (Fe) are found to be highest in the high altitude samples (Cu = 80‰ & Fe = 233‰), intermediate in the river valley samples (Cu = 19‰ & Fe = 49‰) and lowest in the foothill samples (Cu = 6‰ & Fe = 10‰). The concentration of major elements – sodium (Na) gives an average of 1.71%, 1.94% and 1.93% for the foothill, river valley and high altitude samples, respectively; however the concentration of calcium (Ca) gives the values of 22.84%, 22.83% and 24.73% for the foothill, river valley and high altitude bone samples, respectively.

The modern samples of cattle (*Bos indicus*) have also been collected from high altitude, river valley and foothill areas. The concentration of zinc is found to be highest in the high altitude samples (152‰), lowest in the river valley samples 106‰) and intermediate in the foothill samples (110‰). The concentrations of zinc for cattle at different altitudes are statistically significant (f = 38.597 & p = 0.000), however the concentration of strontium is 984‰, 780‰ and 648‰ for high altitude, foothill and river valley samples, respectively, which therefore, shows the same pattern as shown for zinc. The concentration of potassium (K) and Magnesium (Mg) is found highest in foothill samples (K = 1329‰ & Mg = 9889‰), intermediate in high altitude samples (K = 1133‰ & Mg = 8665‰) and lowest in samples from river valley (K = 1098‰ & Mg = 5028‰). The concentration of copper (Cu) is 114‰, 10‰ and 6‰ for high altitude, river valley and foothill samples, respectively. The concentration of copper for the cattle at different altitudes are statistically significant (f = 813.643 & p = 0.000), however the values of iron (Fe) is 326‰, 11‰ and 8‰ for high altitude, foothill and river valley samples, respectively. The concentration of sodium (Na) is 2.2%, 1.9% and 1.8% for high altitude, foothill and river valley cattle samples, respectively; however the concentration of calcium (Ca) is 26.8%, 24.9% and 23.7% for high altitude, foothill and river valley cattle samples, respectively.

The carbon ($\delta^{13}C/^{12}C$) and nitrogen ($\delta^{15}N/^{14}N$) isotopic value of cattle (*Bos indicus*) is ($\delta^{13}C$) -18.27‰ and -16.60‰, and ($\delta^{15}N$) +8.21‰ & +4.20‰ for high altitude and river valley, respectively. Based on these isotopic results it may be suggested that the present day cattle at high altitude and river valleys have a high proportion of C_3 plants in their diet. The nitrogen isotopic value of the sample of high altitude cattle indicates that the animal must have consumed nitrogen rich plants.

The modern wild samples have been collected from the reserve forest of Tarai Bhabar of Kotdwara, located in the foothills of the lesser Himalaya. The bone samples of herbivore animals for present study are Red deer (henceforth, deer), chousingha (Four horned antelope), languor and elephant. Besides this, the bone samples of some omnivore (cat)[2] and carnivore (tiger) animals were also collected for the study. Red deer (*Cervus elaphus*) and chousingha (*Tetraceros quadricornis*) both are herbivore in dietary nature, who mainly feed on shrubs, grasses, leaves, twig and also ferns, lichens, tree shoots (deciduous and conifers), kelps and bark (particularly rawan, willow, and pine etc). They are predominantly grazers. The concentrations of strontium are 116‰ and 230‰ for chousingha and deer, respectively; however the concentrations of zinc for both animal samples are 39‰ and 68‰, respectively. The concentrations of magnesium and potassium for chousingha samples are 8779‰ and 1688‰, however for deer samples they are 8946‰ and 1435‰, respectively. The concentrations of manganese in chousingha and deer bone samples are 25‰ and 23.7‰, respectively. The concentrations of copper and iron are 104.6‰ and 120‰ in chousingha, and 107.8‰ & 53.6‰ in deer bone samples. The concentration of sodium is same (1.82%) for both chousingha and deer, however the concentrations of calcium are 27.8%, 27.9% in chousingha and deer bone samples, respectively.

Languor (*Presbytes entellus*) samples were collected from foothill forest. The concentration of strontium in languor bone samples is 561‰, whereas the concentration of zinc is 76‰. The concentrations of magnesium and potassium are 8517‰ and 1383‰, and the concentration of manganese, copper and iron are 23‰, 106‰ and 55‰, respectively for languor bone samples. The concentrations of major elements – sodium and calcium – are 1.86% and 27.16%, respectively for the languor bone samples.

Elephants (*Elephas maximus*) spend about more than 70% of their time in feeding. The elephants mainly subsist on grasses, bamboos and reed, though seasonal differences could be found on the availability of food. The elephants also like to feed on bark, leaves and branches of various trees. The concentration of strontium in elephants bone samples is 178‰, and the concentration of zinc is 41‰. The concentrations of magnesium and potassium are 8315‰ and 3169‰, and the concentrations of manganese, copper and iron are 25‰, 109‰, and 235‰, respectively for elephant bone samples collected from Tarai Bhabar forest. The concentrations of sodium and calcium are 1.91% and 27.62%, respectively.

Jungle cat (*Felis chaus*), essentially a carnivore, shows an omnivorous trait as it predates on rodents, birds as well as amphibians, reptiles, fish, insects, and rarely on carrion (sheep and deer). Tiger kills are also be scavenged. The concentration of strontium in cat bone samples is 76‰, however the concentration of zinc is 128‰. The concentrations of magnesium and potassium in cat bone samples are 8036‰ and 1146‰, whereas, the concentrations of manganese, copper and iron are 15‰, 126‰ and 244‰, respectively for cat bone samples. The concentrations of major elements – sodium and calcium – are 2% and 30% respectively.

Tiger (*Panthera tigris tigris*) is purely carnivore and almost top level predator in the forest ecosystem. The tiger is the largest member of the cat family. It is found in a variety of habitats, but mostly preferes a dense vegetative cover for hunting and access to reliable source of water. The principal prey of tiger consists of various species of deer and wild pigs, which includes sambar, chital, swamp deer, red deer, rusa deer and wild boar and Himalayan porcupine and hog badger (Rabinowitz 1989).

The tiger needs high protein and fat for nutritional requirements (Dierenfeld et al. 1994). The concentration of strontium in tiger bone samples is 73‰, whereas the concentration of zinc is 102‰. The concentrations of magnesium and potassium are 7769‰ and 809‰, respectively. The concentrations of manganese, copper and iron in the tiger bone samples are 13‰, 139‰ and 53‰, respectively. The concentrations of sodium and calcium in tiger bone samples are respectively, 2.12% and 30.3%.

The archaeofaunal and human samples were also taken up for the isotopes and trace elemental analyses that provide interesting results. These are summarized below.

The cattle (*Bos indicus*) and goat (*Capra jharal*) samples for the present study were taken from different archaeological sites of Thapli, Banderkhet, Supana and Ufalda. The carbon ($\delta^{13}C/^{12}C$) and nitrogen ($\delta^{15}N/^{14}N$) isotopic values for Cattle is $\delta^{13}C$ -10.33‰, -10.14‰, -10.97‰, and -11.45‰ and $\delta^{15}N$ +4.80‰, +4.90‰, +4.18‰ and + 5.12‰ for Supana, Banderkhet, Ufalda and Thapli Cattle bones, respectively. However the carbon ($\delta^{13}C/^{12}C$) and nitrogen ($\delta^{15}N/^{14}N$) isotopic values for bone samples of goat (*Capra jharal*) from Banderkhet is $\delta^{13}C$ -17.5‰ and $\delta^{15}N$ +5.6‰, respectively. Based on these isotopic results it may be suggested that the archaeological cattle (*Bos indicus*) of river valley had a high proportion of C_4 plants in their diet, however the goat (*Capra jharal*) at the site of Banderkhet has a high proportion of C_3 plants in the diet. Besides the isotopic values, the trace elemental analyses of the bone samples have also been carried out. The concentrations of trace elements of zinc in *Bos indicus* bone are 117‰, 125‰, 159‰, 113‰, 65‰ and 130‰ at Supana, Banderkhet, Mordhwaj, Ranihat, Purola and Ufalda, respectively. The concentrations of zinc for all the archaeological specimens are statistically significant (f = 7.930 & p = .000), however the concentrations of strontium are 319‰, 517‰, 722‰, 555‰, 450‰ and 420‰ from Supana, Banderkhet, Mordhwaj, Ranihat, Purola and Ufalda, respectively. The concentrations of strontium for specimens at different archaeological sites are statistically significant (f = 16.690 & p = .000). The concentrations of magnesium are 5659‰, 7630‰, 7429‰, 7831‰, 7533‰ and 3892‰, whereas the concentrations of manganese are in the average of 25‰ in the bone samples from Supana, Banderkhet, Mordhwaj, Ranihat, Purola and Ufalda sites, respectively. The concentrations of copper are 119‰, 144‰, 122‰, 130‰, 110‰, 124‰, and those of iron are 113‰, 3.53‰, 1.33‰, 1.30‰, 2.09‰, 11.42‰ in the *Bos indicus* bone samples from Supana, Banderkhet, Mordhwaj, Ranihat, Purola and Ufalda, respectively. The concentrations of potasium are 690‰, 709‰, 917‰, 734‰, 833‰ and 712‰, and the concentrations of barium give an average of 209‰ in the bone samples of *Bos indicus* from Supana, Banderkhet, Mordhwaj, Ranihat, Purola and Ufalda, respectively. The concentration of calcium for cattle gives a range from 23.29% to 26.51% in all archaeological sites, whereas the concentration of sodium for this animal gives a range between 1.5% and 2.1% in the bone samples of *Bos indicus* of Supana, Banderkhet, Mordhwaj, Ranihat, Purola and Ufalda, respectively.

The goat (*Capra jharal*) samples have been collected from the early historical site of Supana. The concentration of zinc is 55‰, and the concentration of strontium is 362‰. The concentration of iron is 866‰ and that of magnesium is 7376‰. The concentrations of manganese and copper are 25‰ and 133‰, respectively, and those of potassium and barium are 785‰ and 151‰, respectively. The concentration of calcium is 25.27% and that of sodium is 1.66% in the Supana goat samples.

The carbon ($\delta^{13}C/^{12}C$) and nitrogen ($\delta^{15}N/^{14}N$) isotopic values for jhuppu (see endnote 1) of the high altitude site at Malari are $\delta^{13}C$ -19.39‰, and $\delta^{15}N$ +8‰. The trace elemental analysis shows that the concentration of strontium is 178‰, however the concentration of zinc is 216‰. The concentration of iron in bone sample of jhuppu is 280‰ and the concentration of magnesium gives an average of 3953‰. The concentrations of manganese, copper and iron are 16‰, 130‰, and 813‰, respectively in the bone samples of jhuppu, whereas the concentration of barium in jhuppu skeleton is 199‰. The concentrations of sodium and calcium in jhuppu sample are 1.83% and 26.16%, respectively.

Human (*Homo sapiens sapiens*) skeletons were collected from the high altitude site at Malari. The concentration of zinc in human skeletons is very high with an average of 256‰. The concentration of strontium (169%) is slightly lower than that for herbivore. The concentrations of magnesium and potassium in human bone samples are 3916‰ and 1071‰, respectively, however the concentrations of manganese, copper and barium fall within the average of 15‰, 156‰ and 85‰, respectively. The concentration of calcium is 27.2%, however the concentration of sodium falls in the average of 1.99%.

The carbon ($\delta^{13}C/^{12}C$) and nitrogen ($\delta^{15}N/^{14}N$) isotopic values of Malari human skeleton are: $\delta^{13}C$ -12.62‰ in collagen; however in apatite fraction, the value comes around -7.28‰. The $\delta^{15}N$ value gives an average of +10.15‰. A comparative study of the results obtained from both the labs, falling in the same range, not only shows a clear conformity in the results, but also confirms the reliability of these results.Based on the carbon isotopic values it may be suggested that the male individuals had largely consumed the C_4 plants (amaranths and millets), however based on the nitrogen isotopic value it may be suggested that animal flesh was the main dietary item of the individuals belonging to high altitude. The trace elemental concentrations of human skeleton also indicate the same trend in dietary preference of the individual at the high altitude site of Malari.

Discussion and Conclusion

In the present study the researchers have examined three groups of bone samples from the study area. These are 1) human skeleton of the high altitude site at Malari, 2) archaeofaunal remains from different excavated sites of mid-central Himalaya, and 3) the bones of modern domestic and wild animals, which were studied for isotopic and trace element analyses. On the basis of carbon isotopic results ($\delta^{13}C$ -12‰), it may be said that about four hundred years ago the male individuals (datable to 1600 A.D.) belonging to the high altitude site at Malari mainly subsisted on C_4 plants like amaranthus and millets, and the high nitrogen isotopic value of $\delta^{15}N$ (+10.15‰) suggests that along with it they might have also consumed a fair amount of meat in his food. On the other hand, the isotopic values for jhuppu ($\delta^{13}C$ -19.39‰, $\delta^{15}N$ +8‰), domesticated by the protohistoric settlers around 2100 B.P. suggest that the jhuppu mainly grazed on the C_3 grasses, rich in nitrogen content. In this context the isotopic values of carbon and nitrogen ($\delta^{13}C$ -18.27‰, $\delta^{15}N$ +8.21‰) for the bones of modern day cattle (*Bos indicus*) also suggest grazing on C_3 grasses like *Agrostis munroana, Poa alpina, Carex nubigena* and nitrogen rich *Astra* sp., which are rich in nitrogen content. The identical isotopic values of carbon and nitrogen in the bones of jhuppu and modern cattle indirectly indicate that there is a dominance of C_3 grasses at high altitude, and the available evidence shows that the practice of grazing of herbivores on C_3 grasses have not changed during the last 2000 years (Figure 4). These isotopic values may also have some bearing on the climatic conditions of the region because any change in climatic condition would also have changed the composition of grasslands at high altitudes. But it is difficult to draw any definitive conclusion on the basis of limited isotopic data available in our study.

In contrast to the high altitude region, the carbon isotopic signatures in the bones of domesticated animals, particularly cattle (*Bos indicus*), from different archaeological sites of Alaknanda valley (average $\delta^{13}C$ -10‰) show that cattle domesticated by PGW settlers largely subsisted on C_4 plants from the beginning of settlement at Thapli around 140 B.C. This feature continued till 7th-8th centuries A.D. as recorded in the isotopic ratio of the bones of the late historic site at Supana (4th century A.D.) and Ufalda (7-8th centuries A.D.) also in Alaknanda valley. This definitely suggests that for over a period of 1000 years the domesticated livestock of the early and late historic settlers were largely fed with C_4. In sharp contrast, the present day bone samples of cattle from the same valley ($\delta^{13}C$ -16.60‰) clearly indicate a shift in the dietary profile from C_4 to C_3 plants (Figure 4). At the present state of the research work and the limited results obtained so far, it is difficult to pinpoint the precise reason for the dietary shift of the domesticated animals in the river valley in the lesser Himalaya.

The variation in the trace element concentrations between the modern and the ancient samples from the same site in Alaknanda valley shows an interesting picture. The t-test between the modern and the ancient site of Supana, Ufalda, and Ranihat shows difference in the levels of trace elements. At Supana a significant variation in the levels of Sr, Fe, Cu, K and Ca (Tables 10 & 11) has been found, and at Ufalda a significant variation has also been found between the different elements like Sr, Fe, Mg, Cu, K, Na and Ca, excepting the zinc (Table 12), while in the bone samples of the Ranihat, a significant variation has been found in the levels of Fe, Mg, Cu and K (Table 13). The statistical analysis also proves that this difference in the trace element levels between the ancient and modern samples is significant in the sense that the different food items had remarkable effect on the trace element levels of the bones of these domesticated animals. The effect of diet is also reflected in the isotopic signatures of the bones as discussed above. On the basis of isotopic and trace element data it may be said that the domesticated cattle in the riverine valley received a similar diet for about 1000 years (from 140 B.C. till 8th Cent. A.D.), but the grazing or feeding behaviour shifted in the present time.

Unfortunately the human and faunal samples have not been found in large numbers in excavated sites from mid-central Himalaya, therefore, the present researchers could analyze only a limited set of bone samples. In order to find out the trace element levels of animal groups with known dietary behaviour, the researchers collected the wild and domestic animal bones from different areas of Garhwal. The isotopic and trace element data provided a baseline for examining the effect of altitudinal variation in chemical signatures of the present day bones.

The herbivore stock of modern animals of the foothill area is further distinguished into domestic and wild categories. The dietary and physiological patterns of these animals are almost the same, as these herbivore animals largely subsist on grasses, leaves, twig, tuber and bark. The levels of strontium, zinc, copper, iron, magnesium, sodium and calcium have been found to be different in the domestic and wild herbivores. In domestic herbivores a higher level of zinc and strontium has been found, while in wild herbivore the levels of copper, iron, magnesium, sodium and calcium have been found higher (Table 14). The earlier studies have observed that a higher concentration of zinc and strontium indicates a cereal-based diet (Underwood 1977; Gilbert 1985). In this regards it has been found that the domestic herbivores must have had consumed cereals (granary components) in their diet, however the wild herbivores did not have any cereal components in their diet.

The modern cattle (*Bos indicus*) and goat (*Capra jharal*) at different altitudes (i.e. high altitude, river valleys and foothills) also provide a significant difference in the trace element levels. The levels of zinc, strontium, potassium, magnesium, copper, iron, sodium and calcium vary at different altitudes (Tables 15 & 16; Figure 5), because these herbivore animals mainly subsist on the vegetation, which are conditioned to a large extent due to altitudinal variation. The trace element analysis of these herbivore animals gives indirect evidence that the altitudinal conditions induced change in the dietary behaviour of the animals, thus resulting into the change in the trace element levels of the bones of the animals.

The trace element levels have been found different in herbivore, omnivore and carnivore species. A higher concentration of zinc has been found in omnivore species, while it is lower in herbivores (Table 17; Figure 6). The strontium concentration has been found higher in herbivores and lower in omnivore and carnivore species. The concentration of Iron has been found to be highest in omnivore animals and lower in carnivores, while magnesium has been found higher in herbivores and lower in carnivores. The concentration of copper has been found higher in carnivores and lower in herbivores, however potassium has been found significantly higher in herbivores than that in omnivore and carnivore species.

Therefore, based on the isotopic and trace element analyses, the following conclusions can be drawn:

1. The jhuppu being domesticated by the protohistoric settlers around 100B.C. at Malari at 12,000 feet in the high altitude of Dhauliganga valley, were primarily grazed on C_3 grasses ($\delta^{13}C$ -19.39‰, $\delta^{15}N$ +8‰), which had nitrogen rich contents. The modern samples of cattle ($\delta^{13}C$ -18.27‰, $\delta^{15}N$ +8.21‰) also indicate similar practice of grazing on C_3 grasses as found for the domestic jhuppu by the protohistoric settlers (Figure 4). The continuity in dietary practices suggests that the domestic animals at high altitude sites were fed on C_3 plants over a period of 2000 years.

2. The carbon and nitrogen isotope signatures on the skeletal remains of a human individual ($\delta^{13}C$ -12‰, $\delta^{15}N$ +10.15‰), datable to 1600 A.D., at Malari also provides a picture about his palaeodiet and gives a strong indication that this individual subsisted on a diet, mainly based on C_4 crops (possibly of amaranthus and millets), which was supplemented by a high protein diet resulting from the consumption of meat (Figure 4). The practice of diet based on high consumption of meat is still prevalent in high altitudes where the villagers do not have sufficient stocks of crops round the year.

3. In the Alaknanda valley the palaeodietary profile of the livestocks is also interesting. The isotopic (average $\delta^{13}C$ -10‰) and trace elements data definitely suggest that the domesticated animals of ancient settlers during a span of 900 to 1000 years [from PGW (140 B.C.) till late historic period (7-8th centuries A.D.)] largely grazed or fed on the C_4 rich diet (Figure 4). However this practice in present time has shifted towards the C_3 diet ($\delta^{13}C$ -16.60‰).

4. The concentrations of trace elements of Sr, Zn, K, Mg, Mn, Cu, Fe, Na, Ca are different in diverse feeding groups of animals (Figure 6). The herbivores show high concentrations of Sr, K, Mg, Mn, low concentrations of Zn, Cu, Na and Ca, and a moderate concentration of Fe. In sharp contrast, the carnivores show higher concentrations of Cu, Na and Ca, and very low concentrations of Sr, Mg, Mn, K and Fe; Zn has been found in a moderate concentration. In omnivores only Zn and Fe have been found in higher concentrations, while other elements of Sr, K, Mg, Mn, Cu, Na and Ca have been found in moderate concentrations.

The distinct and clear behaviour of the trace elements in different groups of animals definitely confirms that the feeding behaviour plays an important role in the distribution of the trace element levels in the bone.

5. The altitudinal variation of trace element concentrations in herbivore animals, i.e. cattle, also provides a distinct picture (Figure 5). The concentration of Sr, Zn, Cu, Fe, Na and Ca have been found in higher concentrations, while K and Mg have been found in moderate concentrations at high altitudes. In sharp contrast, the concentrations of all the above elements have been found to be low excepting Cu in the River valleys. In the foothills, the concentrations of K and Mg have been found to be high, while Sr, Zn, Fe, Na and Ca have been found in moderate concentration and the concentration of Cu has been found to be low. The distribution of all these trace elements in different altitudes also confirm that the distribution of trace elements in the diet is directly proportional to the altitudinal changes as demonstrated in our study.

Notes

1 Jhuppu is a local name of a large bovid (similar to Yak) known to have been domesticated since 100 B.C. by the ancient settlers at Malari in the high altitude region of the Dhauliganga valley (12,000 feet).

2 Jungle cat (*Felis chaus*), which is essentially a carnivore, has been described in our analysis under the omnivore category due to their wide ranging food habit (see the text, p. 246).

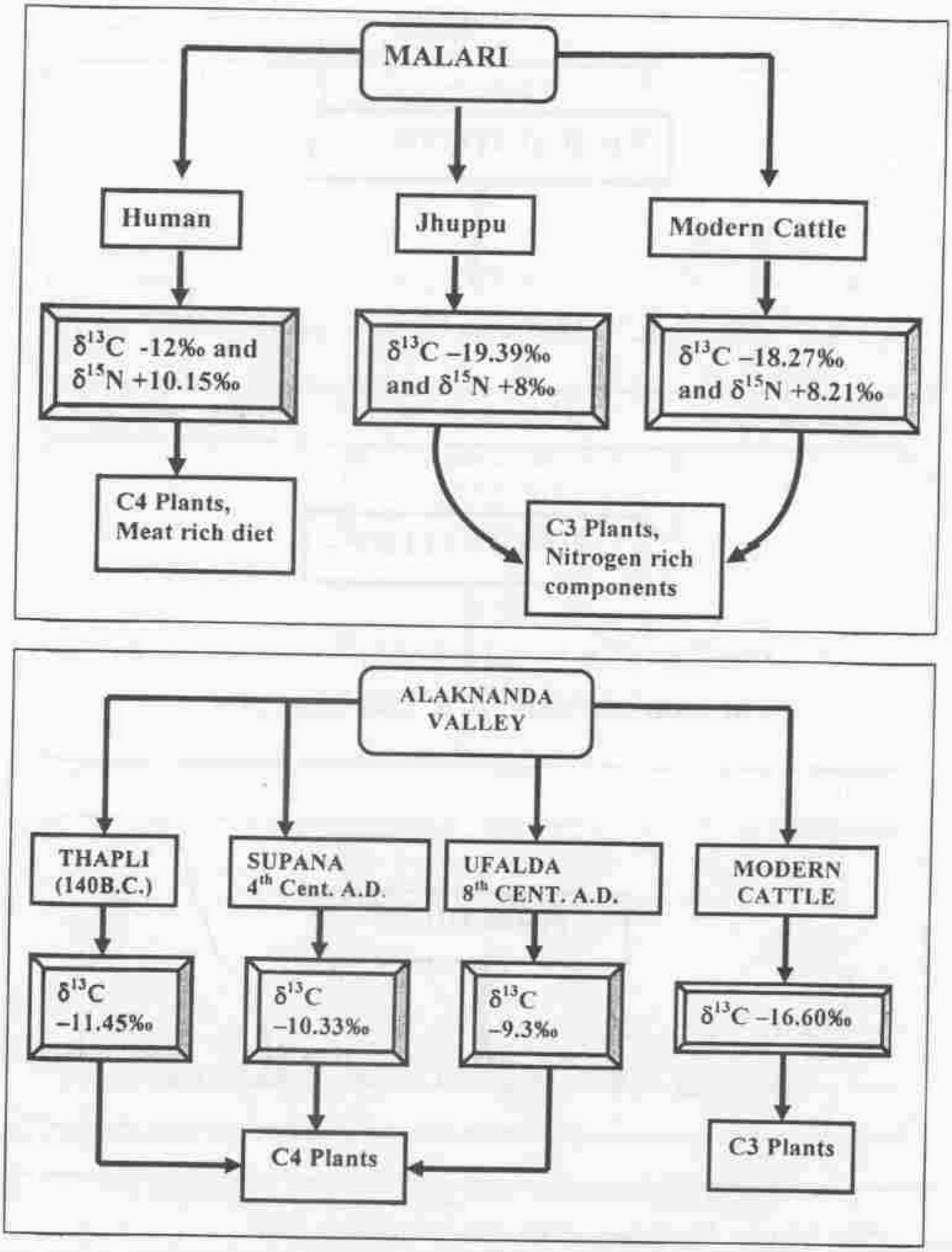
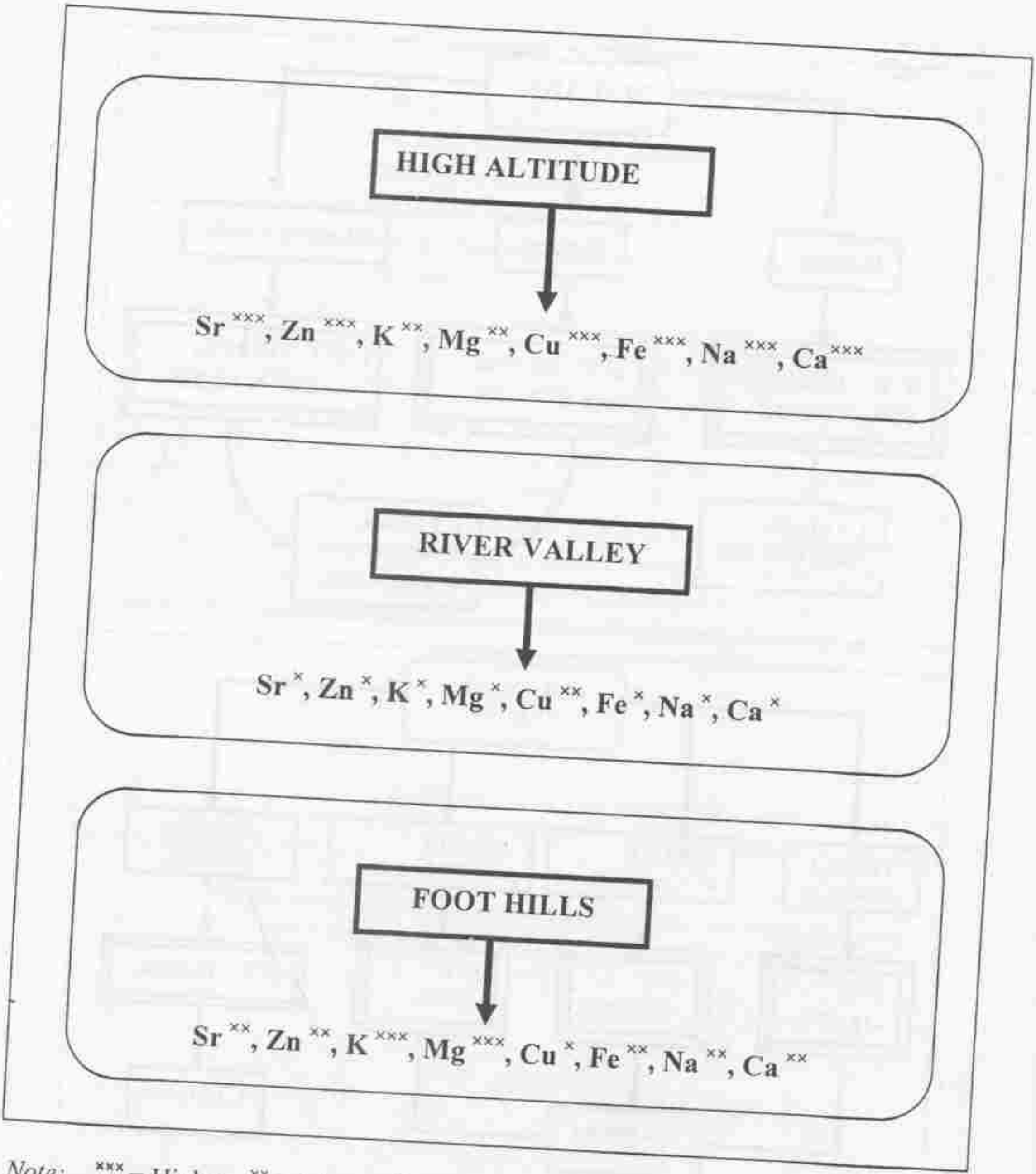
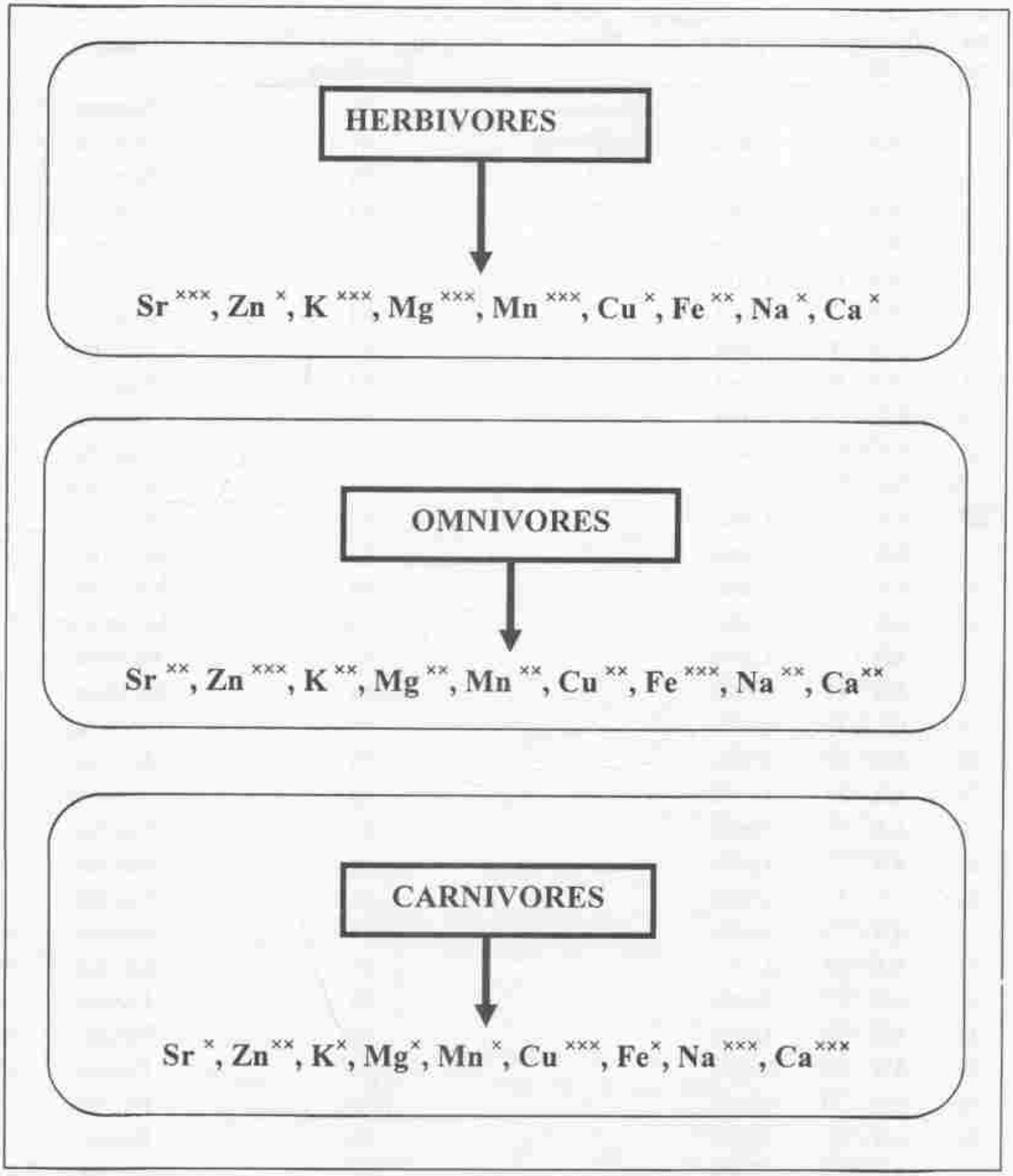


Figure 4. Reconstruction of dietary behaviour through isotopic signatures



Note: $^{\times\times\times}$ = Higher, $^{\times\times}$ = Intermediate, and $^{\times}$ = Lower Level

Figure 5. Behaviour of trace elements in cattle in different altitudinal zones



Note: $^{\times\times\times}$ = Higher, $^{\times\times}$ = Intermediate, and $^{\times}$ = Lower concentration

Figure 6. Behaviour of trace elements concentration in different feeding types in wild animals.

Table 1. Archaeological samples

Sr. No.	Specimen No.	Species	Bone	Age & Sex of Specimen	Site
1	AA - 1	Cattle	Humerus	NI	Supana
2	AA - 2	Cattle	Long Bone	NI	Supana
3	AA - 3	Cattle	"	NI	Supana
4	AA - 4	Cattle	"	NI	Supana
5	AA - 5	Cattle	"	NI	Supana
6	AA - 6	Cattle	"	NI	Supana
7	AA - 7	Goat	"	NI	Supana
8	AA - 8	Goat	"	NI	Supana
9	AA - 9	Goat	"	NI	Supana
10	AA - 10	Goat	"	NI	Supana
11	AA - 11	Goat	"	NI	Supana
12	AA - 12	Cattle	"	NI	Banderkhet
13	AA - 13	Cattle	"	NI	Banderkhet
14	AA - 14	Cattle	"	NI	Banderkhet
15	AA - 15	Cattle	"	NI	Banderkhet
16	AA - 16	Cattle	"	NI	Banderkhet
17	AA - 17	Cattle	"	NI	Mordwaj
18	AA - 18	Cattle	"	NI	Mordwaj
19	AA - 19	Cattle	"	NI	Mordwaj
20	AA - 20	Cattle	"	NI	Mordwaj
21	AA - 21	Cattle	"	NI	Mordwaj
22	AA - 22	Cattle	"	NI	Ranihat
23	AA - 23	Cattle	"	NI	Ranihat
24	AA - 24	Cattle	"	NI	Ranihat
25	AA - 25	Cattle	"	NI	Ranihat
26	AA - 26	Cattle	"	NI	Ranihat
27	AA - 27	Cattle	"	NI	Purola
28	AA - 28	Cattle	"	NI	Purola
29	AA - 29	Cattle	"	NI	Purola
30	AA - 30	Cattle	"	NI	Purola
31	AA - 31	Cattle	"	NI	Purola
32	AA - 32	Cattle	"	NI	Supana
33	AA - 33	Cattle	"	NI	Supana
34	AA - 34	Cattle	"	NI	Supana
35	AA - 35	Cattle	"	NI	Supana
36	AA - 36	Cattle	"	NI	Supana
37	AA - 37	Cattle	"	NI	Supana
38	AA - 38	Cattle	"	NI	Supana

Sr. No.	Specimen No.	Species	Bone	Age & Sex of Specimen	Site
39	AA - 39	Cattle	"	NI	Supana
40	AA - 40	Cattle	"	NI	Supana
41	AA - 41	Cattle	"	NI	Supana
42	AA - 42	Cattle	"	NI	Supana
43	AA - 43	Cattle	"	NI	Supana
44	AA - 44	Cattle	"	NI	Supana
45	AA - 45	Cattle	"	NI	Ufalda
46	AA - 46	Cattle	"	NI	Ufalda
47	AA - 47	Cattle	"	NI	Ufalda
48	AA - 48	Cattle	"	NI	Ufalda
49	AA - 49	Cattle	"	NI	Ufalda
50	AA - 50	Cattle	"	NI	Ufalda
51	AA - 51	Cattle	"	NI	Ufalda
52	AA - 52	Cattle	"	NI	Ufalda
53	AA - 53	Cattle	"	NI	Ufalda
54	AA - 54	Cattle	"	NI	Ufalda
55	AA - 55	Human	Femur	App. 30-35 year, Male	Malari
56	AA - 56	Human	Femur	App. 30-35 year, Male	Malari
57	AA - 57	Human	Humerus	App. 30-35 year, Male	Malari
58	AA - 58	Human	Tibia	App. 30-35 year, Male	Malari
59	AA - 59	Human	Tibia	App. 30-35 year, Male	Malari
60	AA - 60	Human	Radius	App. 30-35 year, Male	Malari
61	AA - 61	Human	Radius	App. 30-35 year, Male	Malari
62	AA - 62	Human	Ulna	App. 30-35 year, Male	Malari
63	AA - 63	Human	Ulna	App. 30-35 year, Male	Malari
64	AA - 64	Human	Rib	App. 30-35 year, Male	Malari
65	AA - 65	Human	Rib	App. 30-35 year, Male	Malari
66	AA - 66	Human	Rib	App. 30-35 year, Male	Malari
67	AA - 67	Human	Rib	App. 30-35 year, Male	Malari
68	AA - 68	Human	Rib	App. 30-35 year, Male	Malari
69	AA - 69	Human	Rib	App. 30-35 year, Male	Malari
70	AA - 70	Human	Rib	App. 30-35 year, Male	Malari
71	AA - 71	Jhuppu	Femur	NI	Malari
72	AA - 72	Jhuppu	Humerus	NI	Malari
73	AA - 73	Jhuppu	Tibia	NI	Malari

Table 2. Modern domestic samples

Specimen No.	Species	Bone	Age & Sex of Specimen	Site
MD -1	Dog	Femur	2year, female	Foothill (Kotdwara)
MD -2	Dog	Femur	4year, Male	Foothill (Kotdwara)
MD -3	Dog	Femur	3year, Female	Foothill (Kotdwara)
MD -4	Dog	Femur	4year, Female	Foothill (Kotdwara)
MD -5	Dog	Femur	5year, Female	Foothill (Kotdwara)
MD -6	Dog	Humerus	5year, Female	Foothill (Kotdwara)
MD -7	Dog	Humerus	NI,Male	Foothill (Kotdwara)
MD -8	Dog	Humerus	4year, female	Foothill (Kotdwara)
MD -9	Dog	Radius	4year, Female	Foothill (Kotdwara)
MD -10	Cattle	Femur	10year, Female	Foothill (Kotdwara)
MD -11	Cattle	Femur	15year, Female	Foothill (Kotdwara)
MD -12	Cattle	Femur	20year,Female	Foothill (Kotdwara)
MD -13	Cattle	Metatarsals	12Year, Female	Foothill (Kotdwara)
MD -14	Cattle	Humerus	10year, Male	Foothill (Kotdwara)
MD -15	Cattle	Metatarsals	9year, Male	Foothill (Kotdwara)
MD -16	Dog	Radius	2year, Male	Foothill (Kotdwara)
MD -17	Dog	Radius	2year, Male	Foothill (Kotdwara)
MD -18	Dog	Femur	2year, Male	Foothill (Kotdwara)
MD -19	Dog	Femur	2 year, Male	Foothill (Kotdwara)
MD -20	Dog	Humerus	2 year, Male	Foothill (Kotdwara)
MD -21	Dog	Humerus	2 year, Male	Foothill (Kotdwara)
MD -22	Dog	Tibia	2 year, Male	Foothill (Kotdwara)
MD -23	Dog	Tibia	2 year, Male	Foothill (Kotdwara)
MD -24	Dog	Fibula	2 year, Male	Foothill (Kotdwara)
MD -25	Dog	Fibula	2 year, Male	Foothill (Kotdwara)
MD -26	Goat	Metatarsal	3 year, Female	Foothill (Kotdwara)
MD -27	Goat	Tarsal	3 year, Female	Foothill (Kotdwara)
MD -28	Pig	Femur	Mature, Female	Foothill (Kotdwara)
MD -29	Pig	Femur	Mature, Female	Foothill (Kotdwara)
MD -30	Pig	Radius	Mature, Female	Foothill (Kotdwara)
MD -31	Pig	Ulna	Mature, Female	Foothill (Kotdwara)
MD -32	Pig	Radius	Mature, Female	Foothill (Kotdwara)
MD -33	Pig	Ulna	Mature, Female	Foothill (Kotdwara)
MD -34	Cattle	Femur	Mature, Female	Srinagar Valley
MD -35	Cattle	Carple	Mature, Female	Srinagar Valley
MD -36	Cattle	Tarsal	Mature, Female	Srinagar Valley
MD -37	Cattle	Femur	Mature, Female	Srinagar Valley
MD -38	Cattle	Humerus	Mature, Male	Srinagar Valley

Specimen No.	Species	Bone	Age & Sex of Specimen	Site
MD -39	Cattle	Femur	Mature, Male	Srinagar Valley
MD -40	Cattle	Femur	Mature, Male	Srinagar Valley
MD -41	Cattle	Femur	Mature, Male	Srinagar Valley
MD -42	Cattle	Humerus	Mature, Male	Srinagar Valley
MD -43	Cattle	Metacarple	Mature, Male	Srinagar Valley
MD -44	Cattle	Metacarple	Mature, Male	Srinagar Valley
MD -45	Cattle	Metatarsal	Mature, Female	Srinagar Valley
MD -46	Cattle	Tarsal	Mature, Male	Srinagar Valley
MD -47	Cattle	Metatarsal	Mature, Female	Srinagar Valley
MD -48	Goat	Radius	3 year, Male	Foothill (Kotdwara)
MD -49	Goat	Humerus	3 year, Male	Foothill (Kotdwara)
MD -50	Goat	Femur	5 year, Male	Foothill (Kotdwara)
MD -51	Goat	Femur	5 year, Male	Foothill (Kotdwara)
MD -52	Goat	Tarsal	Mature, Female	Foothill (Kotdwara)
MD -53	Goat	Metatarsal	Mature, Female	Foothill (Kotdwara)
MD -54	Goat	Scapula	Mature, Female	Foothill (Kotdwara)
MD -55	Goat	Metacarple	Mature, Male	Foothill (Kotdwara)
MD -56	Goat	Ulna	Mature, Male	Foothill (Kotdwara)
MD -57	Goat	Tarsal	Mature, Male	Foothill (Kotdwara)
MD -58	Cattle	Femur	Mature, Female	High Altitude (Malari)
MD -59	Cattle	Tarsal	Mature, Female	High Altitude (Malari)
MD -60	Cattle	Metatarsal	6 Year, Female	High Altitude (Malari)
MD -61	Cattle	Long Bone	3year, Female	High Altitude (Malari)
MD -62	Cattle	Long Bone	4 Year, Male	High Altitude (Malari)
MD -63	Cattle	Patella	4Year, Female	High Altitude (Malari)
MD -64	Cattle	Rib	Mature, Female	High Altitude (Malari)
MD -65	Cattle	Rib	Mature, Female	High Altitude (Malari)
MD -66	Cattle	Rib	Mature, Female	High Altitude (Malari)
MD -67	Cattle	Long Bone	8 Year, Male	High Altitude (Malari)
MD -68	Goat	Humerus	Mature, Male	High Altitude (Malari)
MD -69	Goat	Femur	Mature, Male	High Altitude (Malari)
MD -70	Goat	Femur	Mature, Female	High Altitude (Malari)
MD -71	Goat	Long Bone	Mature, Female	High Altitude (Malari)
MD -72	Goat	Radius	Mature, Female	High Altitude (Malari)
MD -73	Goat	Tarsal	Mature, Female	High Altitude (Malari)
MD -74	Goat	Metatarsal	Mature, Female	High Altitude (Malari)
MD -75	Goat	Carple	Mature, Male	High Altitude (Malari)
MD -76	Goat	Carple	Mature, Female	High Altitude (Malari)
MD -77	Goat	Tarsal	Mature, Female	High Altitude (Malari)
MD -78	Goat	Long Bone	Mature, Male	High Altitude (Malari)

Specimen No.	Species	Bone	Age & Sex of Specimen	Site
MD -79	Goat	Rib	Mature, Male	High Altitude (Malari)
MD -80	Goat	Rib	Mature, Female	High Altitude (Malari)
MD -81	Goat	Metatrasal	Mature, Female	High Altitude (Malari)
MD -82	Goat	Metacarple	Mature, Female	High Altitude (Malari)
MD -83	Goat	Rib	Mature, Male	Srinagar Valley
MD -84	Goat	Metatarsal	Mature, Male	Srinagar Valley
MD -85	Goat	Radius	Mature, Male	Srinagar Valley
MD -86	Goat	Long Bone	Mature, Male	Srinagar Valley
MD -87	Goat	Long Bone	Mature, Male	Srinagar Valley
MD -88	Dog	Femur	4Year, Male	Srinagar Valley
MD -89	Dog	Tibia	4Year, Male	Srinagar Valley
MD -90	Dog	Humerus	5Year, Male	Srinagar Valley
MD -91	Dog	Femur	3 year, Female	Srinagar Valley
MD -92	Dog	Tibia	3 year, Female	Srinagar Valley
MD -93	Dog	Humerus	5 year, Female	Srinagar Valley
MD -94	Dog	Humerus	Mature, Male	Srinagar Valley
MD -95	Dog	Femur	Mature, Male	Srinagar Valley
MD -96	Goat	Femur	2 year, Male	High Altitude (Malari)
MD -97	Goat	Tarsal	3 year, Male	High Altitude (Malari)
MD -98	Pig	Tibia	Mature, Male	Foothill (Kotdwara)
MD -99	Pig	Fibula	Mature, Male	Foothill (Kotdwara)
MD -100	Pig	Tibia	Mature, Female	Foothill (Kotdwara)
MD -101	Pig	Fibula	Mature, Female	Foothill (Kotdwara)
MD -102	Pig	Limb Bone	Mature, Female	Foothill (Kotdwara)
MD -103	Pig	Limb Bone	Mature, Female	Foothill (Kotdwara)
MD -104	Pig	Limb Bone	Mature, Female	Foothill (Kotdwara)
MD -105	Pig	Limb Bone	Mature, Female	Foothill (Kotdwara)
MD -106	Pig	Limb Bone	Mature, Female	Foothill (Kotdwara)
MD -107	Pig	Limb Bone	Mature, Male	Foothill (Kotdwara)
MD -108	Pig	Limb Bone	Mature, Male	Foothill (Kotdwara)
MD -109	Pig	Limb Bone	Mature, Male	Foothill (Kotdwara)
MD -110	Pig	Limb Bone	Mature, Male	Foothill (Kotdwara)
MD -111	Goat	Femur	Mature, Male	Foothill (Kotdwara)
MD -112	Goat	Femur	Mature, Female	Foothill (Kotdwara)
MD -113	Goat	Femur	Mature, Female	Foothill (Kotdwara)
MD -114	Goat	Humerus	Mature, Female	Foothill (Kotdwara)
MD -115	Goat	Humerus	Mature, Male	Foothill (Kotdwara)
MD -116	Goat	Radius	Mature, Male	Foothill (Kotdwara)
MD -117	Goat	Femur	Mature, Male	Foothill (Kotdwara)

Specimen No.	**Species**	**Bone**	**Age & Sex of Specimen**	**Site**
MD -118	Goat	Femur	Mature, Male	Foothill (Kotdwara)
MD -119	Goat	Femur	Mature, Male	Foothill (Kotdwara)
MD -120	Goat	Radius	Mature, Female	Foothill (Kotdwara)
MD -121	Goat	Femur	Mature, Female	Srinagar Valley
MD -122	Goat	Femur	Mature, Male	Srinagar Valley
MD -123	Goat	Humerus	Mature, Male	Srinagar Valley
MD -124	Goat	Humerus	Mature, Female	Srinagar Valley
MD -125	Goat	Femur	Mature, Male	Srinagar Valley
MD -126	Goat	Radius	Mature, Male	Srinagar Valley
MD -127	Goat	Radius	Mature, Male	Srinagar Valley
MD -128	Goat	Humerus	Mature, Male	Srinagar Valley
MD -129	Goat	Radius	Mature, Female	Srinagar Valley
MD -130	Goat	Radius	Mature, Female	Srinagar Valley
MD -131	Goat	Femur	Mature, Male	High Altitude (Malari)
MD -132	Goat	Femur	Mature, Male	High Altitude (Malari)
MD -133	Goat	Radius	Mature, Male	High Altitude (Malari)
MD -134	Goat	Radius	Mature, Male	High Altitude (Malari)
MD -135	Goat	Long Bone	Mature, NI	High Altitude (Malari)
MD -136	Goat	Long Bone	Mature, NI	High Altitude (Malari)
MD -137	Buffallo	Femur	Mature,	Srinagar Valley
MD -138	Buffallo	Femur	Mature,	Srinagar Valley
MD -139	Buffallo	Tibia	Mature,	Srinagar Valley
MD -140	Buffallo	Tibia	Mature,	Srinagar Valley
MD -141	Buffallo	Radius	Mature,	Srinagar Valley
MD -142	Buffallo	Radius	Mature,	Srinagar Valley
MD -143	Buffallo	Humerus	Mature,	Srinagar Valley
MD -144	Buffallo	Humerus	Mature,	Srinagar Valley
MD -145	Buffallo	Hip Bone	Mature, Male	Srinagar Valley
MD -146	Buffallo	Long Bone	Mature, Male	Srinagar Valley

Table 3. Modern wild samples

Sr. No.	Specimen No.	Species	Bone	Age & Sex of specimen	Site
1	MW1	Chausinga	Rib	15year, male	Kotdwar
2	MW2	Chausinga	Rib	15Year, Male	Kotdwar
3	MW3	Chausinga	Rib	15Year, Male	Kotdwar
4	MW4	Chausinga	Rib	15year, male	Kotdwar
5	MW5	Chausinga	Rib	15year, male	Kotdwar
6	MW6	Chausinga	Rib	15year, male	Kotdwar
7	MW7	Chausinga	Rib	15year, male	Kotdwar
8	MW8	Chausinga	Rib	15year, male	Kotdwar
9	MW9	Chausinga	Rib	15year, male	Kotdwar
10	MW10	Chausinga	Rib	15year, male	Kotdwar
11	MW11	Chausinga	Rib	15year, male	Kotdwar
12	MW12	Chausinga	Pelvis	15year, male	Kotdwar
13	MW13	Chausinga	Femur	15year, male	Kotdwar
14	MW14	Chausinga	Tarsal	15year, male	Kotdwar
15	MW15	Chausinga	Femur	Adult, NI	Kotdwar
16	MW16	Deer	Femur	Adult, NI	Kotdwar
17	MW17	Langoor	Femur(R)	Adult, Female	Kotdwar
18	MW18	Langoor	Femur(L)	Adult, Female	Kotdwar
19	MW19	Langoor	Radius(R)	Adult, Female	Kotdwar
20	MW20	Langoor	Ulna(R)	Adult, Female	Kotdwar
21	MW21	Langoor	Radius(L)	Adult, Female	Kotdwar
22	MW22	Langoor	Ulna(L)	Adult, Female	Kotdwar
23	MW23	Langoor	Fibula(R)	Adult, Female	Kotdwar
24	MW24	Langoor	Tibia(R)	Adult, Female	Kotdwar
25	MW25	Langoor	Tibia(L)	Adult, Female	Kotdwar
26	MW26	Langoor	Fibula(L)	Adult, Female	Kotdwar
27	MW27	Langoor	Humerus(R)	Adult, Female	Kotdwar
28	MW28	Langoor	Humerus(L)	Adult, Female	Kotdwar
29	MW29	Langoor	Femur(R)	Adult, Male	Kotdwar
30	MW30	Langoor	Femur(L)	Adult, Male	Kotdwar
31	MW31	Langoor	Radius(R)	Adult, Male	Kotdwar
32	MW32	Langoor	Ulna(R)	Adult, Male	Kotdwar
33	MW33	Langoor	Radius(L)	Adult, Male	Kotdwar
34	MW34	Langoor	Ulna(L)	Adult, Male	Kotdwar
35	MW35	Langoor	Fibula(R)	Adult, Male	Kotdwar
36	MW36	Langoor	Tibia(R)	Adult, Male	Kotdwar
37	MW37	Langoor	Tibia(L)	Adult, Male	Kotdwar
38	MW38	Langoor	Fibula(L)	Adult, Male	Kotdwar

Sr. No.	Specimen No.	Species	Bone	Age & Sex of specimen	Site
39	MW39	Langoor	Humerus(R)	Adult, Male	Kotdwar
40	MW40	Langoor	Humerus(L)	Adult, Male	Kotdwar
41	MW41	Deer	Metatarsal	5year, Male	Kotdwar
42	MW42	Deer	Radius	5year, Male	Kotdwar
43	MW43	Deer	Ulna	5year, Male	Kotdwar
44	MW44	Chausinga	Metatarsal	Adult, NI	Kotdwar
45	MW45	Chausinga	Rib	Adult, NI	Kotdwar
46	MW46	Chausinga	Rib	Adult, NI	Kotdwar
47	MW47	Chausinga	Rib	Adult, NI	Kotdwar
48	MW48	Chausinga	Rib	Adult, NI	Kotdwar
49	MW49	Chausinga	Rib	Adult, NI	Kotdwar
50	MW50	Chausinga	Rib	Adult, NI	Kotdwar
51	MW51	Chausinga	Rib	Adult, NI	Kotdwar
52	MW52	Chausinga	Rib	Adult, NI	Kotdwar
53	MW53	Chausinga	Rib	Adult, NI	Kotdwar
54	MW54	Chausinga	Femur	Adult, Male	Kotdwar
55	MW55	Chausinga	Humerus(R)	Adult, Male	Kotdwar
56	MW56	Chausinga	Metatarsal(R)	Adult, Male	Kotdwar
57	MW57	Chausinga	Humerus(L)	Adult, Male	Kotdwar
58	MW58	Chausinga	Metatarsal(L)	Adult, Male	Kotdwar
59	MW59	Chausinga	Radius(R)	Adult, Male	Kotdwar
60	MW60	Chausinga	Ulna(R)	Adult, Male	Kotdwar
61	MW61	Chausinga	Femur(R)	Adult, Male	Kotdwar
62	MW62	Chausinga	Radius(L)	Adult, Male	Kotdwar
63	MW63	Chausinga	Ulna(L)	Adult, Male	Kotdwar
64	MW64	Chausinga	Femur(L)	Adult, Male	Kotdwar
65	MW65	Chausinga	Metacarpal	Adult, Male	Kotdwar
66	MW66	Elephant	Rib	Adult, Female	Kotdwar
67	MW67	Elephant	Rib	Adult, Female	Kotdwar
68	MW68	Elephant	Rib	Adult, Female	Kotdwar
69	MW69	Elephant	Rib	Adult, Female	Kotdwar
70	MW70	Elephant	Rib	Adult, Female	Kotdwar
71	MW71	Elephant	Pelvis	Adult, Female	Kotdwar
72	MW72	Elephant	Metacarpals	Adult, Female	Kotdwar
73	MW73	Elephant	Radius	Adult, Female	Kotdwar
74	MW74	Chausinga	Tarsals	Adult, NI	Kotdwar
75	MW75	Chausinga	Humerus	Adult, NI	Kotdwar
76	MW76	Chausinga	Femur(L)	Adult, NI	Kotdwar
77	MW77	Chausinga	Femur(R)	Adult, NI	Kotdwar
78	MW78	Chausinga	Radius	Adult, NI	Kotdwar

Sr. No.	Specimen No.	Species	Bone	Age & Sex of specimen	Site
79	MW79	Chausinga	Ulna	Adult, NI	Kotdwar
80	MW80	Cat	Femur(L)	Adult, Female	Kotdwar
81	MW81	Cat	Femur(R)	Adult, Female	Kotdwar
82	MW82	Cat	Humerus(L)	Adult, Female	Kotdwar
83	MW83	Cat	Humerus(R)	Adult, Female	Kotdwar
84	MW84	Cat	Tibia(L)	Adult, Female	Kotdwar
85	MW85	Cat	Fibula(L)	Adult, Female	Kotdwar
86	MW86	Cat	Tibia(R)	Adult, Female	Kotdwar
87	MW87	Cat	Fibula(R)	Adult, Female	Kotdwar
88	MW88	Cat	Radius(L)	Adult, Female	Kotdwar
89	MW89	Cat	Ulna(L)	Adult, Female	Kotdwar
90	MW90	Cat	Radius(R)	Adult, Female	Kotdwar
91	MW91	Cat	Ulna(R)	Adult, Female	Kotdwar
92	MW92	Tiger	Femur(L)	Adult, Female	Kotdwar
93	MW93	Tiger	Femur(R)	Adult, Female	Kotdwar
94	MW94	Tiger	Tibia(L)	Adult, Female	Kotdwar
95	MW95	Tiger	Tibia(R)	Adult, Female	Kotdwar
96	MW96	Tiger	Fibula(L)	Adult, Female	Kotdwar
97	MW97	Tiger	Fibula(R)	Adult, Female	Kotdwar
98	MW98	Tiger	Humerus(L)	Adult, Female	Kotdwar
99	MW99	Tiger	Humerus(R)	Adult, Female	Kotdwar
100	MW100	Tiger	Radius(L)	Adult, Female	Kotdwar
101	MW101	Tiger	Radius(R)	Adult, Female	Kotdwar
102	MW102	Tiger	Ulna(L)	Adult, Female	Kotdwar
103	MW103	Tiger	Ulna(R)	Adult, Female	Kotdwar

Table 4. Trace elemental data of archaeological samples

Sr.No.	Zn(ppm)	Sr(ppm)	Ba(ppm)	Mg(ppm)	K(ppm)	Fe(ppm)	Cu(ppm)	Mn(ppm)	Na(%)	Ca(%)
AA - 1	108.18	380.28	207	7057.69	709.95	1244.71	125	26.59	1.9	24.14
AA - 2	113.19	415.49	205.12	7153.21	631.07	781.37	104	25	1.8	24.67
AA - 3	107.23	383.27	205.11	7150.68	708.37	1244.07	130.27	25.66	1.4	24.92
AA - 4	115.37	390.01	205.03	7300.37	697.09	1195.32	110.02	26	1.9	23
AA - 5	110.09	421.18	205.03	7307.69	700.28	1233.49	115	25.33	1.8	24.67
AA - 6	112.98	450.12	205.03	7307.27	703.43	970.28	109.95	26.59	1.4	24.92
AA - 7	54.76	345.07	150.22	7423.08	782.77	868.64	130.67	25	1.7	25.23
AA - 8	55.27	340.2	151.26	7343.6	790.38	865.23	135.29	26.59	1.5	25.31
AA - 9	56.38	335.19	150.93	7290.08	782.09	860.97	135.33	26.59	1.7	25.31
AA - 10	55.97	391.27	151.09	7428.27	787.28	867.39	131.09	24.33	1.6	25.31
AA - 11	55.08	400.13	152	7397.21	785.08	868.37	136.02	25.32	1.8	25.23
AA - 12	124.87	521.17	195.24	7615.38	709.95	297.01	141.33	26	1.9	26.1
AA - 13	125.29	500.21	200	7600.38	708.9	298.33	145.2	25.98	1.9	26.2
AA - 14	126.38	529.19	205.3	7711.02	710	296.96	143.07	24.01	1.9	26.2
AA - 15	125.09	523.27	206.15	7599.25	711.02	289.38	149	26	1.9	26.2
AA - 16	125.11	512.72	204.97	7628.19	709.27	295.33	143.97	26.59	1.9	26.2
AA - 17	158.26	732.39	215.33	7480.77	916.26	627.95	120	26.59	2.1	26.51
AA - 18	160.09	730.28	205.64	7513.11	917.03	627.09	121.2	24.87	2.1	26.51
AA - 19	158.37	700.17	200	7435.29	915.95	625	125.3	26	2.1	26.51
AA - 20	159.78	712.38	214	7321.08	919.09	628.38	121.96	24	2.1	26.51
AA - 21	162.33	737.12	210.95	7399.27	919	626.43	124.22	26.59	2.1	26.51
AA - 22	111.52	721.13	218.12	7846.15	734.22	176.67	121.33	25.44	1.9	24.14
AA - 23	115.03	500.21	230.2	7899.13	735.37	176.07	130.96	24.97	2	24.67
AA - 24	113.97	512.11	225	7815.02	735.08	178	133.38	26	1.8	24.92
AA - 25	112.38	525.27	224.61	7798.09	735.33	175.47	123.54	26.59	1.9	23
AA - 26	115.09	521.19	228.37	7800.15	730.97	178.58	145	26.59	1.9	24.67
AA - 27	64.77	450.7	175	7538.46	831.31	462.48	104	26.59	1.6	23.66
AA - 28	65.21	425.79	180.36	7513.08	835	468	109.27	26.78	1.5	23.12
AA - 29	64.39	459.21	185.22	7500.19	833.22	465.48	110	26.59	1.6	23.56
AA - 30	65.07	489.12	189.45	7538.64	835.06	465.37	115.28	25	1.5	23
AA - 31	66.38	427.91	178.46	7528.39	833.96	467	115	26.02	1.4	23.11
AA - 32	74.5	343	207	3656.5	715.22	1235	120	26	1.9	24.14
AA - 33	75.07	343.24	205.12	3750.06	715.66	1234.47	121.23	25.33	1.8	24.67
AA - 34	76.33	327.29	205.11	3670.29	715.88	1230.09	123.97	26	1.4	24.92
AA - 35	73.98	339.01	205.03	3545.13	718.03	1231.11	123.09	25	1.9	23
AA - 36	76.09	292	205.03	8255	714.28	1233.37	122.35	27.01	1.8	24.67
AA - 37	147.5	292.24	205.03	8179	699	1200	127	26	1.4	24.92
AA - 38	146.25	290.45	207	8325.1	697.08	1201.01	125.37	27	1.5	23

Sr.No.	Zn(ppm)	Sr(ppm)	Ba(ppm)	Mg(ppm)	K(ppm)	Fe(ppm)	Cu(ppm)	Mn(ppm)	Na(%)	Ca(%)
AA - 39	148.93	282.21	205.12	8211.21	689.66	1196.38	125.07	25.66	1.8	24.97
AA - 40	150	210	205.11	3393	698.48	1203.25	126	26.59	1.6	24.68
AA - 41	147.5	209.01	206.03	3491.27	650	1190	115	26.59	1.8	23
AA - 42	150.02	215.05	208.03	3420.28	651.02	1197.33	116	26	1.7	24.97
AA - 43	149.37	216.27	210.03	3380.1	652	1190.02	115.93	24.01	1.8	24.68
AA - 44	149.28	277.5	211.54	2971.5	651.98	1189.36	116	24.09	1.5	24.67
AA - 45	102	276.02	215.66	2895.21	712	1300.02	132.02	26.59	1.9	25.04
AA - 46	103	639	214.08	3854.52	711.56	1298	121.25	26	2	25.18
AA - 47	75.5	640.03	220	3840.27	710.98	1297	121.09	26.59	2	25.22
AA - 48	180.03	547	219	2954	712.11	1259	121.08	25.88	2.2	24.61
AA - 49	131	549.8	224	2910.17	709.89	1288	120.97	25.44	2.1	25.62
AA - 50	132.39	190	215.66	4632	710.98	1287	122	26.59	2	25.04
AA - 51	124	190.06	214.08	4652.13	712.64	1288.33	120.02	16	2	25.18
AA - 52	128	394	220	4395	714	1289.25	121.07	18	2.2	25.22
AA - 53	166.05	390.01	219	4395.21	713	1290.02	121.09	16.33	2.1	24.61
AA - 54	166.02	390.22	224	4395.53	713.95	1290.67	142	16.52	2	25.62
AA - 55	221	175	87.3	4078.5	1225.73	372.97	150.12	16.47	1.7	28.48
AA - 56	216.5	174	85.9	4118	1230.07	266.92	159.17	15.22	2	29.05
AA - 57	305	184	85.4	4460.5	1055.83	267.09	160.67	16.25	2.3	29.4
AA - 58	232	150	87.3	4988	1058.33	267.02	161.07	16.34	2.4	29.57
AA - 59	225	180	85.9	5220	1061.23	289.04	170.67	15.89	2.5	28.74
AA - 60	234.5	179.5	85.4	4990	1062.89	290	170	15.66	2.7	28.77
AA - 61	389.9	139	85.4	4530	1256.09	321	163.58	16.02	2.3	28.63
AA - 62	259.5	178.5	84.21	3375.5	1023	264	170.06	16.22	1.8	27.54
AA - 63	259.5	178.5	84.21	3375.5	1023	264	160.06	16.04	1.8	27.54
AA - 64	250	165	83.15	3360	1020	260	149.2	14.22	1.78	25.36
AA - 65	249.2	167.6	83.15	3360	1020.3	261.2	149.2	14.02	1.78	25.36
AA - 66	249.6	168.3	83.15	3360	1019.8	261	149.2	14.55	1.78	25.36
AA - 67	248	165.6	83.15	3360	1018.98	261	149.2	13.21	1.78	25.36
AA - 68	250	165	83.15	3360	1020	261.3	149.2	14	1.78	25.36
AA - 69	248.9	166.2	83.15	3360	1020	261.3	149.2	13	1.78	25.36
AA - 70	250	165	83.15	3360	1021.3	261.3	149.2	14.02	1.78	25.36
AA - 71	175.3	195.8	198.1	3930	812.4	270	129.2	16.2	1.7	26
AA - 72	176.2	200	197.8	3850.2	812	278	129	16.5	1.8	25.9
AA - 73	178	215.2	199	3895	811.5	265.2	130	16	1.81	26.1

Table 5. Trace elemental data of modern domestic samples

Sr.No.	Zn(ppm)	Sr(ppm)	K(ppm)	Mg(ppm)	Cu(ppm)	Fe(ppm)	Na(%)	Ca(%)
MD -1	281.8	320	880.97	8776.01	85	46.5	1.9	29
MD -2	196.53	384.51	880.29	8724.97	30	3.5	1.8	28.7
MD -3	221.54	315.27	881.22	8725.29	61	2.11	1.91	28.9
MD -4	214.86	380.02	879.11	8727.21	40	4.02	1.9	29
MD -5	216.49	315.04	878.23	8725.99	57	4.71	1.84	28.7
MD -6	213.49	395.22	879.21	8725.58	55	5.12	1.9	28.9
MD -7	198.16	350.17	880.03	8725.89	75	4.17	1.84	29
MD -8	218.2	395.02	880	8725.46	40	2.51	1.9	28.9
MD -9	203.17	305.15	878.23	8726.49	155	3.24	1.86	29
MD -10	99.83	770.1	1328.29	9890.17	15	26.01	2	25
MD -11	111.52	840.05	1338.21	9890.15	5	9.55	2	24.9
MD -12	118.2	730.11	1327.01	9889.13	5	7.01	1.9	24.8
MD -13	114.86	730.11	1328.03	9888.64	5	10.11	1.9	24.9
MD -14	118.2	770.02	1330.23	9889.81	5	4.02	2	25
MD -15	99.83	840.06	1327.09	9889.81	5	12.51	2	24.8
MD -16	206.51	370.12	927.19	9891.82	51	4.52	1.9	29
MD -17	216.51	370.12	927.81	8595.22	45	4.03	1.8	28.7
MD -18	211.5	340.11	928.42	8595.24	56	23.51	1.91	28.9
MD -19	186.48	270.54	927.11	8593.97	45	10.01	1.9	29
MD -20	196.49	230.24	928.81	8592.78	57	2.04	1.84	28.7
MD -21	219.87	275.51	927.23	8572.87	65	2.11	1.9	28.9
MD -22	213.19	312.51	928.17	8590.78	54	2.89	1.84	29
MD -23	226.54	245.07	927.03	8591.8	58	4.01	1.9	28.9
MD -24	208.18	320.06	926.93	8591.83	53	4.17	1.86	29
MD -25	216.53	275.12	927	8593.06	56	3.79	1.8	28.9
MD -26	128.21	645.12	813.12	7333.27	20	24.01	1.7	22.9
MD -27	104.84	610.09	814.27	6960.12	25	13.5	1.8	22.94
MD -28	243.24	360.22	2609.23	8020.21	35	3.05	2	28.9
MD -29	206.51	380.15	2603.11	8019.29	34	35.51	2.1	28.7
MD -30	201.5	325.01	2599.01	8019.29	40	4.47	2	28.6
MD -31	213.19	325.06	2598.03	8019.27	35	4.29	2	28.9
MD -32	204.84	295.07	2599.01	8020	25	1.52	2	28.9
MD -33	283.14	320.78	2598.03	8021.33	36	2.98	2.1	28.7
MD -34	116.53	625.17	1171.29	5040	15	3.12	1.8	23.48
MD -35	109.85	275.33	1107.24	4970	5	22.51	1.9	23.49
MD -36	109.85	380.02	1108	5000	5	15.01	1.7	23.9
MD -37	103.17	625.11	1157.21	5040	5	10.02	2.2	23.8
MD -38	89.82	730.18	1105.27	5035.25	5	11.09	2.1	23.81

Sr.No.	Zn(ppm)	Sr(ppm)	K(ppm)	Mg(ppm)	Cu(ppm)	Fe(ppm)	Na(%)	Ca(%)
MD -39	101.5	695.24	1151.19	5050.05	15	7.84	2	23.78
MD -40	89.82	625.08	1157.21	5051	5	8.52	2	23.8
MD -41	106.51	695.44	1008.23	5050.44	25	12.34	1.7	23.91
MD -42	111.52	730.12	1015.94	5035.39	21	13.11	1.7	23.9
MD -43	96.49	805.17	1090.37	5030.22	20	7.05	1.6	23.56
MD -44	106.51	730.11	1110	5031.27	5	3.06	1.5	23.9
MD -45	126.54	695.14	1178.21	5032.19	5	2.59	1.6	23.89
MD -46	121.54	730.05	1008.01	5000.05	5	2.77	1.7	23.85
MD -47	106.51	730.09	1009.23	5031.29	5	2.54	1.7	23.87
MD -48	119.87	730.22	1600.02	7399.08	5	2.55	1.7	22.94
MD -49	124.87	730.11	1600.24	7429.11	5	3.05	1.8	22.89
MD -50	104.84	730.11	1600.01	7545	5	3.14	1.6	22.9
MD -51	119.87	730.66	1600	7547.23	5	3.51	1.7	22.91
MD -52	129.88	805.09	1590.25	7429.37	5	2.05	1.5	22.87
MD -53	126.54	805.12	1593.98	7398.29	5	14.57	1.7	22.9
MD -54	128.21	1085.08	1597.03	7000.08	5	33.52	1.6	22.87
MD -55	123.21	770.18	1593.31	7293.01	5	19.04	1.7	22.91
MD -56	116.53	625.12	1597.54	7219.11	5	3.02	1.6	22.8
MD -57	104.84	625.12	1591.07	7197.55	5	8.94	1.5	22.9
MD -58	128.21	590.43	1090.89	8498.07	110.02	7.21	2.3	26.9
MD -59	127.23	840.11	1055.21	8574.05	110	5.64	2.2	26.8
MD -60	128.27	840.63	1042.03	8572.33	109.23	4.95	2.3	26.9
MD -61	169.7	783.09	1009.21	8570.29	127	271.21	2.1	26.9
MD -62	170.91	905.21	1100	8580.1	115	285.35	2.2	26.89
MD -63	168.28	802.82	1007.28	8576.92	120	297.01	2.3	26.89
MD -64	156.59	1436.62	1256.07	8442.31	109.33	637.08	2.3	26.9
MD -65	158.29	1437.23	1250.33	8455	110	600.03	2.1	26.88
MD -66	157.9	1439.95	1197.21	8500	111	547.73	2.2	26.87
MD -67	163.27	767.61	1328.88	9890.21	125.33	612.91	2.3	26.89
MD -68	139.87	380.28	813.11	7826.92	114.67	206.75	2	24.24
MD -69	131.22	697.27	815.03	9326.91	116.69	265.17	1.8	24.7
MD -70	131.55	611.97	800.97	8038.72	56	312.05	1.84	24.9
MD -71	140.97	373.28	850.71	8038.46	59.75	315.33	2	25
MD -72	150.29	367.1	809	8100.1	58	317.34	1.9	24.87
MD -73	138.11	400.21	811.03	8040.97	55	276.11	1.81	24.9
MD -74	139.23	395.15	855.29	8115.21	58	318.03	2	24.56
MD -75	130.21	340.72	830.21	8038.23	50.73	276.02	2	24.6
MD -76	136.29	377.21	840.02	8100.96	55.21	280	1.9	24.8
MD -77	150.97	450.19	807.23	8040.1	49.23	275.07	1.8	24.9
MD -78	96.49	485.92	851.31	9365.46	50.67	251.88	2	24.85

Sr.No.	Zn(ppm)	Sr(ppm)	K(ppm)	Mg(ppm)	Cu(ppm)	Fe(ppm)	Na(%)	Ca(%)
MD -79	38.97	395.27	735.27	9003	45.2	200.11	1.81	24.9
MD -80	37.29	400.71	700	9004.21	48.1	205.02	1.8	24.91
MD -81	36.37	380.28	758.5	8075.38	104	71.37	1.9	24.89
MD -82	35.11	379.12	750	8076.92	10	75.21	2	24.92
MD -83	71.45	380.28	661.41	7711.54	6.67	26.24	1.8	22.87
MD -84	36.39	380.28	764.56	8365.38	10	41.28	1.9	22.98
MD -85	66.44	239.44	861.65	8065.38	10	56.32	2	22.9
MD -86	39.23	239.21	860.65	8076.92	14	55.11	1.9	22.89
MD -87	40.6	240.44	860.03	8076.92	19	54.02	2	22.8
MD -88	111.52	204.23	879.85	8676.52	44.22	146.58	1.8	28.9
MD -89	117.37	203.13	880.93	8250	45.93	149.01	1.81	29
MD -90	146.41	239.44	4508.5	8250.77	50	11.19	1.9	28.7
MD -91	146.41	274.65	1365.29	8442.31	104	11.19	1.84	29
MD -92	151.42	274.65	2609.22	9000	109	8.19	1.82	28.3
MD -93	143.07	204.23	1334.95	8750	98	11	1.81	28.5
MD -94	145.29	201.17	1304.33	7769.23	97.02	12	1.84	28.9
MD -95	131.39	204.23	3185.68	8050	98	12	1.8	29
MD -96	56.43	169.01	1717.23	8461.23	104	13	2	24.24
MD -97	56.27	168.02	1717.21	8461.54	104.02	13.02	2	24.8
MD -98	140	169.01	1692.96	8019.23	109	11.19	2.1	28.9
MD -99	132	239.44	2609.22	8096.15	109.33	11.19	2.1	28.7
MD -100	143	260.97	2609.22	8975.13	109.33	11.19	2.1	28.6
MD -101	137	240.43	2609.22	8990	109	11.19	2.1	28.9
MD -102	115.23	239.44	4654.02	8076.92	104.02	11.19	2.1	28.9
MD -103	115.23	239.44	4654.13	8076.92	94	11.19	2.1	28.7
MD -104	115.23	239.44	4654.12	8076.21	94	11.19	2.1	28.5
MD -105	115.23	239.44	4650.13	8076.92	104.03	11.19	2.1	28.6
MD -106	115.23	239.44	4651.32	8076.92	104.05	11.19	2.1	28.9
MD -107	115.23	239.44	4650.32	8076.58	104.02	11.19	2.1	28.9
MD -108	115.23	239.44	4655.02	8076.92	104.05	11.19	2.1	28.7
MD -109	116.23	239.44	4653.73	8076.92	104	11.19	2.1	28.4
MD -110	115.23	239.44	4655.02	8076.22	105	11.19	2.1	28.6
MD -111	86.5	547	1600.02	3960	5.1	2.55	1.7	22.9
MD -112	100	353	1600.24	7545	5	3.05	1.8	22.91
MD -113	95.02	540	1600.01	6973	5.2	3.14	1.8	22.9
MD -114	85.3	397	1600	4650	5.2	3.51	1.7	22.68
MD -115	97.37	584	1590.25	4650	5.2	2.05	1.7	22.39
MD -116	90.2	530	1593.98	6990	5.2	14.57	1.8	23
MD -117	81.5	560	1597.03	6970	5.2	33.52	1.8	23
MD -118	79.3	545	1593.31	6975	5.2	19.04	1.8	22.97

Sr.No.	Zn(ppm)	Sr(ppm)	K(ppm)	Mg(ppm)	Cu(ppm)	Fe(ppm)	Na(%)	Ca(%)
MD -119	77.2	594	1597.54	6971	5.1	3.02	1.82	22.9
MD -120	80.27	537	1591.07	6890	5	8.94	1.81	22.3
MD -121	98	343	661.41	7255	16.67	26.24	2.1	23.19
MD -122	85.5	231	764.56	7520	16	41.28	2	22.65
MD -123	96	292	861.65	7246	10.4	56.32	1.8	22.87
MD -124	87.2	340	860.65	7455	10.32	55.11	2.14	23.68
MD -125	84.12	306	860.03	7261	10	54.02	1.9	22.56
MD -126	83.97	310	855.6	7212	8.22	55	1.9	22.5
MD -127	82.11	298	871.67	7268	10	54.98	1.89	22.54
MD -128	90	235	881	7532	19	54.7	2	22.9
MD -129	100	291	884	7515	10	55	2	22.24
MD -130	101	280	880	7500	115.24	53.2	1.9	23
MD -131	154	271	813.11	6541	125.33	206.75	2	24.6
MD -132	159	278	815.03	6540	114.67	265.17	1.96	24.57
MD -133	155	265	800.97	6505	116.69	312.05	1.9	24.6
MD -134	154	269	850.71	6554	112.24	315.33	2.1	24.9
MD -135	156.2	270	809	6500	114	317.34	2	24.61
MD -136	158.2	274	811.03	6501	124	276.11	2	24.4
MD -137	93	466	1171.29	2088.5	25	22.51	1.8	23.24
MD -138	95	450	1107.24	2087	32	15.01	1.9	23.29
MD -139	80.5	190	1108	7940	35	10.02	2.2	22.9
MD -140	81	205	1157.21	7935	22	11.09	2	22.97
MD -141	72.5	210	1105.27	7005	52	22.51	1.5	23.18
MD -142	73.3	217	1151.19	7016	25	15.01	1.57	23.35
MD -143	90	444	1157.21	2000	34	10.02	1.9	23.83
MD -144	90.5	452	1008.23	2001.3	31	11.09	1.89	23.8
MD -145	128	98	1015.94	6265	30	22	2	25.18
MD -146	75.2	280	1090.37	7540	38	25	1.8	24.6

Table 6. Trace elemental data of modern wild samples

Sr.No.	Sr(ppm)	Zn(ppm)	Mg(ppm)	K(ppm)	Ba(ppm)	Mn(ppm)	Cu(ppm)	Fe(ppm)	Na(%)	Ca(%)
MW1	204.23	9.68	8615.38	1589.81	312.5	26.59	98.67	26.24	1.8	28.9
MW2	204.23	10	8615.38	1589.79	312.5	26.59	98.76	26.24	1.8	28.9
MW3	204.23	9.68	8615.37	1590.08	312.5	26.59	98.99	26.23	1.8	28.9
MW4	204.23	9.67	8614.27	1589.81	312.5	26.59	98.67	26.24	1.8	28.9
MW5	204.23	9.6	8615.97	1587.27	312.5	26.59	97.98	26.24	1.8	28.9
MW6	204.23	9.7	8615.29	1589.21	312.5	26.59	97.8	26.24	1.8	28.9
MW7	204.23	9.68	8615.99	1589.81	312.5	26.59	97.77	26.24	1.8	28.9
MW8	205.11	9.7	8615.22	1589.81	312.5	26.59	99.11	26.25	1.8	28.9

Sr.No.	Sr(ppm)	Zn(ppm)	Mg(ppm)	K(ppm)	Ba(ppm)	Mn(ppm)	Cu(ppm)	Fe(ppm)	Na(%)	Ca(%)
MW9	205.12	8	8618.21	1589.83	312.5	26.59	98.67	26.34	1.8	28.9
MW10	204.23	9.7	8617.38	1589.03	312.5	26.59	98.08	26.24	1.8	28.9
MW11	204.97	9.68	8619.01	1589.01	312.5	26.59	97.87	26.24	1.8	28.9
MW12	265.78	29.9	8617.07	1601.03	312.5	26.59	98.79	27.23	1.8	28.9
MW13	274.65	24.71	8623.08	983.01	312.5	26.59	104	2.01	1.6	27.9
MW14	284.95	27.11	8610.07	845.27	312.5	26.59	104.01	2.87	1.9	27.3
MW15	273.71	28.97	8923.08	980.01	312.5	26.59	105.97	3.09	1.9	27.3
MW16	309.86	44.74	8576.92	728.16	312.5	26.59	104	3.01	1.9	27.3
MW17	803.03	46.27	8728.71	2018.79	312.5	25.6	105.23	40.97	1.9	27.3
MW18	802.82	46.41	8730.77	2008.5	312.5	25.87	104	40.18	1.9	27.3
MW19	485.92	49.79	8057.78	1408.5	312.5	24	114.78	43.21	1.9	27.3
MW20	487.22	50.11	8125.23	1425.31	312.5	25	110	44.19	1.9	27.3
MW21	485.92	94.82	8057.69	1413.83	312.5	24.04	114.67	41.28	1.9	27.3
MW22	487.81	93.27	8112.72	1424.11	312.5	25.01	110.79	42.35	1.9	27.3
MW23	556.34	95.59	8711.54	1025.49	312.5	24.22	104	2	1.9	27.3
MW24	521.13	81.47	8788.46	1474.51	312.5	25.01	98.67	86.41	1.9	27.3
MW25	450.7	83.14	8961.54	1237.86	312.5	24.66	104	85.27	1.9	27.3
MW26	560.34	95.59	8715.54	1026.29	312.5	24.11	105	79.18	1.9	27.3
MW27	527.01	97.78	8625.17	1090.31	312.5	24.05	104	70	1.9	27.3
MW28	526.03	97.8	8626.91	1081.03	312.5	24.11	109.01	73.01	1.9	27.3
MW29	810.37	45.02	8708.23	2017.39	312.5	22.33	106.09	41	1.9	27.3
MW30	807.01	45.22	8733.77	2007.49	312.5	24	103.97	41.02	1.9	27.3
MW31	502.22	48.37	8056.79	1407.45	312.5	23.01	113.27	43.33	1.9	27.3
MW32	500.19	49.21	8124.22	1418.32	312.5	24	110.07	44.29	1.9	27.3
MW33	502.09	93.17	8057.7	1400.83	312.5	22.98	113.79	42.02	1.9	27.3
MW34	500.78	92.11	8115.73	1424.29	312.5	22.66	110	42.56	1.9	27.3
MW35	575.23	90.02	8715.54	1024.36	312.5	23.01	104.05	32.54	1.9	27.3
MW36	447.09	80	8789.64	1454.33	312.5	23.01	94.02	85.27	1.9	27.3
MW37	463.32	80.02	8960.24	1237.85	312.5	22.11	104.01	85.39	1.9	27.3
MW38	575.19	89.37	8700.23	1023.12	312.5	23.94	104.98	79.78	1.6	26.8
MW39	550.03	90.03	8600.07	1085.21	312.5	24	104.02	70.02	1.6	25.4
MW40	551.01	94.32	8625.97	1075.03	312.5	24.01	108.58	73.39	1.6	26.4
MW41	205.07	77.67	8827.37	1105.29	312.5	22	108.79	71.11	1.8	27.5
MW42	204.23	76.46	9192.51	1953.88	312.5	23.59	109.33	70.29	1.8	28.9
MW43	203.19	75.07	9190.27	1953.27	312.5	23	109.33	70.06	1.8	27.9
MW44	98.59	74.79	9192.31	922.33	312.5	26	110.23	447.44	1.8	26.8
MW45	98.06	53.09	8865.38	1086.87	312.5	24	105	447.44	1.8	25.4
MW46	98.79	53.09	8865.38	1087.77	312.5	23.66	104	447.44	1.8	26.4
MW47	99.27	53.09	8865.38	1086.98	312.5	23.05	104	445.27	1.8	27.5
MW48	98.59	53.09	8865.38	1086.17	312.5	24	104	445.23	1.8	28.9

Sr.No.	Sr(ppm)	Zn(ppm)	Mg(ppm)	K(ppm)	Ba(ppm)	Mn(ppm)	Cu(ppm)	Fe(ppm)	Na(%)	Ca(%)
MW49	98.09	53.09	8865.38	1086.17	312.5	24	104	449.02	1.8	27.9
MW50	98.37	53.09	8865.38	1087.18	312.5	24.55	104	448.95	1.8	26.8
MW51	98.23	53.09	8795.29	1086.19	312.5	24.56	104.21	447.02	1.8	25.4
MW52	99	54	8795.29	1086.17	312.5	24	103.97	447.22	1.8	26.4
MW53	98.59	55.09	8865.38	1086.27	312.5	23.98	104	448.08	1.8	27.5
MW54	133.8	63.11	9115.38	2609.22	312.5	26.51	103	20.21	1.8	28.9
MW55	133.78	41.4	9096.15	2372.57	312.5	25	105	22.02	1.8	27.9
MW56	140.2	38.97	8550.22	2219.07	312.5	27.22	107.97	19.79	1.8	26.8
MW57	133.78	41.4	9080.76	2380.77	312.5	26	104.21	18.05	1.8	25.4
MW58	133.75	45.27	8540.01	2225.01	312.5	26.59	104.17	21.87	1.8	26.4
MW59	169.71	35.81	8987.11	2387.1	312.5	25	103.91	22.33	1.8	27.5
MW60	170	34.22	8980.01	2385.05	312.5	26.59	103	20.01	1.8	28.9
MW61	134.79	45.17	9097.17	2395.79	312.5	25.33	104	21.79	1.8	27.9
MW62	169.01	42.31	8990.97	2390.07	312.5	26.59	109.07	20.09	1.8	26.8
MW63	170.02	41.97	8989.13	2385.33	312.5	24.11	104.6	22.97	2	29
MW64	133.7	29.72	8711.54	2324.03	312.5	26.59	104.06	21.51	2	29
MW65	173.17	30	8715.17	2350.17	312.5	26	104.71	21.05	2	28.9
MW66	169.01	31.39	8327.11	3240.29	312.5	26.59	104.6	56.32	2	28.9
MW67	169.01	31.39	8325.77	3240.29	312.5	25	113.29	56.42	2	29.01
MW68	168.01	31.39	8326.92	3240.29	312.5	24.87	110.11	56.09	2	29
MW69	169.01	31.39	8326.92	3240.29	312.5	24.68	114.67	56.26	2	29
MW70	169.01	31.39	8326.9	3240.29	312.5	26	114.67	56.09	2	28.9
MW71	170.73	35.97	8320.97	3100.01	312.5	25	110.91	538.12	1.76	25.4
MW72	207.17	65.02	8340.17	3050.27	312.5	27	107	530.28	1.76	25.4
MW73	204.23	73.12	8230.78	3004.71	312.5	26.59	104.67	537.69	1.76	25.4
MW74	170.03	64.77	8450.11	1980.11	312.5	26	104	19.11	1.76	25.4
MW75	169.01	69.78	8423.08	1990.29	312.5	25.99	160.12	20.29	1.76	25.4
MW76	133.8	73.97	9461.54	1947.82	312.5	25.24	109.17	21.97	1.76	25.4
MW77	179.27	72.09	9468.59	1900.27	312.5	26	109.17	21.96	2.01	30.1
MW78	180.01	71.45	8270.11	1950.19	312.5	26.59	108.07	20.23	2.01	29.6
MW79	181.33	78.4	8199.97	1816.5	312.5	27	108.09	20.09	2.01	30
MW80	98.59	101.5	8007.69	1150.27	312.5	16.02	120.12	372.22	2.01	30.1
MW81	97.27	109.02	8018.19	1225.73	312.5	16.29	119.17	372.97	2.01	30
MW82	98.59	129.88	8061.54	1230.07	312.5	15.22	120.67	266.92	2.01	30.1
MW83	99.56	127.98	8040.11	1055.83	312.5	16.02	121.07	267.09	2.01	30.2
MW84	63.38	127.05	8080.77	1058.33	312.5	15.98	130.67	206.75	2.01	30
MW85	62.55	136.56	8050.37	1061.23	312.5	15.67	130	205.98	2.01	30
MW86	63.38	135.22	8080.72	1062.89	312.5	15.22	124.67	206.75	2.01	30.2
MW87	62.17	136.54	8011.54	1183.25	312.5	16	124.08	205.98	2.01	30
MW88	69.44	135.12	8015.23	1184.24	312.5	16.02	123.9	206.75	2.01	30

Sr.No.	Sr(ppm)	Zn(ppm)	Mg(ppm)	K(ppm)	Ba(ppm)	Mn(ppm)	Cu(ppm)	Fe(ppm)	Na(%)	Ca(%)
MW89	68.23	134.22	8050.22	1183.94	312.5	15.98	123.37	205.99	2.12	30.1
MW90	69.24	136.02	8011.54	1180.22	312.5	15.66	141.33	206.28	2.12	30.1
MW91	67.03	136.05	8010.93	1180.92	312.5	15.99	141.21	205.57	2.12	30.1
MW92	63.8	99.83	7423.08	794.9	312.5	13.22	150.67	76.24	2.12	30.5
MW93	63.38	98.16	8023.08	691.75	312.5	14.02	152	78.29	2.12	30.2
MW94	63.38	116.53	8096.15	576.46	312.5	13.66	144	86.41	2.12	30.2
MW95	98.59	74.79	7769.23	837.38	312.5	13.58	136	85.59	2.12	30.5
MW96	88.23	115.23	7670.24	835.23	312.5	14	137.02	56.25	2.12	30.6
MW97	85.55	85.27	7671.29	835.08	312.5	14.05	137.99	56.78	2.12	30.4
MW98	63.38	103.17	7846.15	861.65	312.5	13.97	140	41.28	2.12	30.2
MW99	98.59	121.54	8000	891.99	312.5	13.55	141	45.66	2.12	30.2
MW100	63.38	103.17	7365.38	776.7	312.5	14.55	130.67	26.24	2.12	30.3
MW101	63.38	104.84	7846.15	1074.03	312.5	14.33	136	30.01	2.12	30.1
MW102	63.38	100.12	7764.25	770.09	312.5	14.56	135.97	30.28	2.12	30
MW103	63.38	101.97	7764.25	771.21	312.5	14.23	135	30.28	2.12	30.4

Table 7. Isotopic data analyzed by Department of Anthropology, University of South Florida (USA)

Sr. No.	USF Lab No.	Specimen	Age & Sex	Site	Period	$\delta^{13}C$ (‰) (Coll.)	$\delta^{15}N$ (‰) (coll.)	USF Lab No.	$\delta^{13}C$ (‰) (apat.)
1.	4482	*H. sapiens*	25-30, male	Malari	1600A.D.	-10.9	+11.4	4502	-7.7
2.	4483	*H. sapiens*	-do-	Malari	-do-	-11.6	+10.9	4503	-6.2
3.	4484	*H. sapiens*	-do-	Malari	-do-	-11.7	+11.3	4504	-7.1
4.	4485	*H. sapiens*	-do-	Malari	-do-	-12.9	+11.7	4505	-7.5
5.	4494	*H. sapiens*	-do-	Malari	-do-	-11.9	+10.5	4506	-7.9
6.	4500	Buffalo	M, male	Srinagar	Modern	-9.1	+3.2		
7.	4501	Buffalo	M, male	Srinagar	-do-	-9.9	+3.7		
8.	4491	*Bos indicus*	M,?	Banderkhet	9th -10th cent. A.D	-10.3	+4.1		
9.	4492	*Bos indicus*	M,?	Ufalda	7th - 8th cent. A.D	-9.2	+5.6		
10.	4495	*Bos indicus*	M,?	Supana	4th Cent. A.D.	-14.0	+5.5		
11.	4496	*Bos indicus*	M,?	Supana	-do-	-14.7	+7.5		
12.	4497	*Bos indicus*	M,?	Ufalda	7th -8th cent. A.D	-9.4	+3.1		
13.	4486	*Bos indicus*	M,?	Malari	Modern	-18.0	+11.6		
14.	4487	*Bos indicus*	M,?	Malari	-do-	-16.7	+8.6		
15.	4488	*Bos indicus*	M, male	Srinagar	-do-	-16.1	+5.9		
16.	4489	*Capra jharal*	M,?	Malari	-do-	-15.9	+3.2		
17.	4490	*Capra jharal*	M,?	Malari	-do-	-20.5	+2.9		
18.	4498	*Capra jharal*	M, male	Kotdwara	-do-	-16.2	+4.1		
19.	4499	*Capra jharal*	M, male	Kotdwara	-do-				
20	4493	*Capra jharal*	?	Banderkhet	9th -10th cent. A.D	-17.5	+5.6		

Notes: 1. $\delta^{13}C$ values are relative to PDB; $\delta^{15}N$ values are relative to AIR.

2. 1.5 per mil has been added to modern δ13C values to correct for industrial depletion.

Table 8. Isotopic data analyzed by Research Laboratory for Art and Archaeology, University of Oxford (UK)

Sr. No.	**OU Lab. no.**	**Bone material**	**Specimen**	**Age & Sex**	**Site**	**Period**	**$\delta^{13}C$ (‰) (Coll.)**	**$\delta^{15}N$ (‰) (Coll.)**
1.	VN-1	Humerus	*H. sapiens*	25-30, male	Malari	1600A.D.	-12.56	+9.31
2.	VN-2	Tibia	*H. sapiens*	-do-	Malari	-do-	-12.74	+8.88
3.	VN-3	Femur	*H. sapiens*	-do-	Malari	-do-	-12.43	+9.57
4.	VN-4	Femur	*H. sapiens*	-do-	Malari	-do-	-12.57	+9.21
5.	VN-13	Radius	*H. sapiens*	-do-	Malari	-do-	-12.82	+9.03
6.	VN-19	Radius	Buffalo	M, male	Srinagar	Modern	-11.44	+3.44
7.	VN-20	Femur	Buffalo	M, male	Srinagar	-do-	-12.20	+2.27
8.	VN-10	Femur	*Bos indicus*	M,?	Banderkhet	9th -10th cent. A.D	-10.14	+4.90
9.	VN-11	Femur	*Bos indicus*	M,?	Ufalda	7th-8th cent. A.D	-10.37	+3.73
10.	VN-14	Femur	*Bos indicus*	M,?	Supana	4th cent. A.D.	-10.33	+4.80
11.	VN-15	Femur	*Bos indicus*	M,?	Supana	-do-		
12.	VN-16	Femur	*Bos indicus*	M,?	Ufalda	7th -8th cent. A.D	-10.97	+4.18
13.	VN-5	Femur	*Bos indicus*	M,?	Malari	modern	-18.48	+9.93
14.	VN-6	Tibia	*Bos indicus*	M,?	Malari	-do-	-18.27	+8.21
15.	VN-7	Tibia	*Bos indicus*	M, male	Srinagar	-do-	-16.60	+4.20
16.	VN-8	Femur	*Capra jharal*	M,?	Malari	-do-	-18.32	+9.09
17.	VN-9	Tibia	*Capra jharal*	M,?	Malari	-do-	-22.46	+2.80
18.	VN-17	Femur	*Capra jharal*	M, male	Kotdwara	-do-	-21.87	+3.38
19.	VN-18	Tibia	*Capra jharal*	M, male	Kotdwara	-do-	-21.44	+3.13
20	VN-12	Femur	*Capra jharal*	?	Banderkhet	9th -10th cent. A.D	-18.01	+5.01
21.	VN-23	Tibia	Jhuppu	M,?	Malari	100 B.C.	-19.28	+7.66
22.	VN-22	Humerus	Jhuppu	M,?	Malari	-do-	-19.46	+7.92
23.	VN-21	Femur	Jhuppu	M,?	Malari	-do-	-19.43	+8.43
24.	VN-24	Femur	*Bos indicus*	M,?	Thapli	140 B.C.		
25.	VN-25	Tibia	*Bos indicus*	M,?	Thapli	-do-	-11.45	+5.12

Note: 1. $\delta^{13}C$ values are relative to the VPDB standard, and $\delta^{15}N$ values are relative to the AIR standard.

2. The analytical error (1σ) for all samples is ±0.2‰ for both $\delta^{13}C$ and $\delta^{15}N$.

Table 9. Carbon and Nitrogen ratios (C/N) of different specimens.

Sample No.	Specimen	Site	Cultural context	C%	N%	C/N ratios
I.	Cattle	Supana	Archaeological	4.30	1.02	4.2
II.	Cattle	Ufalda	Archaeological	3.78	0.612	6.2
III.	Cattle	Srinagar	Modern	12.85	3.61	3.6
IV.	Pig	Kotdwar	Modern	16.55	3.89	4.3
V.	Chousingha	Kotdwar	Modern	10.60	3.12	3.4
VI.	Goat	Malari	Modern	14.18	4.37	3.3
VII.	Cat	Kotdwar	Modern	14.06	4.64	3.0
VIII.	Languor	Kotdwar	Modern	12.76	3.90	3.3
IX.	Human	Malari	Archaeological	13.42	4.31	3.1
X.	Tiger	Kotdwar	Modern	12.41	4.00	3.1

Table 10. Comparison of diet of cattle on the basis of periods

	Period*	N**	*Mean*	Std. Deviation	t value	p value
Zn	2.00	14	106.8686	10.62248	-1.394	.176
	4.00	19	117.4663	30.72973		
Sr	2.00	14	648.0179	146.07262	7.686	.000
	4.00	19	319.8747	75.33768		
Fe	2.00	14	8.6836	5.86754	-45.001	.000
	4.00	19	1178.9805	113.15109		
Mg	2.00	14	5028.3679	23.01378	-1.268	.221
	4.00	19	5659.2289	2167.86947		
Cu	2.00	14	10.0714	7.44688	43.080	.000
	4.00	19	119.5395	6.88597		
K	2.00	14	1098.3857	63.76342	22.401	.000
	4.00	19	690.4463	27.98045		
Na	2.00	14	1.8000	.20755	1.554	.132
	4.00	19	1.6895	.19406		
Ca	2.00	14	23.7814	.15427	-3.194	.005
	4.00	19	24.3479	.75190		

Note: * Period 2 = Modern (Srinagar), 4 = Archaeological (Supana)
** N = Number of samples

Table 11. Comparison of diet of goat on the basis of periods

	Period*	N**	*Mean*	Std. Deviation	t value	p value
Zn	2.00	15	77.4673	22.22840	-10.115	.000
	4.00	5	55.4920	.66556		
Sr	2.00	15	293.7100	50.93878	-3.010	.004
	4.00	5	362.3720	30.78384		
Fe	2.00	15	49.2547	10.50299	49.267	.000
	4.00	5	866.1200	3.17570		
Mg	2.00	15	7604.0093	372.13616	-.398	.692
	4.00	5	7376.4480	58.79955		
Cu	2.00	15	19.0347	26.89143	17.210	.000
	4.00	5	133.6800	2.57674		
K	2.00	15	825.9247	76.18374	-6.368	.000
	4.00	5	785.5200	3.39993		
Na	2.00	15	1.9487	.09716	-3.613	.015
	4.00	5	1.6600	.11402		
Ca	2.00	15	22.8380	.33450	13.772	.000
	4.00	5	25.2780	.04382		

Note: * Period 2 = Modern (Srinagar), 4 = Archaeological (Supana)
** N = Number of samples

Table 12. Comparison of diet of cattle on the basis of periods

	Period*	N**	*Mean*	Std. Deviation	t value	p value
Zn	2.00	14	106.8686	10.62248	-2.232	.049
	9.00	10	130.7990	32.70002		
Sr	2.00	14	648.0179	146.07262	3.430	.003
	9.00	10	420.6140	169.41480		
Fe	2.00	14	8.6836	5.86754	-324.972	.000
	9.00	10	1288.7290	11.42632		
Mg	2.00	14	5028.3679	23.01378	4.955	.001
	9.00	10	3892.4040	724.69710		
Cu	2.00	14	10.0714	7.44688	-37.951	.000
	9.00	10	124.2590	7.13583		
K	2.00	14	1098.3857	63.76342	22.660	.000
	9.00	10	712.1110	1.32613		
Na	2.00	14	1.8000	.20755	-3.942	.001
	9.00	10	2.0500	.09718		
Ca	2.00	14	23.7814	.15427	-11.659	.000
	9.00	10	25.1340	.34290		

Note: * Period 2 = Modern (Srinagar), 9 = Archaeological (Ufalda)
** N = Number of samples

Table 13. Comparison of diet of cattle on the basis of periods

	Period*	**N****	*Mean*	**Std. Deviation**	**t value**	**p value**
Zn	2.00	14	106.8686	10.62248	-2.299	.037
	7.00	5	113.5980	1.59818		
Sr	2.00	14	648.0179	146.07262	1.615	.133
	7.00	5	555.9820	92.82085		
Fe	2.00	14	8.6836	5.86754	-100.577	.000
	7.00	5	176.9580	1.30406		
Mg	2.00	14	5028.3679	23.01378	-140.913	.000
	7.00	5	7831.7080	42.30504		
Cu	2.00	14	10.0714	7.44688	-26.048	.000
	7.00	5	130.8420	9.36352		
K	2.00	14	1098.3857	63.76342	21.345	.000
	7.00	5	734.1940	1.86100		
Na	2.00	14	1.8000	.20755	-1.566	.136
	7.00	5	1.9000	.07071		
Ca	2.00	14	23.7814	.15427	-1.438	.222
	7.00	5	24.2800	.77003		

Note: * Period 2 = Modern (Srinagar), 7 = Archaeological (Ranihat)
** N = Number of samples

Table 14. Comparison of wild and domestic herbivores

Ele.	**Category***	**N***	*Mean*	**Std. Deviation**	**t value**	**p value**
Zn	1	79	52.2	27	-9.851	0.000
	2	28	105.9	16.8		
Sr	1	79	290.76	195.72	-9.312	0.000
	2	28	669.98	150.54		
Fe	1	79	108.89	162.34	3.196	0.002
	2	28	10.48	9.49		
Mg	1	79	8661.53	322	6.368	0.000
	2	28	7487.96	1558		
Cu	1	79	105.96	7.7	63.668	0.000
	2	28	6.65	4.9		
K	1	79	1733	672	1.923	0.057
	2	28	1483	218		
Na	1	79	1.84	0.09	3.370	0.001
	2	28	1.76	0.13		
Ca	1	79	27.62	1.22	17.158	0.000
	2	28	23.28	0.87		

Note: *Category = 1, wild herbivore; 2, Domestic herbivore.
* N = Number of samples

Table 15. Comparison of diet of cattle (modern) at different altitudes

	SITE*	N**	*Mean*	**Std. Deviation**	**F value**	**p value**
Zn	1.00	6	110.4067	8.55892	38.597	.000
	2.00	14	106.8686	10.62248		
	3.00	10	152.8650	17.93048		
Sr	1.00	6	780.0750	49.77712	7.245	.003
	2.00	14	648.0179	146.07262		
	3.00	10	984.3700	323.27344		
K	1.00	6	1329.8100	4.27677	18.193	.000
	2.00	14	1098.3857	63.76342		
	3.00	10	1133.7110	115.33428		
Mg	1.00	6	9889.6183	.60928	1041.071	.000
	2.00	14	5028.3679	23.01378		
	3.00	10	8665.9280	433.42411		
Cu	1.00	6	6.6667	4.08248	813.643	.000
	2.00	14	10.0714	7.44688		
	3.00	10	114.6910	6.92015		
Fe	1.00	6	11.5350	7.66026	14.696	.000
	2.00	14	8.6836	5.86754		
	3.00	10	326.9120	261.65327		
Na	1.00	6	1.9667	.05164	22.971	.000
	2.00	14	1.8000	.20755		
	3.00	10	2.2300	.08233		
Ca	1.00	6	24.9000	.08944	2121.741	.000
	2.00	14	23.7814	.15427		
	3.00	10	26.8820	.03048		

Note: * Site 1 = Foot hills and 2 = Srinagar valley 3 = High altitude
** N = Number of samples

Table 16. Comparison of diet of goat (modern) at different altitudes

	SITE*	N**	*Mean*	Std. Deviation	F value	p value
Zn	1.00	22	104.7441	18.50351	6.480	.003
	2.00	15	77.4673	22.22840		
	3.00	23	116.6104	46.64359		
Sr	1.00	22	639.9555	155.37627	43.297	.000
	2.00	15	293.7100	50.93878		
	3.00	23	365.1613	122.33231		
K	1.00	22	1525.1950	230.31923	64.021	.000
	2.00	15	825.9247	76.18374		
	3.00	23	885.3030	265.28177		
Mg	1.00	22	6832.9645	1013.0935	8.717	.000
	2.00	15	7604.0093	372.13616		
	3.00	23	7880.6661	926.96543		
Cu	1.00	22	6.6545	5.18714	52.910	.000
	2.00	15	19.0347	26.89143		
	3.00	23	80.2696	34.37486		
Fe	1.00	22	10.1950	10.07437	82.821	.000
	2.00	15	49.2547	10.50299		
	3.00	23	233.2274	97.82600		
Na	1.00	22	1.7105	.09858	41.360	.000
	2.00	15	1.9487	.09716		
	3.00	23	1.9357	.08898		
Ca	1.00	22	22.8491	.17617	435.156	.000
	2.00	15	22.8380	.33450		
	3.00	23	24.7340	.21993		

Note: * Site 1 = Foot hills and 2 = Srinagar valley 3 = High altitude
** N = Number of samples

Table 17. Comparison of wild animals on the basis diet

Ele.	Subs.	N*	*Mean*	Std. Deviation	F value	p value
Zn	Herb	79	52	27	64·617	0·000
	Omni	12	128	11		
	Carn	12	102	12		
Sr	Herb	79	290	195	14·326	0·000
	Omni	12	76	16		
	Carn	12	73	14		
Fe	Herb	79	108	162	5·864	0·004
	Omni	12	244	64		
	Carn	12	53	23		
Mg	Herb	79	8661	322	63·498	0·000
	Omni	12	8036	27		
	Carn	12	7769	221		
Mn	Herb	79	25.12	1.40	615·810	0·000
	Omni	12	15.83	0.33		
	Carn	12	13.97	0.41		
Cu	Herb	79	105.96	7.70	127·946	0·000
	Omni	12	126.68	7.68		
	Carn	12	139.69	6.37		
K	Herb	79	1733	672	15·724	0·000
	Omni	12	1146	67		
	Carn	12	809	118		
Na	Herb	79	1.84	0.09	71·821	0·000
	Omni	12	2.03	0.04		
	Carn	12	2.12	0.00		
Ca	Herb	79	27.62	1.22	51·331	0·000
	Omni	12	30.07	0.07		
	Carn	12	30.30	0.18		

Note: * N = Number of samples

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